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Foreword

The second symposium on Location Based Services (LBS) and TeleCartography, taking place at Vienna (Austria) from 28 to 29 January 2004, is organized by the Institute of Cartography and Geo-Media Techniques (IKGeoM) of the Vienna University of Technology (TU) in cooperation with the Commission on Maps and the Internet of the International Cartographic Association (ICA).

In the last years activities in the field of applying cartographic presentations on mobile devices (TeleCartography) and developing innovative services, where the location of a mobile device becomes a "variable" of an information system (LBS), have increased internationally. The cartography department of the Vienna University of Technology has been interested in this developments from early stages, which have led to various research projects, students activities, multidisciplinary cooperations and the organisation of the first symposium on TeleCartography and LBS at Vienna in 2002. The success of this first symposium and the further increasing activities in various disciplines related to LBS and TeleCartography have been seen as major arguments for setting up a second symposium at the TU Vienna, being meant as forum for bringing together experts of both academical and economical background as well as representatives of different disciplines.

In modern cartography the main focus is on understanding the processes and methods of "how to communicate spatial information efficiently". In this concern, the "responsibility" of cartography exceeds the creation of cartographic presentation forms, but is rather focused on understanding the relations within the "whole system" of communicating spatial information, including the user, the models and the transmission processes. The engagement of modern cartography in fields like LBS and TeleCartography and the various multidisciplinary approaches including cartographers have to be seen in this context.

As the body for international coordinated activities in cartography the International Cartographic Association (ICA) is trying to generally convey cartographic developments. Within the ICA the Commission on Maps and the Internet has been founded in 1999 and annually the Commission activities are culminating in the Commission Meetings where the intention of bringing together international specialists in the field of Internet Mapping and to disseminate information to a broader audience on new developments and major areas of research is pursued. As the activities in the field of LBS and TeleCartography can be understood as an expansion of Internet Mapping Methods and Techniques on the Mobile Internet, it has been a common interest, to have - after meetings in Ottawa (Canada 1999), Knoxville (USA 2000), Guangzhou (China 2001), Karlsruhe (Germany 2002), Stellenbosch (South Africa 2003) - a meeting 2004 at Vienna, Austria, dedicated to the issues of LBS and TeleCartography.

The program and contributions of the Symposium include various topics, covering various fields of LBS and TeleCartography. Contributors from twelve different countries prove that the actuality and importance of LBS and Mobile Internet Mapping is still increasing and the location Vienna meets the interest of many participants. A "relatively" new field of research activities can always be seen as a challenge in many ways, including the fact, that still heterogenity of contributions in various terms have to be expected. This issue of the "Geowissenschaftlichen Mitteilungen", a joined Journal of the Departments of Geodesy and Geoinformation at the Vienna University of Technology, is therefore especially dedicated to the contributors of the 2004 Symposium on LBS and TeleCartography.

For the help with organizing the meeting and publishing this journal I would like to thank the Cartography Team of TU Vienna, namely Dr. M. Lechthaler, DI S. Uhlirz, DI M. Jobst, DI B. Brunner, V. Derman and E. Gruber.

Vienna, December 2003

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LBS and Telecartography: the evolution continues

Michael Wood, Aberdeen

Abstract

Map-making has been respected for centuries, and especially since the development of printing, for the skills of creating real paper maps. Today, however, with computers and GIS, cartography may have lost some status. Through a review of the history and nature of the subject this paper proposes that cartography is basically an internal, virtual process directed, primarily, at spatial problem-solving. As such it has an essential if informal aspect which everyone employs from day to day. In recent centuries, however, formal externalised cartography has grown through printing and now, computer assistance. With the latter the name may have been partially displaced by the technology behind it (notably GIS) but in truth the subject retains its fundamental identity and has continued to progress and mature *with the aid of* new technologies. The most recent - LBS and telecartography - are now contributing to the less formal branch of mapping, where cartography not only supports scientific investigation but also some of our daily spatial tasks.

1 Introduction

The cartography of recent centuries has been appropriately defined as 'the art and science of making maps' and this process has certainly dominated the cartography of history. However the period of paper maps represents only a brief – if significant – phase, measured in centuries, in the development of a subject which can be traced back over many millennia. In recent decades, especially with the rise of Geographic Information Systems (GIS), the value and status of Cartography have been questioned. Some confusion is experienced by those of the general public who still think of cartography in its more traditional form, and by members of the growing community of GIS developers and users where cartography is regarded as 'output' and system display (as well as a historical paper-based technique[1]). It has even been claimed that GIS has 'replaced' cartography. It is important to observe, however, that, as with printing, the emergence of a new and innovative technology-led phase in our subject has overturned many traditions and ways of working. I believe that the problems referred to will fade with time and co-operative activity, and, as happened with word-processing, the technologies (GIS, Internet, multimedia, etc.) will cease to dominate and become more transparent. Therefore, rather than challenging the above misleading assertions about cartography this essay attempts to go deeper, to identify and clarify the true fundamentals of mapping and map-making without which neither traditional map production nor GIS could exist. This leads to a new and broader definition of the subject, as 'a unique facility for spatial problem-solving'.

The quintessence of cartography lies internally in our minds. Externalisation of this realm (the cognitive map) is an equally important but secondary stage which can range from gesture, through spoken descriptions or instructions, to models, sketches and, eventully, formalised permanent maps, depending on requirements, circumstances and the technologies available. The cognitive stage of mapping, which was essential for human survival during the Palaeolithic period and earlier, still underlies all our actions and communications in the spatial environment. Traditional map-making, epitomising this 'external' phase, has dominated the history of cartography. Although it may have started as informal representations of our inner thoughts, the modern technique required the collection and processing of geographical data, as well as its compilation and design for publication. Because of their specialised knowledge and skills, the makers of these maps (cartographers) of that era formed a loosely-defined but respected profession in the mould of the architect, interpreting the needs of clients and delivering the products required. One difference, however, was that cartographers, unlike architects catered for a wider market (e.g. of users of national topographic maps and educational atlases).

Changes and developments in the use of the cartographic impulse (or mapping instinct) have been affected by technical advances although there was often a time-lag between their introduction and eventual application in map-making. The power of memory and imagination has thus been extended through use of paper maps and, later, digital databases, and a variety of new cartographic facilities are now available for accessing, exploring, analysing and presenting geographic information. The adoption of printing centuries ago, and the resulting distribution of maps to increasingly wider audiences, meant that they became available for sections of the population for whom nothing had existed before! Aspects which traditional cartographers of the mid-twentieth century might

[1] "…maps must be static because it is very difficult to change their contents once they have been printed or drawn….maps must always show two-dimensional views or limited three-dimensional perspectives…" p. 76 (Longley, et al, 2001). The adoption by many practitioners in the 1970s of 'cartography as a communication science' may have encouraged the 'display-only' interpretation, but the communication paradigm was overtaken by the 1990s when it was challenged by those who recognised maps as having other important uses, especially for spatial data exploration and analysis.

have criticised as flaws in the graphic design and accuracy of these new products would certainly have been forgiven, if even noticed, by the contemporary users. As the quantity of spatial data increased, and as more specialised users began to emerge, the careful design of maps, topographic and thematic, became more critical. Advances in printing (e.g. from crude woodcut blocks to sophisticated offset lithography) first improved the visual quality and usability of paper maps. Today the adoption of, and advances in, computer-related technology have transformed the way mappable geospatial information can now be stored, manipulated and made available for use. Printed maps are still published, but Web mapping in particular (supported by other special technologies) offers completely new map-use environments, replacing previously slow and ineffective manual methods. For both experts and novices, these systems can provide not just maps-on-screens but the potential, never before dreamed of, for real-time interactive exploration and analysis. During the era in which maps were only available in printed form (although compiled and designed for a variety of different but still quite generalised needs) users had to make the best of them and, where necessary in research, apply their own knowledge and ingenuity to analyse them. New interactive facilities, however, can remove the unsatisfactory dichotomy between the paper-map (useful for research but quite inflexible) and the research (problem-solving) process itself. The previous difficulty of being limited to the use of 'specific available maps' as components in an investigation has now been replaced by the procedure of 'using cartography itself' – ie. with more direct access to every stage of selection and manipulation of the spatial data (locational and attribute). Maps have indeed been static paper products for centuries but to classify them as such today reveals ignorance of the importance of new mapping on the Internet and elsewhere. Although it has been observed, quite correctly, that "…it is…misleading to think of the contents of a digital representation as a map…" (Longley, et al 2001) but such digital databases do not contain mappable data which have undergone appropriate digital transformation (Tobler, 1976; Clarke 1995).

New Cartography (a casual term used here to define the field) has emerged from instinctive abilities and a knowledge-base which has been growing over the centuries. New research not only addresses issues arising from the use of these geographic (map-based[2]) information systems, but also anticipates future developments. In recognition of this field of research the term 'geographic information science' was coined in 1992 (Goodchild, 1992) to be '..concerned with the way (GI) systems and science interact with society' (Longley, et al, 2001). Although sharply focused on the technology, many cartographic issues are included in this field (e.g. map projections, symbol design and perception, visualisation methods). However other themes which are integral to GIS, such as Analytical Cartography, are not so widely acknowledged.

Modern cartography, therefore, through new technologies such as GIS, increasingly matches the proposed definition as 'a unique facility, deriving from the application of human spatial awareness of the environment (real or imagined), for the support of spatial tasks and problem-solving'. This can satisfy both the communication view (solving the problem of how best to present and communicate) and the concept of maps as aids to exploration and visual thinking[3]. In the context of this conference, location-based services and telecartography fit naturally and comfortably into a maturing, increasingly customisable and individually-focused cartographic provision.

2 An illustrative scenario

In order to analyse the whole cartographic process, consider the following pre-computer scenario: an archaeologist must resolve some spatial problems in preparation for an excavation planned in difficult terrain. He has sufficient geographical knowledge to use cartography directly to explore and analyse the problem. The first phase involves study and interpretation of existing maps – topographic and thematic – but part of the more detailed solution requires the creation of a new large-scale map of the area in question, customised in scale and content to address problem criteria. As his training included field mapping and aerial photographic techniques he can direct and carry out this work with a small team. Once complete the map provides a model of the environment in which further exploration and cartographic analyses can be carried out, such as constructing cross-sections, determining the likely locations for excavation, seeking the extent of water-logged land and the nature, distribution and depth of soils and drift and solid geology. As the archaeologist is fully aware of the contexts of the problems, every stage of the investigation can contribute to the solution. As a knowledgeable and skilled scientist he continually attunes his attention to revelations about the environment he is exploring with minimal interruption to the flow of the investigation, since the investigation 'is itself a process of attention' (Ingold 2000). In this example technical cartographers could have contributed advice during the map compilation process but need only have been employed if high-quality display or printed maps were required. If the archaeologist in the scenario had lacked mapping skills and had to depend more extensively on cartographers at both the analytical and presentational phases, communication difficulties could have arisen over explanations and understanding of the detailed nature of the problems at hand. Solutions could be delayed due to the interrupted and second-hand nature of the investigative process. This scenario illustrates several issues:

1. That the cartographic process begins internally in the imagination – stimulated by the problem context.
2. The archaeologist understands the nature of his problems and this internal awareness guides his investigative path. He seems to be recreating the environment in imagination, identifying issues and rehearsing problem-solving scenarios within this internal but authentic world context.
3. Cartography includes concern for content accuracy and design but the embryonic mappable information is in the form of basic points, lines and polygons – or, today, their digital, co-ordinated transformations. Hence cartographic operations (e.g. analysis) can be applied to these rudimentary elements without elaborate graphic design being introduced.

[2] See Moellering, 1980
[3] Refer to Figure 1.3. (cartography) the map use cube (MacEachren, 1994)

4. The traditional (technical) cartographer was, therefore only involved if the scenario required professionally designed and printed products.
5. The process of 'using maps' has limited potential whereas 'using cartography' is a holistic procedure. It is a combination of map creation, manipulation through analysis, and spatial exploration of either visible maps or virtual databases.

Much recent research into how people interact with their environments has been effectively based on the cognitive science approach of modelling the person as an individual with 'an interior intelligence, the conscious mind, enclosed by a physical container, the body' (Ingold 2000). But of equal interest are some anthropological approaches in which the individual is recognised as 'a centre of agency and awareness in the process of active engagement with an environment' (Ingold 2000). The latter was addressed by the author when investigating the significance of emotion and feelings (the 'somatic marker' - Damasio 1994) in the process of judging the effectiveness of map design (Wood 1996). Both approaches were considered in this essay.

3 Fundamentals: the internal basis of cartography

Although this section offers some general themes and hypotheses, source material is quite sparse and some contrasting theories exist. Survival, one of the most basic of human instincts, is achieved from sustenance and safety, which in turn depend on human ingenuity and spatial awareness - knowledge and understanding of the spatial structure of the environment. This ability may extend far back into prehistory as our hominid ancestors are believed to have "achieved operational intelligence by 300 000 BP" or even before (Wynn, 1989). However the nature of human spatial knowledge and how it is acquired and stored for later use are far from clear and vary in character from person to person. The term commonly used for the spatial memory-store is the 'cognitive map' but its form and content may also vary. Anthropologists observe that our prehistoric ancestors, unexposed to the conventional maps of today, acquired most of their spatial knowledge by wayfinding, and stored it as personal histories of their journeys (Ingold, 2000). For Ingold this is a 'complex-process metaphor' with little or no explicit spatial structure, in contrast with the 'complex-structure metaphor', which would be required for a graphic map-like memory (Kosslyn, 1980). It could also be described as a 'cognitive collage', 'an ad-hoc collection of information from different sources' (Tverksy 1993). But if people also had the basic cognitive mapping abilities of rats, they could build up 'something like a field map of the environment' to help orientate and direct their movement (Tolman et al, 1946). 'Mapping', fundamental to movement through space and to the acquisition and storage of environmental knowledge, may also be intuitive and has been defined variously as how "humans make and deploy mental maps" (Wood, 1992), the actual process of "getting around" (Wood, 1993) or "a kind of retrospective storytelling" (Ingold, 2000). The richness of detail that can emerge from the latter is immense, with reported descriptions by indigenous travellers (e.g. from Inuit communities) taking hours in the telling and frequently involving externalisations such as gesture-based performance 'maps' or sketch-like inscriptions. The latter may be incidental to the main account as when the story-teller lays out objects (such as branches or stones) to represent specific features of his journey, or when he creates linear sketches in sand, dust or snow, or even in the air, marked out by a finger. These temporary artefacts enhance verbal explanation by reducing the need for repetition of the layout of a place. Such externalisations are also used where spatial knowledge of specific locational features may be more complex and must be shared as part of interpersonal dialogue. However this form of incidental map-making should not be confused with attempts to create archival material for later reference. Considering the likely frequency of such verbal/gestural reports past and present, Wood observes that "most maps for most of the time have probably been ephemeral..... or, if committed to a more permanent medium, immediately crunched up and thrown away" (Wood, 1993).

The spontaneous mapping process of the indigenous people of today or of recent history (which may contain some similarities with our distant ancestors) was generally localised. Their subtle yet sophisticated data collection techniques were admirable. One study reported that North American Indians had 'memories so retentive that when they have been once at a place, let it be ever so distant or obscure, they will readily find it again.' (Crone, 1976). Much of this ability has been lost as native peoples were persuaded by western explorers to help them create more conventional 'scientific' maps (Rundstrom, 1990; Bravo, 1996). Sadly, the rich personal content of the indigenous description (e.g. of real forests, pastures, wind and birdsong) were replaced by a conventional cartographic world "where all is still and silent" (Ingold, 2000). Although some people, such as in the Chiapas region of Mexico, even today still appear able to survive without real maps (Bricker and Goosen, 1989), the more complex a spatial problem (and the larger the cognitive challenge it presents) the more urgent the need for extensions to our thinking space, even if they are only ephemeral sketch maps. This form of externalisation of internal mapping knowledge has been referred to by psychologists as 'external cognition' (Scaife and Rogers, 1996) and, as implied above, may also have been employed in very rudimentary form (e.g. sand sketches) during Paleaolithic times (c. 40 000 BP). In many ways modern cartography, in all its manifestations (especially the archival storage of existing spatial data) has evolved to provide this external facility which has many applications and advantages, especially in support of spatial problem-solving. The cognitive map, however structured, is fundamental to the way we operate in our environment but informal externalisation through performance gesture and the spontaneous creation of ephemeral models or sketch-maps should not be equated with true map-making. Although everyone can speak, not everyone can write and neither is map-making a universal human ability. It has developed through historical necessity and circumstance. Human wayfinding (mapping[4]) and performance or spontaneous material maps, however, can be interpreted as contributing to problem-solving – the former to hunt and seek refuge, the latter to help communicate with others. The necessity for such collaboration and communication would have arisen as hominids from about 400 000 BP began hunting in groups. Therefore, although hard evidence is scarce, the importance of the mapping instinct and the rudimentary map-making solutions created to enhance the communication of spatial knowledge and experience have early beginnings and have continued as a present-day ability which can still be developed into a skill.

[4] How 'humans make and deploy mental maps' (Wood 1992)

Spatialisation - developing an awareness of the environment with which problems and possibilities could be assessed – may have been one of the earliest features of consciousness and has been closely linked with language development; 'once hominids had developed names (or other symbols) for places, individuals and actions, cognitive maps and strategies would provide a basis for presentation and comprehension of sequences of these symbols' and '…cognitive maps…provided the structure necessary to form complex sequences of utterences' (Peter, 1978, in Lewis, 1987). Despite the conventional belief that language is innate and speech is an instinctive tendency, speech and writing have also been described as forms of skilled practice which continue to evolve mutually as a natural outcome of human development (Ingold 2000). In this view language only exists through speaking and writing and is profoundly influenced by the latter. Having noted the strong associations between spatialisation and language, could the same model be adapted to aspects of spatial awareness? Are mapping and map-making also expressions of an internal essence - the spatial cognitive core? Evidence may be lacking but one could propose that, as forms of skilled practice, both mapping and map-making (which can be expressed in various ways) can also help our cognitive maps to mature.

Use of the word 'cartography' for this basic theme of our subject could be misleading because of its existing associations with traditional map-making, but the alternative, 'mapping', is too vague with various non-geographical dictionary definitions. I believe that just as the term 'writing' has survived centuries of technological change, the word cartography can do the same. The broadening of a definition need not mean loss of earlier meanings. Writing is still used to refer to words-on-a-page (created by pencil or word-processor) as well as to the ability, intellect and style behind the literature. Cartography could continue to refer to hand-drawn or computer-generated products as well as virtual human cognitive mapping or the virtual digital map transformations on which Geographic Information Systems are built. But even without such word-play it is important for those involved in mapping of all types to recognise the cognitive essence of the subject and the arguments supporting its foundational nature.

4 The beginnings of real (externalised) cartography

From the analysis of fundamentals we can observe that all cartographic processes begin internally. They appear to depend on effective use of human imagination for reviewing, previewing and anticipating environmental activities prior to and during wayfinding. Increased intelligence has been characterised by:

- Delaying an instinctive response to permit exploration of the circumstances
- Storing already acquired information (mainly in memory)
- Abstracting and generalising complex situations
- Carrying out the required responses to the information processed.

However this list is based on the scientific model and should be qualified by our own knowledge of real life experiences. Such actions (delay, data storage, simplification and responsive action) will, in the case of an experienced practitioner, flow together and be supported by important feedback from emotional markers (e.g. memories of past actions carrying good or bad feelings). Such aboriginal, personal and small-group experiences would employ externalised maps such as gestures, speech, song and dance, and even spontaneous ephemeral sketches.

This world of personal spatial experiences has continued to the present day. Even now most people most of the time will not use maps for everyday wayfinding. They will guess, use gut feelings, receive brief verbal instructions from other people (who may or may not have the knowledge!), and obtain on-going support from signs, signals, advice from chance encounters and even a general 'sense of direction'. All these are encounters between personal cognitive maps and selective externalised information from other sources.

Although material maps of over 25 000 years are known, maps from formalised field measurements for specific or archival purposes (e.g. topographic and military), began less than 4000 years ago in Egypt, the Middle East and China. Other innovations such as the square grid, world and astronomical maps, latitude and longitude and maps of buildings and cities, appeared between the 10th and 15th centuries. The traditions of map-making seem to have developed independently in various locations across Europe and Asia and involved what have been called '…a series of cognitive transformations..' e.g. recognition that the map-like image '…could record and structure human experience about space' and how 'maps have become deliberately designed graphic artefacts…recognizable to the *intended* viewers[5].' (Harley and Woodward, 1987). This led to an awareness of "the idea of the map…as a basic form of human communication….a reciprocal process of cognition in which both perception and representation become increasingly structured by different map models.' (Harley and Woodward, 1987). Returning to the speech-and-writing analogy, just as 'written records were thought of and treated as reminders rather than representations' (Olson, 1994) so were certain maps from the Middle Ages, which provided routes, details and guidance to travellers (de Certeau, 1984). This inventory or database function was to grow in importance until the introduction of computer techniques. A significant transitional form of non-graphic external map was the sailing 'rutter' or seaman's guide used by navigators in the Middle Ages, the word probably deriving from the French word "routier". They gave directions, showed coastal landmarks and hazards, and as they were kept up-to-date they were greatly prized by sailors. These and the earliest customised professional maps, the 'portolani' (named after the written sailing directions) which appeared between the 13^{th} and 15^{th} centuries, represented a significant stage in the advanced provision of geographical information for commercial users. Although an analysis of early maps includes the following applications:

[5] This author's italicised emphasis.

•Sacred and cosmological representations of the world
•Promotion of secular ideologies

the functions being examined in this essay are geographical wayfinding and inventory/archival maps. The geometrical structure and design of maps gradually became distinctive although there seems to have been no progress of map style. Even from very early times perspectives, plans, pictorial and abstract images can be identified, and uses included, economic, political, and cultural. Map-making was an activity of elite groups within the population which 'manipulated maps for their own purposes' (Delano-Smith, 1987), but although there were more users than makers, the numbers were also small. Not until the European Rennaissance in the 15th century did real changes occur.

Over the last five centuries mapping has featured strongly in the growth and application of geographical knowledge. Maps were the only spatial (i.e. non-text) archives of information gathered but also, through their visual nature, they offered direct support for spatial thinking and problem-solving. By making maps more available, printing '…solemnised a fertile marriage of practice and theory unique in the previous history of mankind…The cloistered mathematician of the university now came into courtship with new problems of…surveying and navigational astronomy, hitherto the closely guarded secrets of the craftsman.' (Hogben, 1949). Due to the increasing demand for printed materials (including maps) the cartographer and printer became professionals quite rapidly in the 15th century (Woodward, 1975). Early printing also brought controls to the manuscript mapmaker who, previously, had been his own master, and this also led to some standardisation of image. From the 16th and into the early 18th century in particular, printing helped launch periods of true cartographic expansion. Maps were increasingly founded on careful surveys and had improved graphic symbolism. During that period the map 'slowly disengaged itself from the itineraries' associated with the original field surveys, the only remnants of which continued as decorative pictures of landforms, people and animals on cartouches, etc. (de Certeau, 1984). Supported by growth in publishing, maps of many kinds could now reach a wider audience and thus were increasingly compiled and designed to target and help resolve the common problems of specific user groups in the scientific, military and eventually outdoor sporting communities such as mountaineering.

Mapmakers through time have engaged in many cognitive and practical activities relating to utilitarian and non-utilitarian functions. They have been described as platt-makers, cosmographers, chartmakers and chorographers, and it is perhaps not surprising that when the Viscount de Santarem, in December 1839, invented the term 'cartography' (even if originally intended for the study of early maps) it was quickly adopted by all mapmakers. The authors of 'Cartographical Innovations' note that '…the cartographer had many forerunners in those who had applied their skills to mapmaking…Ptolemy, Ortelius, Mercator…lived and died without knowing that they were cartographers..' (Wallis and Robinson, 1987). By the end of the 19th century the term had spread to other European regions.

5 Cartography and problem-solving

The opening of the previous section referred to the internal (cognitive) basis of cartography and the common spatial information we received on a typical day, which, of course, is neither formal nor consistently reliable. Until recent centuries, most travellers would have to depend on information from the cognitive maps of others. However with the arrival of the first inventory maps (military, topographic and thematic) radical new sources became available to increasing numbers of people. Casual input would continue at a personal level but at least there were alternatives rich with detail and of some reliability. Spatial tasks and problems face us on a daily basis and such map input was of great value. However, unlike the focused advice some people had received from expert colleagues this new information was quite generalised and often failed to provide what was required to support the specific problem at hand. Most published maps in the past came from government and commercial agencies, and their production was separated (to varying degrees) from the 'using' environments for which they were intended. As a result of this dichotomy, real focused problem-solving with such maps (which were normally designed to be optimal for general and not highly specific tasks) depended heavily on the experience and interpretative abilities of map-users. This is the aspect of map use (more correctly 'using cartography') referred to in the introduction, which may have been overlooked and undervalued in the past by a profession increasingly concerned with the careful compilation and design of maps and map series for broad purpose-based categories. Mathematical formulae are devised to facilitate the solution of individual problems but the subject, mathematics, is applied more generally to study relationships using numbers. Imaginative use of mathematics, therefore, is much more valuable than the employment of a single group of formulae. Equally while most 'traditional' cartographers have drawn maps to satisfy particular needs, there are other investigators who have also 'used' cartography but in more analytical ways. In the past this involved making new maps (e.g. by tracings) from official topographic and thematic maps to examine, by overlay, the relationships between distributions, or to identify routes. Such exploratory 'working' maps were often simple (even quite sketch-like) in construction and design (and discarded after use) but were essential for effective investigative procedures[6]. Some such 'users of cartography' (especially in urban and landscape planning) came to recognise the possible contributions of computing for such tasks and thus became major contributors to the establishment of what would become known as geographical information systems. Cartographic literature on analytical cartography – including terrain visibility, map overlay, and mobility - (considered outside the field of GISystems) is scarce. But important thinking was instigated in the 1970s by Waldo Tobler and his students[7], and has been followed up in recent years by a special issue of Cartography and Geographical Information Science (CAGIS) on 'The nature of analytical cartography' (Moellering, 2000). Such increasingly sophisticated 'uses of

[6] For explanations of the roles of maps in scientific research, see DiBiase (1990) and MacEachren (1994)
[7] See the reference to Moellering, 2000.

cartography' almost certainly has origins which pre-date the cartographic focus on design and accuracy, which led, in the 1970s and 1980s, to the belief that cartography was fundamentally about presentation/communication. All traditional applications of maps have depended on representation but each application in its way is basically a spatial problem (or series of problems) requiring solution. Even the decision to communicate information presents a whole series of problems relating to map task analysis, data selection, symbol design and map composition. This is supported by MacEachren's statement that "The map is..... a source of information or an aid to decision-making and behaviour in space" and that mapping and map use are processes of knowledge analysis and construction and not just knowledge transfer and communication (MacEachren, 1995)

6 A period of divergence

The impact of computing on cartography began in the 1950s (Tomlinson, 1988) but a significant divergence began in the 1960s which reflected the interests of those involved in two aspects of cartography at that time (i) making maps for well-established groups, and (ii) using cartography to support exploration and analysis. The map-making branch was the professional discipline adopting yet another new technology (digital computing) to facilitate production processes. The second group began with simple but innovative statistical mapping and then progressed to automated sieve mapping, a manual overlay method used in landscape planning, especially by Ian McHarg (1969). Both branches had their problems, partly related to the limited power of early computers and the rudimentary quality of usable software. Major advances took place with the development of database management systems (DBMS) in the 1970s when some 'intelligence' was introduced into data-handling processes, and there was gradual improvement of display technology and graphic software. Both branches progressed in different ways but although the spatial data handlers were also essentially 'using cartography' (including concepts developed in analytical cartography) as defined above, the 'magic box' of technology began to dominate, it lost its cartographic tag and the whole subject became known as Geographic Information Systems (GIS)[8]. As many GISystem developers were unfamiliar with the wider field of cartographic theory or practice, they quickly restricted their use of the term to the display (or output) component of the systems. This ignores the fact that the digital spatial data (a form of virtual map) stored in the systems are basically cartographic transformations[9] which can permit statistical and spatial manipulation before being transformed once more back into graphical form for display. Even the basic spatial analysis functions have been referred to as the 'digital equivalents of analogue procedures that cartographers have used for fifty years' (Robinson et al., 1995, p. 307). What is not in doubt is that perhaps the majority of GIS applications have been related to map-making and, with suitable intelligence and control facilities, a GIS can function very well for the production of maps. GIS may seem to have 'hijacked' cartography but now is only acknowledged for its value in visualisation and not in the internal function of the system where it is also essential.

7 New Cartographic environments

The research communities in cartography and GIS are still divided, but software for manipulating data and presenting maps and map-like visualisations are being used increasingly across the whole spectrum of spatial sciences, including subjects such as archaeology, geology, hydrology, agriculture and planning. Just as GIS developments in the 1960s were led by inspired enthusiasts, those now immersed in developments in multimedia[10] and Telecartography with Location-based Services (LBS) are doing the same for cartography. GIS technology now offers transparent and user-friendly facilities for a wide range of new Web-based cartographic environments, most of which employ maps as an interface to the structured geographic information (GI) which 'lies behind' them. Cartwright has observed that global communication systems and global publishing offer opportunities to create dynamic interactive geographic visualisations which can grow from the exciting virtual environments of computer games (Cartwright, 2000). Internet systems (such as electronic atlases) linked to Geospatial Data Infrastructures and their own customised data sources can offer an almost ideal investigative environment for both experts and beginners. Once introduced to the Web and the use of browsers and different search engines, people can carry out spatial investigations of varying complexity.

As explained above, cartography has both visual and virtual status. Virtual (cognitive) maps are part of our psyche and serve to guide and control much of our spatial activity. Virtual maps, appropriately transformed, also reside in GIS and as spatial databases. But it is the visualisation which has carried much of the unique power of cartography. Assuming that an information system can present selected datasets, allowing them to be searched and manipulated on-screen, it is the combined power of the eye and brain and some understanding of the nature of the problem which can drive the investigation. This is why the relationship between cartography and scientific visualization has been so successful. Working with Visualization and Multimedia it has investigated data representation in environmental science and especially dynamic cartographic visualisation for exploration and analysis to gain understanding and insight into data (URL1).

[8] Just as if the whole future of text data handling had become known as 'Wordprocessing' (after that technology) instead of becoming transparent (as it has) to its applications in all literary work.
[9] See Tobler, 1979.
[10] Multimedia now subsumes the terms interactive, multimedia and hypermedia

8 LBS and Telecartography

We could identify stages in the history of cartography as follows:

- •Pre-history: Internal cartography but no permanent maps – when personal spatial knowledge was only available through informal interaction. This mode has continued through time as an undercurrent beneath the bigger developments.
- •Early history: Maps began to appear but only for elite groups.
- •Post Rennaissance period: Surveying, printing and mass cartography. Maps as inventory and designed for broad applications, but slow to create and never up-to-date.
- •Late-twentieth century computer mapping: More maps, more choice, less time in production.
- •Today: Convergence of many technologies offering major data sources and flexible access and interaction. Map users on the Web have now become 'users of a dynamic new cartography'.

These new technologies (GIS, Internet, Multimedia) can surely provide all that anyone would want? But no! If we return to the first category, above, the essence of cartography and environmental interaction is internal and unconfined by out-of-date map sheets or inaccessible desktop computers. When left on our own we are restricted to personal advice, spoken and gestured directions, and reliable sketch maps – if we are lucky!

Only now have service-oriented mobile concepts (Location based Services, LBS) and telecartography has closed the circle. A unique combination of hardware, software and communication facilities has truly overcome the frustration of dreams! Instead of receiving uncertain advice from a passing pedestrian you can obtain reliable data and images when required. Not only handheld computers but car navigation systems benefit, some of which use representations which have returned to the simple forms of prehistoric external maps – gesture icons (arrows) - and speech-based maps. These small devices may not have the visual coverage of a large paper map, but for specific applications they have great potential. The power at depth of virtual and analytical cartography is acknowledged in these systems but the need for good and appropriate design, static or dynamic is ever present. Although visual presentation is only the surface of the cartographic facility the wisdom and experience of cartographers are unique and this aspect must be maintained at all costs.

9 Conclusion

This review of the origins and nature of cartography has confirmed the significance of the human 'mapping' ability, and the internal imagination-based essence of cartography. These human characteristics may be unchanged in that 'knowing, like the perception of the environment in general, proceeds along paths of observation' (Ingold, 2000). Even although people in early Western societies became dominated by the concepts of simple planimetric maps, in everyday situations people still describe their familiar environment to one another, by retracing routes through it in narrative rather than laying out its landmarks in a geometric space (Wood, 1992). Unfortunately the map inscriptions which emerge during the story-telling of journeys, cannot be equated with map-making. That is an artificial process which has grown through the necessities of history. Nevertheless map-like externalisations were the origins of the cartography of history and the value of their modern computer-based counterparts, for data-storage and in problem-solving, has been unquestionable. Unfortunately the formal mapping of the past five centuries has been largely ineffective for specific individual problems, and solvers have had to resort to imaginative and often informal procedures to reach a result. If map production has been the core of cartography, the process of 'using cartography' for investigative purposes (just as valuable) has been largely ignored. Not until the intervention of computers, the establishment of GIS and the creation of the new interactive investigative environment has its value been truly appreciated. Web access for GI is now almost an everyday activity for both experts and novices as they search Multimap or a national atlas information system. The anthropological view of modern mapping is that it is cold and lifeless, devoid of the experiences and memories of the original surveyors. Perhaps new technologies can help us come full circle as we interact with the web-map and zoom in until we are at the level of the original aerial photo, or even obtain virtual reality (VR) experiences of localities allowing the viewer to 'travel' in and 'relive' the landscape. LBS and telecartography have closed this circle also. You can now travel the world, enjoy the experiences of real forests, pastures, birdsong and wind, and still obtain the geospatial information you require when and where you need it.

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URL 1: http://www.geovista.psu.edu/sites/icavis/

TELECARTOGRAPHY

Adaptive techniques for delivery of spatial data to mobile devices

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Abstract

The constraints of distributing customised and useful spatial data to mobile devices are primarily technical (for example, related to bandwidth and the display capability of the device) but the serving of data also needs to take into account a range of other parameters such as location of the user and the task to be performed. In effect, the supply of data needs to be optimised. We suggest that one method of optimising the flow of data is to attach 'profile' information to each element of the system – each object in the server database, the subset of objects chosen for transmission, the channel along which the objects are sent, the devices used in the system, the task to be performed, the characteristics and preferences of the user, the location of the receiving device etc.

Common low-level network approaches to optimisation are less appropriate to the wide variation in context which spatially-enabled mobile devices possess. The approach described here investigates an application-level adaptation, relying on profiles (a well-established technique in computer science), attached in a similar way to metadata, and coded in a high level profile definition language.

The intention is to develop an emergency planning and disaster response scenario based on oil spill in the Niger Delta (Nigeria), in which a range of people and organisations need delivery of significantly different spatial data sets to remote locations in the field, for a variety of environmental management tasks.

1 Introduction

In the post-PC era, mobile devices are becoming increasingly important as a core technology, and the need to address optimisation of the delivery of spatial data and services to such devices is clear. Research effort in this area in the last decade has produced many adaptive techniques (Brusilovksy, 1996). These techniques are applied to satisfy a wide range of environment and user preferences, such as constraints of display size, storage and bandwidth, when users interact with mobile and ubiquitous devices. However most of the adaptation methods are applied to the data being handled, in order to provide it in a particular format, or for adjusting the bit rate of compressed video streams and reducing resolution (Franti et al., 2002). These techniques suffer from significant limitations for the class of applications where structured data is used. While it may, for example, be sufficient in web browsing to indicate that one does not wish to receive images ('Text Only' button), the provision in more sophisticated systems of multiple format data files or data adjusted to a small range of users requires complex adaptation. We believe that there is the need for more practical solutions than just provision of standard translation or restrictions according to devices.

Therefore it is suggested that a practical response to the variation in context which mobile devices are subject to, is an application-level, instead of a data-level, adaptation. In addition to issues like memory storage, bandwidth, display size and user centred factors, situational aspects, like location, and the task which the mobile user wants to perform need to be considered for the adaptation process. The emergence of location based services (LBS) allows the provision of information about the surrounding environment to be filtered in one way, but the task the user wants to undertake in using the mobile system represents, perhaps, an even more important optimisation factor. For example in an oil spill incident, a user concerned with evacuating human population will have different preferences for information compared to a user concerned with the protection of an environmentally sensitive area or a user concerned with controlling the source of the spill, even though they may all be at the same geographical location.

This paper presents the initial study of a profile-based approach for specifying and expressing user preference based on the task the end user wants to accomplish. This extends the conventional low-level adaptive approaches by allowing for description of user preference, selection of most appropriate data and formulation of various adaptation problems as constrained utility-maximisation problems. The rest of this paper is organised as follows: section 2 explains the concept of adaptive techniques, section 3 describes the profile-based approach as a solution, and section 4 describes an oil spill emergency response scenario in the Niger Delta (Nigeria).

2 Adaptive concept and techniques

According to Holland (1992), the first attempts at technical description and definition of adaptation came from biology. In that context, adaptation defines any process whereby a structure is progressively modified to give better performance in its environment The structure may range from a protein molecule to a horse's foot or a human brain. In extending the definition more generally, adaptive processes have a critical role in fields as diverse as psychology (for assessing learning, for example), economics (e.g. in optimal planning), machine control, artificial intelligence, and computational mathematics. Basically, one can describe adaptation as having to do with fitting, changing, modifying or selecting something to suit a different purpose or new environment. In spatial data handling we can adapt content to fit increasing heterogeneity in mobile client devices with different capabilities, as well as the special needs and preferences that end users of the content might have (Erharuyi and Fairbairn, 2003b).

The architectural paradigms that have been used to build static systems (personal computers) do not fit the needs of mobile systems (hand held computers, PDAs) particularly well. Mobile systems must be adaptable for a number of reasons: they have limited resources and resource needs constantly change in the face of changing environmental conditions and user requirements. Mobile devices are, and will always be, more constrained in terms of resources compared to static systems. As a result, resource allocation needs to be optimised.

Some adaptation methods are already in widespread use: compression, colour depth reduction, and image scaling are examples. However, these are data level adaptations, and cannot be applied in all cases. It seems that application-level adaptation is a more practical and flexible approach than merely the provision of standard translations or restriction according to device parameters (Ma, 2000). The study described here is concerned with applications involving mobile end users who have already acquired knowledge of a particular area and would like the system to use contexts to provide relevant information, where relevance depends on user's task.

3 Specification and selection optimisation

So, currently, profile information is attached to a device to help to determine the amount of possible data transfer, its format and its rate of transmission. It can also be attached to its calculated position to help determine the type of data required, and its content. But task dependency is also important and can be used to more finely tune the data delivery. For this, the 'profiles' must be attached to the data, and the location, but also to the task being undertaken and the user.

3.1 Specifying data domain

In an age of information overload, there is more information available than a human can perceive at one time; there are too many available services; and often too much information per service. This is intensified in the era of ubiquitous computing. The Internet itself is an example of general information overload; the Environmental Sensitivity Index (ESI) datasets used to assist in oil spill planning worldwide (Gundlach et al., 1987; Gundlach et al., 2001) are examples of a large amount of information supplied on one service. One of the most common reasons for information overload is a poor structuring of the relevant information space.

Today, existing ESI datasets are designed with the assumption that they are to be handled on a static desktop system. If the datasets are to be readily available to on-site field workers in a dynamic and flexible way, reflecting their situation, task and available resources, the use of mobile technologies will be of importance. With the volume of the typical dataset, fixed storage on mobile devices is undesirable: dynamic delivery of this information is preferable for a range of tasks: the use of profiles (Erharuyi and Fairbairn, 2003a) to specify the objects of interest, and their utility due to context, is a solution to information handling problems.

The idea of using profiles for data delivery optimisation is focused on the specification of the data items (*domain*) that are of interest to a user, and describing the importance (*utility*) of each of the items in the domain, and the domain itself, to the user. Such a profile can be defined as a function (a mathematical relation in which each element of one set is associated with at least one element of another set) that maps the universe of data objects to a dynamic ranking system that allows, for example, task, bandwidth or screen display to be considered as constraints of differing and varying weight.. Therefore if Ω is the universe of data objects that we are able to profile, S is a general domain set expression (for deriving the intended data of interest) and E is an object expression, then any specific expression e formed according to E, is a function which identifies an object of interest,

$$[e]: \Omega \rightarrow \Omega$$

This defines objects of interest according to a function which maps valid objects in Ω to a subset of objects in Ω (the domain). Any domain set expression, s that is formed according to S, can be tested for its overall level of interest

$$[s]: \Omega \rightarrow Bool$$

This returns true of any domain of objects in Ω that belong to the set denoted by s. There is likely to be a large number of possible combinations of valid objects. Each of these combinations forms a domain, D.

3.2 Specifying data utility

Apart from using profiles to specify data of interest (using the function $[e]$ above), they can also serve the purpose of expressing the user preference in terms of priorities (*utility*) among data items due to context. Existing content adaptation techniques take into

account numeric values associated with a number of factors such as content versions or coding strategies. In addition, however, in order to meet requirements for quality of service to the user, the utility should take into account issues such as the tasks to be performed.
If a domain *D* has been specified by the data set expression, *s*, we can write $\sigma_D(\Omega)$ to denote the set of all the objects in *D*

$$\sigma_D(\Omega) = \{x \in O \mid [s](x)\}$$

P is any profile, expressible as *P(S, E)* (i.e. it is related to the object set expressions and the domain set expression), and $D = \{D_1, \ldots \ldots, D_n\}$ is the set of domains it defines such that D_i □ *D*. The utility value, *U*, of the domain D_i is specified by the weight equation,

$$U(D_i) = W_i.$$

Then profile, P can be defined as a function,

$$[P]: 2^\Omega \rightarrow Int$$

that maps any set of objects to the value of that set, as specified by the weight equation in *P*. Thus for any domain, *D* consisting of objects belonging to *Ω*,

$$[P](D) = \sum (W_i(\sigma_{D\,i}(\Omega), \Omega))$$

We are thus able to define the overall weight value of a set of objects in a domain which is a valid domain of interest, and make this equivalent to the profile.

3.3 Optimization of the selection process

The profile now needs to be processed to optimise the selection of subsets of known objects that have the highest utility value to the end users, whilst taking account of the constraints of limited resources. We model the content adaptation as the following resource allocation problem:

Let us assume there are *n* valid domains $D_1, \ldots, D_n$ with average bit-rate/buffer requirement $S_1, \ldots, S_n$ (in bytes) that may be included in a mobile device, and a pre-specified device buffer or bandwidth constraint/capacity *C* (in bytes) that must not be exceeded. The inclusion of a domain to the mobile device increases the overall utility by $U(D_i)$ and decreases the available resource by its size S_i. At this stage we have several assumptions:

- Domains have been pre-generalised into available alternatives at a constant bit-rate, thus S_i correspond to the target bit-rate at which D_i is encoded and D_i is therefore held optimally in terms of size
- From above, *U* is a measure of the utility of D_i (which may encode a priority listing based on task, on location or on user perceived utility)
- The objective is to include subsets of domains that maximise the overall utility and satisfy the constraints.

Using the above notations and assumptions, the problem may be formulated as:

$$\text{Maximise } \sum_{i=1}^{n} U(D_i)$$

$$\text{Subject to : } \sum S_i D_i \leq C$$

$$\text{With } D_i \in \{0,1\}$$

for i=1, ... , n.

This then maximises the objective function.

4 Emergency planning and disaster response scenario based on Niger delta oil spill

4.1 Oil spill incidents in Nigeria

Oil spill incidents are a regular occurrence in various part of the Niger delta in Nigeria. Between 1976 and 1998 a total of 5724 incidents resulted in the spill of 2,571,114 barrels of oil into the environment (Nwilo and Badejo, 2001) and contemporary newspaper reports indicate an increase in the number of incidents. Such spillage is caused by corrosion of pipes (about 50%), sabotage (28%), oil production operations (21%), with the rest down to failures of machinery and inadequate care.

Despite the level of oil activity taking place within the country, oil spill contingency arrangements are relatively undeveloped. A number of state laws already exist in the Nigerian oil industry, although only few of these (DPR, 1991) provide guidelines on the issue of pollution. This observation has prompted the enactment, by central government and its agencies, of newer, more appropriate, legislation aimed at environmental conservation and sustainability (Salu, 1999). Also, in an effort to minimise spill impact on the environment and in response to the limited specific environmental information available from government, the petroleum operators have created environmental sensitivity index (ESI) datasets that describe specific geographies and ecosystems at risk and are designed to provide the necessary environmental information to the user. Such datasets are intended to help in decision-making, particularly in specifying spill response priorities and applicable cleanup methods.

4.2 Oil spill emergency response

To date the ESI datasets have been designed for and targeted at emergency managers running static, desktop client systems, and are often used for long-term oil spill planning. This process usually involves recording the ESI information on hard copies (notably in map form), which are then transported to a command centre. However during an emergency, time is critical and the situation is often characterised by activities and locations not amenable to such a desktop information system. In order for on-site workers to benefit significantly from information about response decisions, resource allocation and other condition at their location, there is need to develop advance techniques for adaptive and personalised exploitation of ESI data content within a mobile environment.

An oil spill incident requires a flexible and mobile response, ideally carried out by a number of workers equipped with limited storage capacity PDA-based devices. Intuitively the data ought to follow users in their travels. While this may be impractical for all data for all users, it might be possible for popular data to move to a location (such as an incident command post) that is 'closest' to the highest number of interested users. While the concept of profiles is being examined in this paper for content generalisation and selection for delivery to mobile devices, they can also be used to plan and optimise the effective flow within data network infrastructure, for example through intelligent caching and pre-fetching (Erharuyi and Fairbairn, *2003b*).

4.3 Adaptation of the ESI dataset

At the initial stage of a spill, typical user objectives may include considering evacuation procedures, defining priorities for dealing with sensitive area or identifying resources at risk in spill vicinity. The implication of this is that we may have more than one incident user having dynamic access through their mobile device, to the same shared cache but receiving different data sub-sets from that shared cache. Thus, a user engaged in evacuation will only be given data relating to the census and route plans, whilst a user engaged in the protection of environmental sensitive areas will be given information on vegetation, and environmental sensitivity categorization. The individualization of this data set received can be driven by the user's profile, which defines the task and context of his activity. As is evident from the earlier description, the user profile should specify the data objects of interest to the user (the domain) and what is the value or relative importance of each interesting set of objects (utility). For example, below a universal set of data objects (the ESI dataset) is broken down into three different domains. For User A the domains have varying utilities (weights): an optimisation procedure is needed to ensure that the maximum combined weighting is selected and that (in this case) the two domains HPP and ESR are sent to the mobile device, if possible.

PROFILE User A
DOMAINS:
HPP = habitat priority protection area objects
ESR = environmental sensitivity ranking objects
REL = response equipment location objects
UTILITY:
U (HPP) = 3
U (ESR) = 2
U (REL) = 1
U (HPP with REL) = 4
U (HPP with ESR) = 5
U (ESR with REL) = 3

The optimisation procedure will result in HPP and ESR being chosen as the domains of interest (as they maximise utility), but only if the device is capable of handling S_{HPP} plus S_{ESR}.

The user profile is specified in an informal way here. However, a user profile should be specified using a formal language both for the data domain and the utility, and such a language must satisfy certain requirements: it should be declarative, allow for class membership and, more importantly, data dependency and threshold levels (Hinze and Voisard, 2003).
The process of optimisation involves applying an algorithm which is specified to maximise the perceived utility to the user by treating different objects according to their weights and selecting among the variants of each objects according to their utility. A number of algorithms exist to do this, and they are the subject of future work. *Figure 1* shows a part of the ESI dataset of the Niger delta showing variation in specification according to task engaged in (*Figure 1a* addressing coastal pollution; *Figure 1b* for population evacuation).

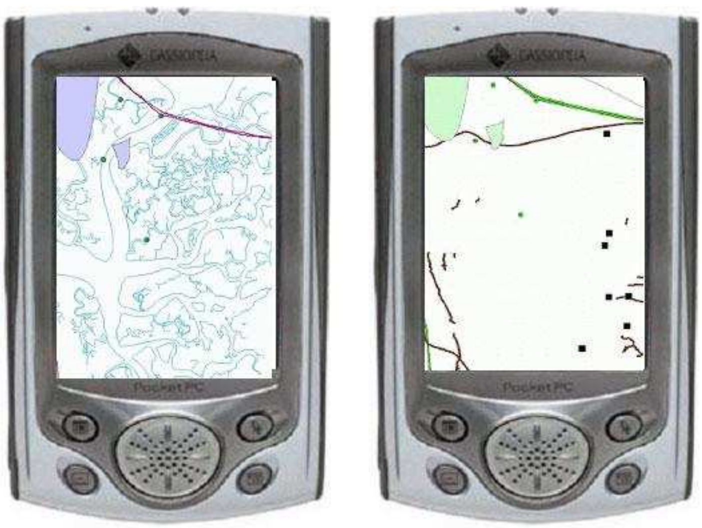

Fig.: 1

5 Conclusions

Adaptive content delivery depends upon knowledge of a user's interests and context, information maintained in user profiles. This paper has described an adaptive technique for spatial data delivery to a mobile device based on profile modelling of user preference. But in addition to user preference a range of other factors must be taken into account to create a set of profiles which can be manipulated for optimum delivery of data. Constraints have been taken into account, and this introduces the concept of optimisation of content adaptation. The task oriented nature of the specification enables context-mediated interaction which provides for a natural means for implementing adaptive applications in the mobile world where heterogeneity of device types should not make a difference.

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Design of an adaptive mobile geovisualisation service

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Abstract

This paper describes the design of a mobile geovisualisation web service with adaptation capabilities. The service design is based on our research on mobile cartography and adaptive geovisualisation. The objective is to shift the focus from LBS to more context-aware and context-adaptive geovisualisation services tailored to the current usage situation. We will put emphasis on the adaptation of the presentation form and demonstrate how to use *Scalable Vector Graphic* (SVG) for delivering adapted content to mobile users. The prototype service implementation is founded on the web service paradigm and makes heavy use of open source software and technologies, such as SOAP, OGC *Web Feature Server* (WFS), Batik toolkit for SVG, XSLT, and the TinyLine API. A few map examples illustrate the possibilities of this geovisualisation web service for generating different visualisations from the same information source.

1 Introduction

The latest buzzwords in IT have reached cartography. Mobile Internet and mobile computing are increasingly adopted from the GI community. GIS and web mapping move a step further, since the dissemination of digital geospatial data is no longer bound to the desktop platform. The technological progresses are partly accompanied by and partly the motor for different social trends. One trend, globalisation, is tightly coupled to an ever faster, mobility-defined life. Mobility leads to the fact that more people travel and move in areas unfamiliar to them. A world, however, which becomes increasingly global and spins faster and faster calls for order and security. In such a modern world people do not necessarily have more freedom, but are forced to manage their individual lives and their mobile everyday activities, which gets more and more complicated. The organisation of this accelerated daily life requires supporting tools and information. This is especially the case for geographic information that is attached to almost any everyday activity.

The user mobility has several consequences with regard to geovisualisation: the usage of geographic information is very different from a stationary case and is affected by changing modes of movement, different and changing activities beside the usage, a potential of distractions, different and fast changing contexts, and harder usage conditions, e.g. a limited time budget. Of course the user mobility has a strong effect on the usability of mobile geovisualisation solutions. Often the usability is hindered by inadequate geovisualisation, either caused by the use of scanned paper maps designed for a medium with different characteristics or the production of illegible and cluttered maps that fit a large screen, but not the small mobile device screen with lower resolution. Geovisualisation that is not adapted to the usage context, supporting functionality that is not tailored to the users' mobile activities, and poorly designed user interfaces not taking into account the different input modes and conditions of mobile interactivity cause further usability problems.

Geovisualisation for the small displays of mobile devices is restricted by several technical limitations, such as the small display size and resolution, the lack of processing power and memory, and most critical, the battery lifetime. Furthermore, the mobile network bandwidth is considerably smaller than that in fixed networks. Especially the small display poses an immense generalisation pressure. However, generalisation alone cannot assure the fitness for use required in mobile geographic information usage situations. The lack of map space also implies that there is no room for auxiliary elements such as a map legend, which makes the map reading process difficult.

The challenge for modern cartography lies in supporting as many people as possible with mobile usage of geographic information. A mobile assistance system would incorporate analytical functions, be aware of the user's context and characteristics to assist the user in a mobile environment. This kind of mobile assistance is the only way to ensure also for future times an efficient communication of geographic information and to prove the usability of new mobile technologies. In the cartographic community only a few exponents have addressed these problems, e.g. (Zipf 2002; Edwardes et al. 2003; Nivala and Sarjakoski 2003; Urquhart et al. 2003; Reichenbacher 2003).

A possible solution to these challenges is an adaptation in the sense of providing the user more relevant, detailed, accurate and thus adequate information meeting his/her needs better. There are three reasons for this. First, the increasing quantity of information and the danger of over-stimulation urge a suitable channelling of the information stream. Second, adaptation could lead to greater acceptance of new, yet partially still immature technologies. Third, new value-added (web) services which users have to pay for need customisation to guarantee user satisfaction.

Cartography should provide new and enhanced services that could be combined with existing services, thus bring added value to users. These new services ought to close the gap between the benefits of web mapping or online GIS and the freedom of mobility. Services are more flexible in supporting the manifold requirements of human life, such as spontaneous decisions and serendipities. Only recently several proposals for the architecture of map services specifically based on SVG can be found in the SVG community, e.g. (Schaer 2003; Spanaki and Lysandros 2003; Takagi and Kobayashi 2003). However, most of these proposals are either not mobile services or do not incorporate service adaptation.

2 Geoservices

The most general notion of geoservices are services that give precise answers to specific spatial questions. Geoservices are understood as web services that provide, manipulate, analyse, communicate, and visualise any kind of geographic information (Meng and Reichenbacher 2003). There are several types of geoservices, not all aimed at mobile users. One instance of geoservices comprises location based services (LBS). These services are accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the terminals to provide mobile users information dependent on their current location. Often, but not in any case, part of that information is communicated through maps.

Another category of geoservices are geovisualisation services that provide any kind of visualisation of geographic information. For mobile cartography, geovisualisation services are of the utmost interest (Meng and Reichenbacher 2003). A service-oriented understanding of geovisualisation differs in many regards from traditional map products. The trend to more flexible, on-demand delivery of geovisualisation initiated through web mapping will continue even stronger in the mobile Internet. Table 1 gives a rough, yet incomplete overview of the main differences.

	map products	**geovisualisation services**
information detail	more detailed	less detail
information content	comprehensive	focussed, more relevant
personalisation	one size fits all	can be adapted
usage	more enduring	short-term, instant
design and production	by cartographers	automatically, based on cartographic methods
graphic quality	high	inferior, but enhanced quality in use
link to other information	more difficult, poor interoperability	built-in (service chaining), better interoperability
functionality	greater functionality	limited functionality

Tab. 1: Comparison of map products and map services.

Furthermore, in IT the paradigm of web services has matured. Web services seem to be one of the new buzzwords in information technology. The basic concept of web services is a distributed set of software with limited functionality and standard interfaces allowing the inter-communication of different web services (Cerami 2002). The concept includes a service provider who describes the capabilities of the service and its interface with *Web Service Description Language* (WSDL). To register and later to discover services *Universal Description, Discovery, and Integration* (UDDI) is used. To encode messages for communication between the services the *Simple Object Access Protocol* (SOAP) is used. Web services are mostly transported over HTTP. Web services can be differentiated according to their level of functionality. There are basic or low-level services that offer simple functions and complex or high-level services that combine several functions within one service. One way to achieve more complex and enhanced functionality is the bundling of basic services. The web service architecture provides a mechanism called service chaining. The chaining of services means that the response of one service acts as an input for another or other services. Such an approach offers great flexibility to combine several distributed services in a way as if it were one powerful service. The prerequisites for service chaining are a description of the service, well defined interfaces, and syntactic and semantic interoperability.

The services described so far can be ordered in a hierarchy. Although a geoservice must not necessarily be distributed and web-based, geoservices normally are a subset of web services. A geoservice is the most general category of service related to geographic information. LBSs and geovisualisation services are subsets or implementations of a geoservice. Both, LBSs and geovisualisation services, can be based on lower level services such as web feature services or web map services. Furthermore, they can also incorporate one another, i.e. there are LBS with a geovisualisation component and geovisualisation services based on LBS functionality.

ISO 19101 provides a classification of geographic services with the Extended Open Systems Environment (EOSE) model for geographic information. Geovisualisation services are also called *portrayal* (ISO 19117) or *presentation service* (OGC). The OGC has proposed a framework for geoservices, named Open Web Services (OWS) that fits well in the geoservice model mentioned before. The OGC Open Location Services (OpenLS) specification defines Core Services and Abstract Data Types (ADT). For web mapping the OGC has defined several specifications such as Web Map Servers (WMS) and Web Feature Server (WFS). Other standardisation efforts have brought up XML based formats for modelling geographic data, the Geography Markup Language

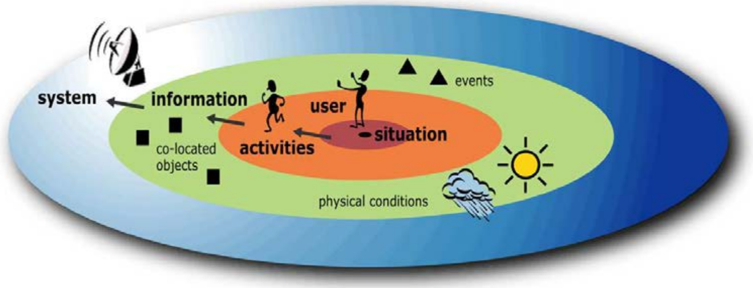

Fig. 1: Context dimensions

(GML), and presenting geographic data as vectors, the Scalable Vector Graphics (SVG). Frameworks for geoservices based on Open Source software have recently been developed, e.g. (Badard and Braun 2003) or (Sarjakoski and Lehto 2003).

3 Context-adaptation in geoservices

In mobile cartography context is understood as the more general concept embracing the more specific dimensions like situation (location and time), user, activities, information (e.g. co-located objects, physical environment conditions), and system (see Fig. 1) that have many and complex inter-relationships. The major difficulty with context here is to select from the vast amount of possible context dimensions or parameters those that are relevant for mobile cartography and have a significant impact on the mobile geospatial information usage. (Nivala and Sarjakoski 2003) list apart from the dimensions mentioned so far purpose of use, social context, cultural context, physical context, orientation context, and navigation history context.

In mobile usage situations the relevance of the geoinformation is strongly dependent on the user activity. However, the user activity cannot be determined so easily. In (Reichenbacher 2003) a basic set of elementary spatial user actions is presented. These actions are locating, navigating, searching, identifying, and checking and are connected with other actions to form more complex activities. These activities are also important for defining spatial zones. Activity zones or social zones can in many mobile usage situations be more expressive than Euclidean space. Von Hunolstein and Zipf (2003) propose an approach for activity maps and Klippel and Richter (2004) offer a similar concept of focus maps. Maps that are adapted to the usage context and specifically to the user activities can be termed *ego-maps*, because they are egocentric in the sense that the user is in the centre. This centre can be the spatial centre, the centre of activity, the centre of interest and so on. It will be necessary to establish activity ontologies and modelling activity zones, i.e. the region or spatial scope of an activity (see Fig. 2) for the purpose of activity maps.

Based on these context dimensions Reichenbacher (2004) proposes a first attempt to incorporate context parameters in the process of ad-hoc map design and generation. The parameters are used in controlling the adaptation of the geovisualisation, i.e. the fitting of adaptation objects (e.g. symbolisation) to the adaptation target (context). Methods of mobile map adaptation

- select map features (filters, e.g. based on user profiles)
- reduce the map content (only few object classes)
- reduce the information density (limitation to selected, important objects and information)
- remove, omit or eliminate map objects (based on map saturation or capacity)
- prioritise information
- substitute or exchange equivalent presentations (map – topogram – image – text – language; e.g. symbol through image)
- switch between predefined design alternatives (e.g. map symbol styles) or encodings (e.g. languages)
- change presentation; (re)change symbolisation (e.g. different opacities for relevance) colour depth reduction; colour to greyscale; change dimensionality (area to line/point)
- (re)configure map components (e.g. different base maps or scales for different purposes or movement speeds); dynamic composition of layers for the base map (e.g. with or without public transport network)
- adapt the user interface (reducing the degrees of freedom for interactivity)
- change encoding (e.g. vector to raster, SVG to JPEG)

The combination of different context dimensions has several advantages over a more one-sided approach as for instance LBS. The sole use of location as context parameter does not always lead to value-added solutions. The more comprehensive approach that includes time, personality, user activity, co-located information, etc. has a better chance to enhance the overall relevance of the service and thus the user satisfaction. The use of more context parameters also facilitates the interoperability with other services which once more can enforce the effect of a relevance improvement. The consultation of a multi-dimensional context allows for generating egocentric geovisualisation beyond the spatial notion of ego-centre. The most important task in producing ego-maps, i.e. adapting the geovisualisation is highlighting important features to emphasise their importance or relevance. Reichenbacher (2004) discusses different graphical means to put a visual emphasis or focus on a feature. The most promising adaptations are colour, opacity, and crispness. Of course animation and acoustic variables are important means though they have not been evaluated for their

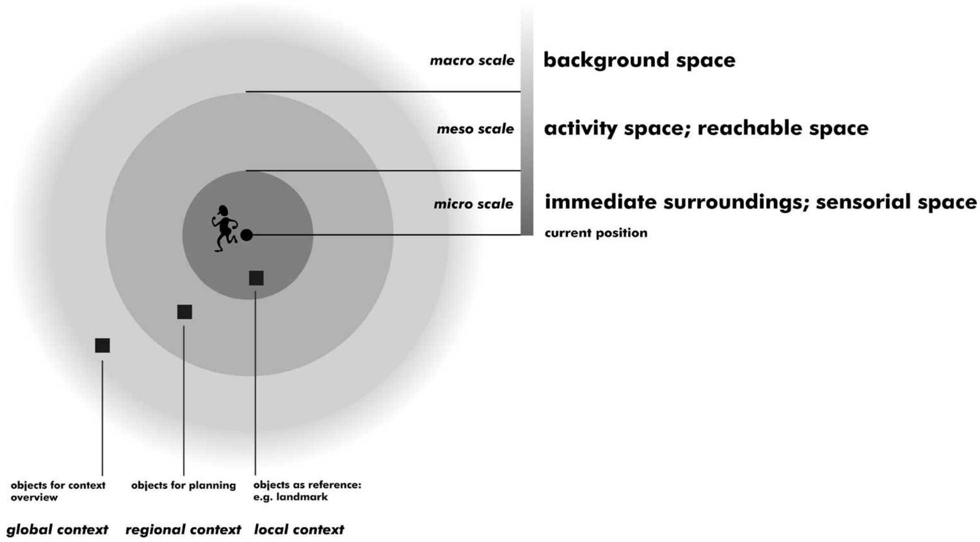

Fig. 2: Context and Scope of activities (adapted from Heidmann and Hermann 2003; Edwardes et al. 2003)

distraction potential or noise sensitivity in mobile environments. With graphical focussing less important or less relevant information can be displayed as layers or groups of map features with lower opacity or lighter colour. This moves this information in the visual middle ground and emphasises the more important information. This could also be interactively initiated and reversed by the user. In (Reichenbacher 2004) an example of mapping relevance values to opacity values is described.

4 Service architecture

For the design of a prototypical geovisualisation service a few basic assumptions have been made. The client is supposed to be a Personal Digital Assistant (PDA) connected to the Internet and it is assumed that the position of the device is known, i.e. that is provided by a positioning service or a GPS receiver. To invoke the geovisualisation service and realise a basic set of functions, it is assumed that the PDA is capable of running Java applets in a Personal Java compliant VM and is able to render SVG content. For the map examples points of interest (POI) with attributes are stored as a Point Theme in Arcview. Two different data repositories have been configured. Firstly, the point attribute table containing the POI data acts as a file-based data source that can be accessed from a Java application over a JDBC:ODBC bridge. Secondly, the point data was registered as a data source in the WFS Capabilities description file of the Deegree WFS, a freeware implementation of the OGC WFS specification (www.latlon.de).

The general platform used for the implementation of the prototypical geovisualisation service is shown in Fig. 3. Server-side the Apache Tomact servlet engine is used for running the service. The adaptive component of the prototype is realised server-side by dynamic generation of SVG with a Java web service (based on Apache SOAP 2.3.1) and Batik 1.5. Batik is an Apache open source Java API for generating and manipulating SVG documents (xml.apache.org/batik). The SVG maps are adapted to context based on

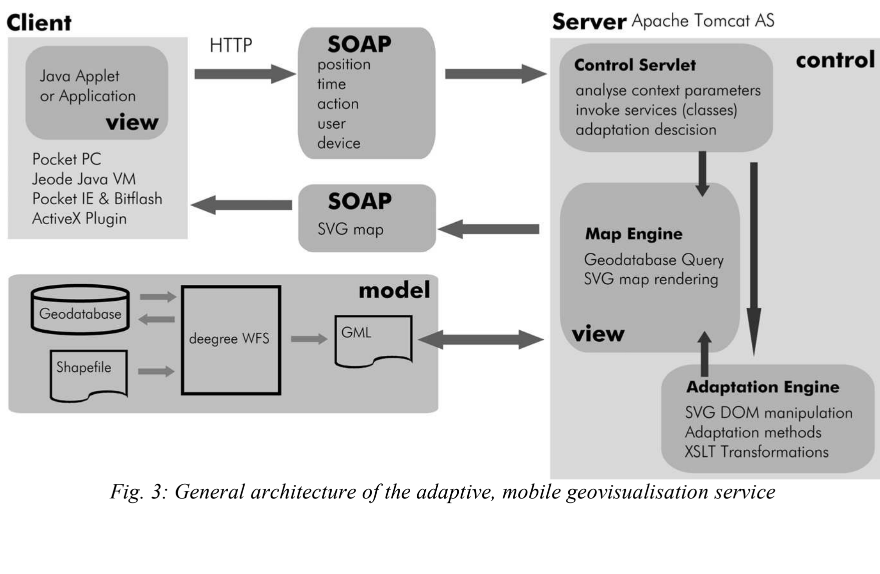

Fig. 3: General architecture of the adaptive, mobile geovisualisation service

information sent with the client request and transferred back to the Client. The data sources are accessed with the Deegree WFS 1.1.0.

The client tier is constituted by an applet running on a PocketPC and the SVG encoded maps are displayed with TinyLine Viewer, a Java based render engine for the SVG Tiny profile (www.tinyline.com). Although TinyLine only supports the Mobile SVG Tiny Profile, this use case demonstrates the core functionality of the geovisualisation service and shows basic visualisation possibilities of SVG on mobile devices. The main map functions provided by the viewer are the display of SVG maps and the panning and zooming within the displayed map. Fig. 4 (left) shows a screenshot TinyLine viewer and its available map functions: select, pan, zoom in, zoom out, and reload.

Fig. 4: TinyLine Java SVG viewer

To show some more advanced features (e.g. opacity, filters, transformations of text (rotate) etc.) supported by Mobile SVG Basic Profile, the Bitflash ActiveX Plugin for the PocketIE is used (www.bitflash.com). With the Bitflash viewer SVG documents embedded in HTML are directly displayed in the PocketIE browser window.

The applet should at least provide a very basic interface for initiating user requests. Fig. 4 (right) depicts a mock-up of such an interface. The button panel on the bottom is only visible if needed and through clicking on one of the icons for a specific mobile spatial action further user interface widgets appear. With the chosen actions and its associated parameters the user goal can at least roughly be defined.

The server side functionality is more ample and complex. In the proposed architecture (Fig. 3) a Java web service implemented as a SOAP service accepts SOAP requests from the client as input and invokes the adaptation methods. The responsibility of the service is to extract the SOAP message and analyse the contained context parameters. SOAP is a platform neutral, XML based message protocol for web services specified by the W3C. SOAP has no language and transport protocol binding, though in most cases it is used over HTTP. A SOAP service is based on exchanging messages. Such a SOAP message is an XML document with the following structure (Cerami 2002):

- an Envelope element, the root element containing all other elements
- an optional Header element specifying header information such as authentication
- a Body element giving details about call and response information
- an optional Fault element providing information about errors that occurred while processing the message

SOAP offers an interoperable standard protocol to encode context parameters and user requests for mobile service. The following code example shows a SOAP request of the client with the basic context parameters:

```
<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
    <SOAP-ENV:Body>
        <ns1:retResponse xmlns:ns1="urn:examples:testservice" SOAP-
ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
            <loc_x xsi:type="xsd:int">4468540</loc_x>
            <loc_y xsi:type="xsd:int">-5332680</loc_y>
            <cal xsi:type="xsd:date">2003-11-18</cal>
            <screen_x xsi:type="xsd:int">240</screen_x>
            <screen_y xsi:type="xsd:int">320</screen_y>
            <usergrp xsi:type="xsd:string">C</usergrp>
            <cat xsi:type="xsd:string">11001.0</cat>
        </ns1:retResponse>
    </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

After reception and analysis of the context encoded in the SOAP message decisions about adaptation necessity and appropriate methods have to be taken. In a next step appropriate spatial filters might be designed and a WFS request or an SQL string for a direct database connection is generated. The service then accesses the WFS or the POI database and retrieves the features. In the WFS case the features are returned as *Geography Markup Language* (GML) and are transformed to SVG with an *Extensible Stylesheet Language Transformation* (XSLT). The XSLT approach offers great flexibility in adapting the symbolisation through application of different stylesheets. If a database table with point data is directly accessed the data can be processed by the service with Batik to generate the corresponding SVG elements and adapt the. Several methods to adapt the map that is sent back to the client are imaginable. The two basic groups of methods considered here are:

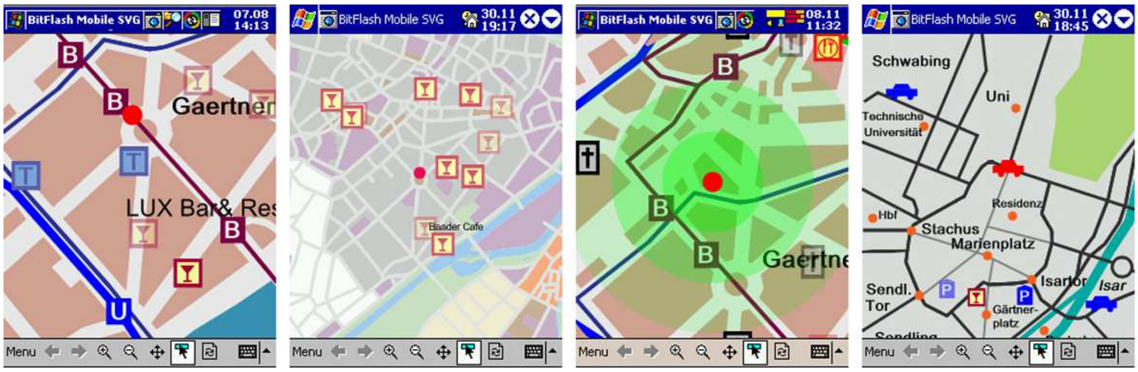

Fig. 5: Examples of dynamically generated adaptive, mobile maps

- map symbology adaptors: these methods can have global or more local effects. Changing the symbology for the complete map can be done with an exchange of the stylesheets (CSS or XSLT). For partial changes the elements can be manipulated through the *Document Object Model* (DOM), e.g. assigning a different opacity value.
- map components configuration adaptors: these methods can either configure the individual components of base map and/or configure additional landmark and thematic components (e.g. transport network).

Different XML technologies can be used to manipulate the map features encoded as SVG. For the adaptation of SVG encoded maps the DOM is specifically important. The DOM is a language and platform independent representation of an XML document in the memory and can thus be accessed during run time of an application. The other important mechanism for XML processing is the *Simple API for XML* (SAX) that is used for parsing XML documents. This process is event-based, i.e. if the parser gets an event (an element), it notifies the application which will take some action.

The service architecture proposed here is a first proof of concept, but can be extended in many directions and needs to be refined. First examples of mobile, adapted maps produced with the service are depicted in Fig.5.

So far we described the adaptation of mobile maps to external context factors. The map itself can also internally be adapted. An example is the adaptation of text and symbol placements in order to avoid overlaps. The first case is external adaptation and the latter internal adaptation. An internal adaptation could be understood as a self-adaptation resulting in complete self-adaptive maps. An approach to self-adaptive maps is the introduction of constraints. The map examples in Fig. 6 illustrate the application of constraints for an internal map adaptation.

A proposal for using constraint-based SVG is described by Marriott et al.(2002). Constraints have been successfully applied in map generalisation. Since adaptation and especially internal adaptation is closely related to generalisation the combination of the two concepts should lead to enhanced mobile maps. An architecture for generalisation of mobile maps is presented in (Burghardt et al. 2004).

5 Conclusion

Open source technology and interoperable standards are powerful means for designing and implementing adaptive, mobile web services. Further research is needed in modelling and formalising context for mobile cartography, the design of adaptation methods along with establishing rules and constraints for governing the adaptation process. Furthermore, activity ontologies have to be defined for the generation of ego-maps or activity-based maps. And finally, the usability of different adaptation versions/alternatives have to be tested in practice with usability test series.

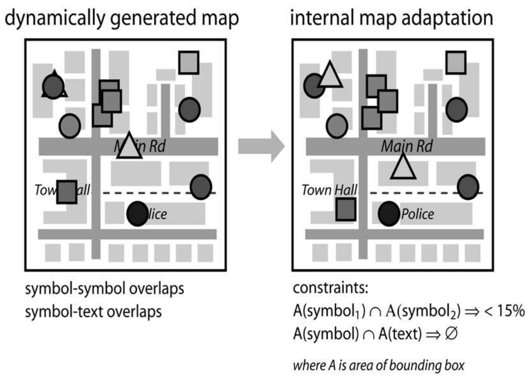

Fig. 6: Internal mobile map adaptation

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Context–based cartographic display on mobile devices

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Abstract

A “mobile GIS” needs to be an adaptive system i.e. a system that modulates its response according to certain characteristics such as knowledge or context. To implement those characteristics on the system, it must be “context aware” and contain procedures that can be adapted harmoniously with respect to the context. This way the needs of the mobile user are efficiently accommodated and he/she is provided with the appropriate response under varying conditions. Besides context-awareness the system should take into account the user’s profile. Quite often the response of the system is in the form of a map. Maps play an important role in the application domain of Location Based Services, due to their inherent characteristic as efficient means for communication of spatial information. In order to implement these capabilities in the system environment, it must be supported by adaptation methods. These methods are executed when events are triggered by the changes of the context structure or the user’s profile. The design of the context-based cartographic display system is based on the modeling of the context structure. The context model provides a variety of parameters used by the system to conduct the cartographic process, which in turn includes the necessary analytical operations that are applied to the database so that selection, generalization and visualization can be achieved. The implementation of the system is based on Web Services technologies, which allow the utilization of distributed software systems developed in accordance with widely adopted standards. Data is encoded in XML and the cartographic display is based also on existing XML open standards for vector data (SVG) enabling high quality, dynamic, interactive and stylable graphics to be delivered over the web using accessible and human readable XML.

1 Introduction

Contemporary people, in order to confront the complexity of the geographic reality, while living in a dynamic environment and performing various tasks (e.g. scheduling entertainment, leisure, touring or roaming in terra incognita), need vivid information about the geographical space. Maps are efficient means of communicating information about phenomena, events and incidents relative to geographic space. Traditionally, printed maps “on the go” are used. The evolving technology of ubiquitous computing, which supports hand held mobile micro-computers with wireless communication capabilities, allows for the use of electronic mobile maps that are generated dynamically on demand on the user’s mobile display [1], [2]. In general, mobile maps are dynamic maps with interactive capabilities. One of the characteristics of mobile systems is that they incorporate GIS functionalities enabling them to respond to spatial queries and provide mobile users with a variety of services. Such systems can be called “mobile GIS systems” [3]. Systems that take into account user’s position like Location Based Systems – LBSs, can also be considered as mobile GISs [4]. A mobile GIS needs to be an adaptive system, e.g. a system that modulates its response according to certain characteristics of its knowledge or context. Particularly, the cartographic display in a number of GIS applications is desirable to be properly and dynamically adaptive to the context, in order to satisfy the needs of a mobile user.

This paper introduces the concept of a system that has the potential to provide the mobile user with cartographic display and interaction capabilities taking into account information pertinent to the specific location, time and user profile. Such a system can be called *“context-based cartographic display system”*. The core of the system’s functionality is the context structure. The paper elaborates on the context’s information characteristics, the adaptive visualization process, the design of a model that describes the important parts of context information with regard to the system and the technology that can be used for the implementation of the *context-based cartographic display system*.

2 The context-based cartographic display system – Conceptual approach

The *context based cartographic display system* has the potential to provide the mobile user with proper cartographic presentations and adaptive user interfaces, so that he/she can accommodate his/her needs while he/she moves. The display and the structure of the map will be adapted automatically so that proper information is communicated. The cartographic display should be able to display the dynamic and complex environment through proper generalization and inclusion of those characteristics that are of special interest to the mobile user at specific time. To accomplish the above, the system should have a flexible information structure, which constitutes the context’s information structure, enabling the description of the dynamic environment. The term “context” refers to situations or circumstances under which a computational work takes place. According to Dey and Abowd [6][7], context is every piece of information that describes the condition of an entity that can be used in interactive functions in a computational system. Applications that are aware of the context and utilize this information through their functions are characterized as “context aware”.

In general, context awareness is desirable in many applications of ubiquitous computing [8]. A context aware mobile system, provides friendly user interaction and information presentation, which lead to the personalization of service.

3 Characteristics of context information

The most important element of information for the *context based cartographic display system* is the geographic location. The knowledge of position enables the system to "understand" that it functions in a mobile mode. This information can be utilized for the adaptation of the cartographic display in order to portray the geographic entities that surround the mobile user through the extraction of important parameters of context information e.g. proximity of the activity, geographic reality that surrounds the user, purpose of the map usage, navigation history of the user etc. The position is made available to the system through electronic positioning sensors e.g. GPS receivers. Other important parameters of context information that consist the context's structure are orientation and user's profile.

The collection of context information is achieved:

- Directly from the user
- Through electronic sensors that enable the equipment to comprehend the physical world e.g. geographic position could be received by a GPS integrated in the mobile device, orientation through electronic compass and temperature through an electronic thermometer.
- Through system's software processing results e.g. the proximity's computation could be carried out if proximity has been defined in the system.
- Indirectly from other sources e.g. user's profile.

Context information managed by the system has the following characteristics:
a) Temporal characteristics: Context information could be characterized as static or dynamic.
b) Imperfect characteristics: In general, context information is by itself imperfect when it is unable to describe a condition or incomplete when certain context's aspects are not known. Mobile computational environments are highly dynamic and may result to considerable delays between provision and usage of context information. Secondly, context sources like sensors, algorithms and users may provide fault information. On the other hand, connection problems or system failures may result to the interruption of the link between context source and the user.

c) Alternative presentations: Considerable part of the context information in mobile systems is derived from sensors. There is usually a significant gap between sensor output and the level of information needed by the applications and this gap must be bridged through processing of context information. For example, a location sensor can supply x,y,z coordinates but what is of interest to the application is the kind of building or room where the user is in. Parameters that describe context information can be extracted in various ways resulting to alternative ways of presentation.

d) Context information is highly interrelated: Context information could be related with derivation rules, which describe the way information is acquired. For example, current activities information could be produced from other context information like the user's position and history (past activities) referred as *dependency* [5].

4 Visualization process in context based cartographic displays

The visualization process depends on the changes in context structure. The system perceives these changes and initiates the visualization process. At the implementation phase the system will be equipped with adaptation methods. These methods are executed when events are triggered by the changes of the context structure. These methods will conduct the cartographic process, which in turn includes the necessary analytical functions that are applied on the database so that selection, generalization and visualization can be achieved (Fig. 1).

For the implementation of the system for a particular application, the type of context information to be utilized must be specified. Then the system should be able to compute the parameters of context information. Provided that in the visualization process of an adaptive system the context information structures are utilized, the problem is the identification of the specific application. The system knowing the situation through the appropriate context structure is able to dispose the required algorithms. The term "appropriate" refers to the "intelligent map" [9] that will display what the user wants to see while moving. An important research subject is the formal description of these conditions so that the various problems can be algorithmically solved.

5 The context model

Context information description has been based on a model introduced by Henricksen et al [5]. The model exposes context information characteristics and works as a conditional tool for further system analysis and especially for building context mining algorithms. The model constitutes a formal base for presentation and reasoning of context information attributes like persistence, temporal characteristics, quality and inter-dependences.

The conceptual model does not refer to a particular application scenario and does not include particular information of technological nature. It describes in an abstract way important parts of the context information influencing the adaptation of cartographic display. The modeling of context information is built around a set of entities that describe a physical or conceptual object. Properties of entities are represented by attributes e.g. the profile of a person. An entity is linked to its attributes and other entities through a uni-directional arrow that is called association. Furthermore associations between entities are allowed. Associations could be considered as assorting their parent entity and a context description can correspondingly be viewed as a set of such assortments. Then, special symbolization describes in a formal way context information assorting associations in the following categories:

a) Static associations are relationships that remain fixed over the lifetime of the entity that owns them. Context that is captured by this type of association is typically known with a high degree of confidence.
b) Dynamic associations are those associations that change over an entity's life time. These are categorized as follows:

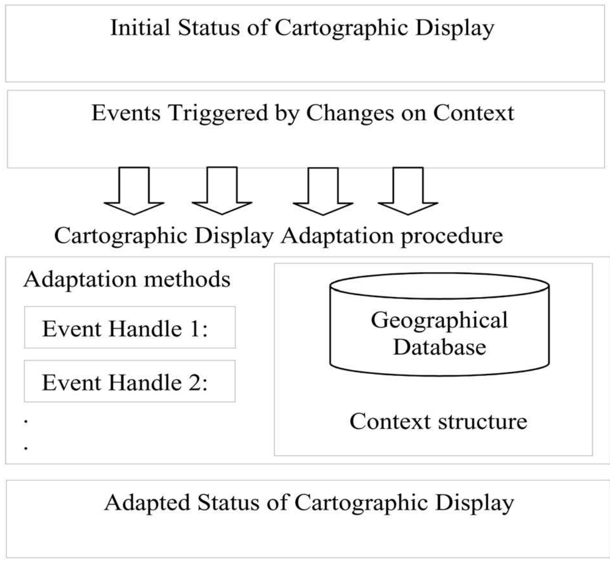

Fig. 1. Visualization process in a context based cartographic display

- Sensed associations: This information usually is not input directly into the model from the sensor, but is transformed in a way in order to be abstracted. Context information through sensors usually changes and suffers from aging problems e.g. transmission delay to client. Furthermore, it can carry mistakes due to the technology of manufacturing sensors.
- Derived associations: They are obtained from one or more associations using a derivation function that may range in complexity from a simple mathematical calculation, a database query up to a complex artificial intelligence algorithm.
- Profiled associations with information supplied by the users: Every kind of relation also characterizes the degree of confidence that the particular information has.

From this categorization conclusions can be derived about the information quality and persistence. For example, conflicts can be solved taking into account the most reliable classes (static follow profile associations) and then those who are more error prone (derivation associations and sensed associations). Further symbolization ([], *, v) introduces structural constraints on associations categorizing them into simple and complex associations. An association is simple if each entity participating as owner of the association, participates once in this role. An example of this type of association is the named association of person. An association is composite if it is not simple. Further refinement identifies associations into collections, alternatives and temporal associations. Collections are used to represent the fact that the parent entity can simultaneously be associated with several attribute values and/or other entities i.e. a geographic entity can have more x, y describing the spatial type. Alternatives differ from collections in that they describe alternative possibilities that can be considered to be logically linked by the "OR" operator rather than the "AND" operator. One example of an association of this type is the required relationship between channels and devices. By classifying the role as an alternative rather than a collection, it acquires the semantics that a channel requires one of the devices it is associated with, rather than all. This type of association is useful when the context model must capture a number of different presentations of the same information or when two or more sources of context information supply contradictory information and it is desirable to capture each one of the different possibilities. Finally, a temporal association is also associated with a set of alternative values but each of them is attached to a given time interval. This type of association can be viewed as a function mapping each point in time to a unique value.
For the *context-based cartographic display system* the use of the following context model is suggested: The model is built around five types of entities: user, device, geographic entity, cartographic display (map) and cartographic entity that is associated with a number of attributes, e.g. cartographic entity with symbol and position. The building of the context model refers to the segments of information relevant to the semantics of the problem to be solved (figure 2).

6 Adaptation in context-based cartographic displays

The model shows the dynamic environment where the context-based cartographic display system will operate. Some context information is necessary to be derived through processing while others are acquired straight away e.g. context information that are obtained by sensors or those supplied by the user. It is clear that the system consists of two main parts: context's structure and the part which produces this structure. To a certain degree both parts can be treated as independent. In the implementation phase, the first part seeks for extraction ways of the context's structure parameters that describe some context model for a particular application and the second part will simulate the dynamic structure that is described in the context model. These methods will adapt properly the cartographic display utilizing context structure so that selection operations, generalization and visualization can be performed. The complexity of the algorithms that are called to deal with the above procedures will vary from simple to complex. These algorithms have to be as efficient as possible.

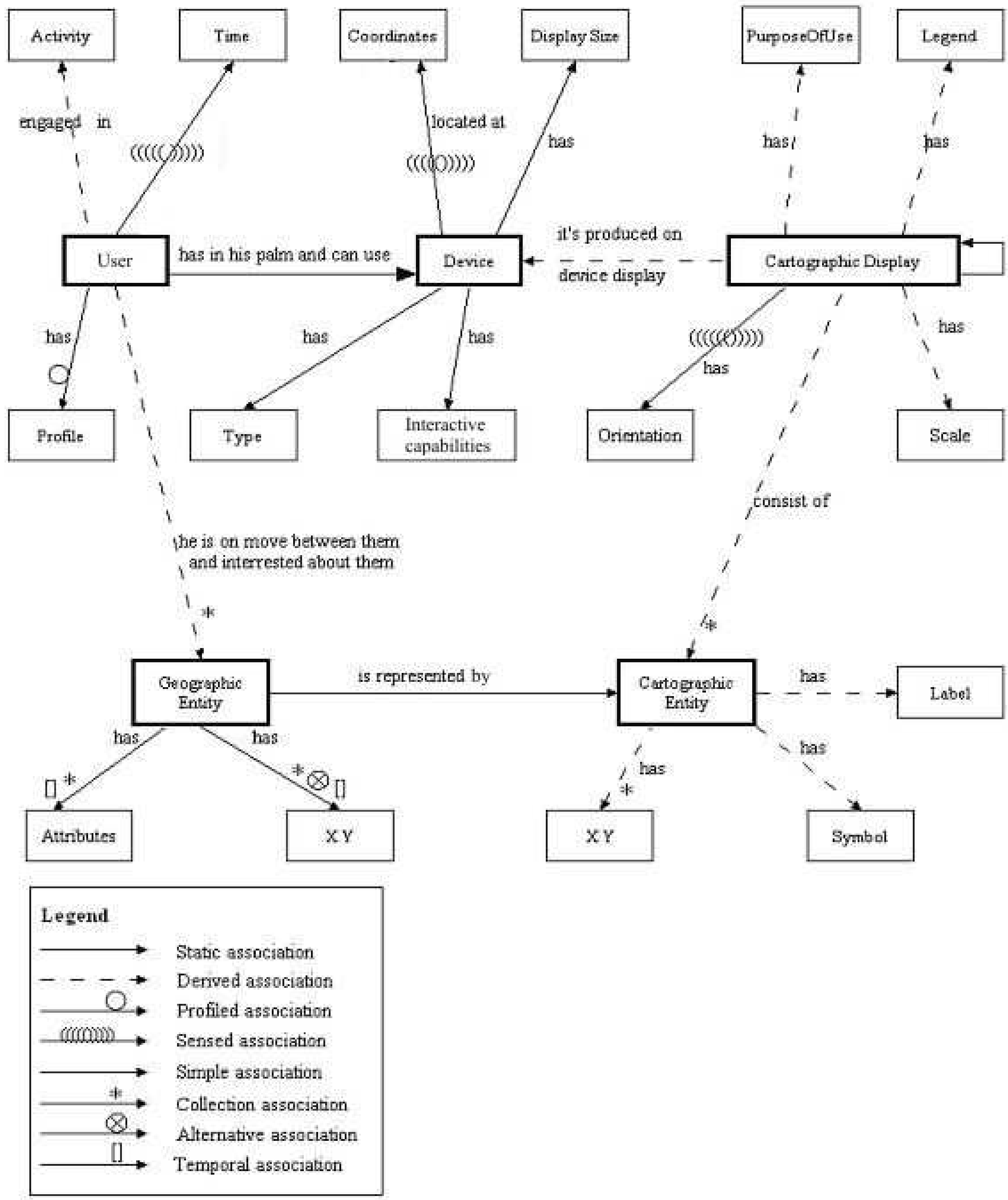

Fig. 2. Context Model

```
adaptation method(Context c, Geographical Database gdb)
{
        if (adaptivity == true)
        {
        selection(c, gdb);
        generalisation(c, gdb);
        visualization();
        }
}
```

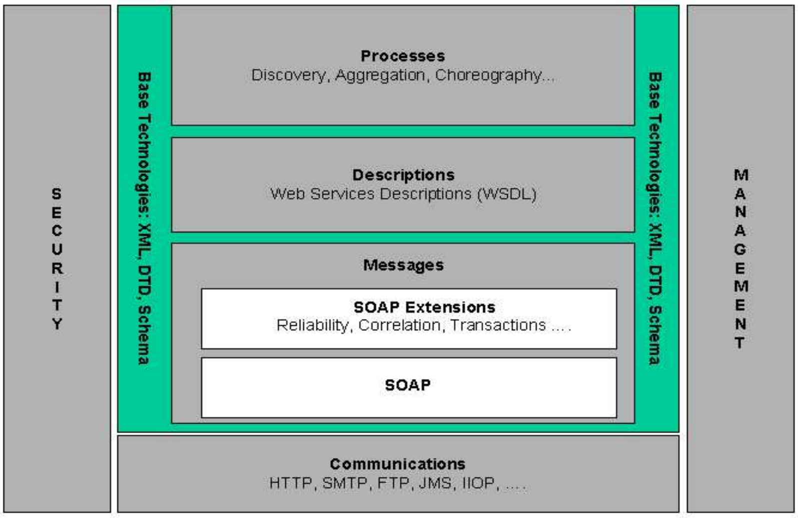

Fig. 3. Stack Diagram

7 Implementation technologies

For the implementation of the system the following technologies will be used:

Web Services
Web services provide a standard means of interoperability between different software applications, running on a variety of platforms and/or frameworks [11]. XML Web services are the fundamental building blocks for distributed computing on the Internet. Open standards and the focus on communication and collaboration among people and applications have created an environment where XML Web services are becoming the platform for application integration. Applications are developed using multiple XML Web Services from various sources that work together regardless of their location or the way they have been implemented. [13]

A more precise definition for the term Web Service might be an application component that [14]:

- Communicates via open protocols (HTTP, SMTP, etc.)
- Processes XML messages framed using SOAP
- Describes its messages using XML Schema
- Provides an endpoint description using WSDL
- Can be discovered using UDDI

Web Services Architecture
There are a number of technologies widely used in the deployment of Web Services and other technologies that will ie merge in the future. Web Services Architecture (WSA) involves a number of layered and interrelated technologies. There are many ways to visualize these technologies, just as there are many ways to build and use Web Services. Figure 3 provides an illustration of some of these families of technologies [11].

First and foremost, XML is the "backbone" of the Web Services Architecture (WSA). One can imagine Web Services that do not depend on the SOAP envelope framework or processing model, or that do not employ WSDL to describe the interaction between a service and its consumers, but XML is fundamental. It provides the extensibility and vendor, platform, and language neutrality that is the key to loosely-coupled, standards-based interoperability that constitutes the essence of the Web Services. Furthermore, XML helps to clear the distinction between "payload" data and "protocol" data, allowing easier mapping and bridging across different communication protocols. Those protocols are necessary in many enterprise IT infrastructures, which are built on industrial-strength but proprietary components. Thus, the "base technology" of the WSA consists of some key XML specifications, including XML 1.x, XML Schema Description Language and the XML Base specification.

XML and Web Services
A Web Services interaction refers to two, or more, software agents exchanging information in the form of messages. The data exchanged is usually XML encoded, carried over an underlying transport or transfer protocol such as HTTP. Similarly, XML is the foundation for many of the descriptive technologies such as SOAP, WSDL, OWL and others. In effect, the use of XML is critical to the overall picture of Web Services [11]. The reason behind the importance of XML is that it solves a key technology requirement

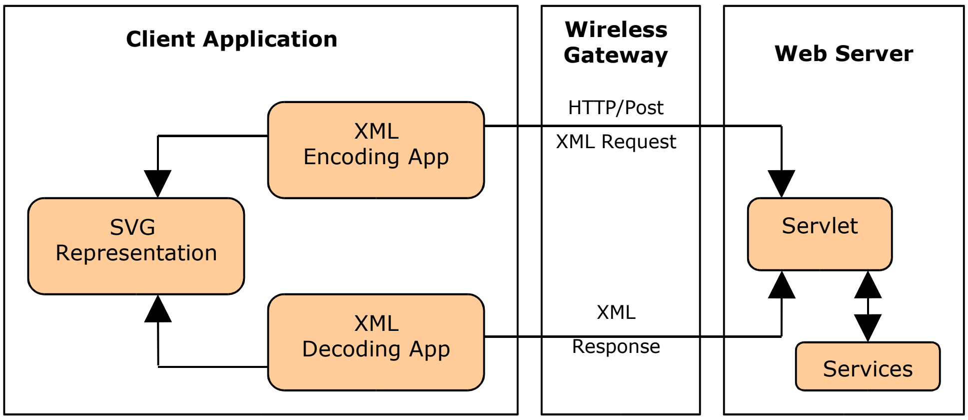

Fig. 4. Usage Pattern for Request/Response pairs

that appears in many places: by offering a standard, flexible and inherently extensible data format, XML significantly reduces the burden of deploying the technologies needed to ensure the success of Web Services [11].

Location Based Services (LBS) and XML

A wireless service that uses geographic information to serve a mobile user and exploits the position of a mobile terminal usually uses XML technologies. The location services market requires a technology that complies with the principle of simplicity so that these services will be widely adopted throughout the wireless realm. The objective is to shield the wireless provider from "GIS complexity". Mobile SVG is one of the technologies that have emerged for wireless applications in the domain of graphics presentation [12]. Figure 4 illustrates the general usage pattern for XML based Request/Response in such a service. Provided that some basic assumptions have been made and that general requirements have been taken into account, the use case starts with the execution of a client application that processes a user's request for service. This in turn leads to a request for the use of a service, e.g. a directory service. The client application encodes the request for the service as an XML request. Using the HTTP/post method, the XML request is sent to a servlet. The servlet parses the XML request and - according to the request tags - generates the proper function call to the service. The service processes the request and sends back the response to the servlet, which in turn encodes the response as an XML response and forwards it to the client application.

The client application decodes the XML response and applies the proper presentation functions for display on the client device. In the case of thin client devices, it is possible that the parsing of the XML response is done on the server and the portrayal content is streamed directly to the client device. This content may contain SVG maps or graphics, so that the client can see them in his SVG viewer enabled device.

Scalable Vector Graphics

For the display of cartographic data the Scalable Vector Graphics (SVG) will be used, which constitute an open presentation standard for cartographic data and has advantages like: collection, selection, cartographic generalization, cartographic display, dynamic visualization and interactive capabilities. SVG seems well suited for presenting dynamic and adapted geoinformation content to mobile users, since it offers a lot of useful features for this task. [10]

Mobile SVG

SVG Working Group has committed itself to a concerted effort to create a profile specification suited to display vector graphics on small devices. A single such profile is not sufficient to deal with the variety of mobile devices, because each mobile device has different characteristics in terms of CPU speed, memory size, and color support. To address the range of different device families, two profiles are defined. The first low-level profile, *SVG Tiny* (SVGT) is suitable for highly restricted mobile devices, while the second profile, *SVG Basic* (SVGB) is targeted for higher level mobile devices. To ensure interoperability between content and software tools compliant with different profiles, SVGT is specified to be a proper subset of SVGB, and SVGB to be a proper subset of SVG 1.1. Due to the low memory, low CPU power and limited display of mobile devices, Mobile SVG profiles introduce constraints on content, attribute types, properties, and user agent behavior [15].

Mobile SVG format is also intended to be supported in multimedia messaging services (mms) in 3rd generation mobile phones. In order to guarantee a minimum support and compatibility between multimedia messaging capable terminals, mms user agent shall comply with media formats such as text, speech, audio, synthetic audio, still image, bitmap graphics, video, file format for dynamic media, media synchronization and presentation format and vector graphics. For terminals supporting media type "2D vector graphics" the "Tiny" profile of the SVG format will be supported, and the "Basic" profile of the SVG format may be supported [16].

The mandatory format for media synchronization and scene description of multimedia messaging is SMIL, which in combination with Mobile SVG can give interesting map graphics representations in the future mobile mapping applications. [17]

8 Conclusions

Location-based services will be a default service in future systems. With location-based information and applications, mobile subscribers can access a wide range of services such as traffic and weather reports, restaurant, theatre or movie ticket bookings. Interactive maps displaying areas of interest, will be an important part of these services. GPS receivers will be an integral part of the mobile devices and XML technology will be the undelying technology of the context-based cartographic display mobile system. Mapping will be implemented with the use of SVG, which is a vector graphics format suitable for this kind of application. Many people are familiar with wireless Internet, but many don't realize the value and potential to make information services highly personalized. The powerful combination of technologies integrated in the context-based cartographic display mobile devices, will result to a user friedly environment that will soon be an indispensable piece of equipment for the contemporary people.

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An architecture for automatic generalisation of mobile maps

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Abstract

Within the EU research project WebPark a platform for location based, personalised information services for protected and recreation areas is being developed. One research priority is the dynamic cartographic visualisation of spatial information on mobile devices. Small screens and real time requests impose constraints for automated cartographic generalisation, which will be necessary for transforming geographic data into easily readable map information. This paper presents an architecture for automated generalisation of dynamically generated maps.
The generalisation component utilises a Java framework from the free software project Deegree (Deegree, 2003). Deegree Web Map Server and Deegree Web Feature Server are used as standard tools for web mapping and provide access to distributed geographic data sources. The generalisation component implements an OGC Web Map Server Interface and makes the required feature types and symbology accessible with the help of an OGC styled layer descriptor (SLD). The suggested generalisation approach is based on a software pattern called model-view-controller from object-oriented development theory. The main components are model generalisation, an organisation and interpretation component, and cartographic generalisation.

1 Introduction

WebPark, a European research and development project (duration 10/2001-09/2004), has the goal of creating a platform for location based services in protected and recreation areas (Mountain et. al, 2003, Burghardt et. al, 2003). The developed services will be adapted to the individual requirements of tourists and park visitors and will allow access to distributed information sources with help of current technology and standards of information delivery (OpenLS, OpenGIS). A web service can be understood as an interface, which describes a number of operation used with standard internet protocols (Kreger, 2001).

Since the end of the nineties a change has taken place in the area of geographic information systems from information preparing to communication supporting systems. Characteristics of these are an intensive utilisation of internet technology, as well as the consequent use of services based architectures (Fitzke and Greve, 2002). Prerequisite for such development was and is the efforts in standardisation by the Open GIS Consortium (OGC). Important results in the standardisation process driven by the OGC are, among others, the "Web Feature Server Interface" specification (WFS) and the "Web Map Service" specification (WMS). The WMS specification standardises the access to geo data. The WMS specification describes the standard interface for delivering maps over the internet.

Location Based Services (LBS) describes the provision of information which is adapted to the requirements of the user and therefore more than a consideration of location during information selection. Whilst the information is adapted through a consideration of the current position, time and personal interests of the user, so to is the process of information delivery. The adjustment of information delivery is realised through modifications of the user interfaces (e.g. language selection), through the media of presentation (e.g. portrayal type), as well as, through consideration of the device used (e.g. screen size, resolution). Related to that, Reichenbacher (2003) identified 4 basic levels of adaptation in the area of mobile cartography – information, user interface, presentation and technology. Viewing Location Based Services in this extended context, it seems suitable to name them also adaptive information services.

In the most cases the requested information has a spatial relation, therefore presentation with the help of maps is well suited. Additional explanation can be given through text, pictures or video, which is connected to map presentation. Several possibilities of interaction, like mouse over effects, hyperlinks, animation etc., compensate existent restrictions of the small screen sizes of the mobile devices (Gartner, 2003). Distinctions between analogue map views and screen presentation are comprehensively described by Malic (1998) und Neudeck (2001).

The provision of information on small devices also places particular constraints on generalisation, which are not encountered in production or desktop/internet cartography. There are three principal considerations; the screen size and resolution, the mode of operation and the context of operation. The screen size and resolution places the obvious constraint on the amount of information that can be displayed. Because the size is so small, many of the techniques of more traditional map generalisation cannot be used. The manner in which a PDA is interacted with is much more intermittent and referential than other forms of cartography, which can present more complex interactions for browsing over extend periods. The context of operation of a PDA means that information must be provided that is timely, location-based and relevant to a user's preferences. Taking all of these aspects into consideration means generalisation needs to be highly dynamic and configurable and able to answer questions graphically, in a simple and highly focused way, i.e., by reducing the degree of interpretation of the data and answering single questions quickly.

Fig. 1: ***Screenshot from a WebPark application (selection of positions for viewing animals and plants) without cartographic generalisation***

Fig. 1 illustrates the need for generalisation in WebPark. Here data for a limited set of animal observations is shown, symbolized pictographically. In this example, the generalisation process would seek to reduce this data set according to spatial and temporal resolution and context (such as the time of year), identify significant clusters in the data to be preserved and symbolize these data points in such a way as to enhance some aspect of the clusters such as the distribution or the density of observations.

2 Generalisation architecture

2.1 Portrayal model

A common reference model for categorisation of basis services for provision of geospatial information comes from Cuthbert (1998). Four states of geospatial information can be distinguished – data holding (data source), accessing geographic objects (features), creation of graphical objects (display elements) and visualisation on the device (image). Several basis services are responsible for transformation of the geospatial information. From data holding to map presentation the following processing steps need to be executed:

- Accessing the data by applying spatial and semantic filter, as well as provision of geometry and attribute information with help of Geography Markup Language (GML)
- Applying feature-centered rules of styling features e.g. with Styled Layer Descriptor (SLD) for the creation of graphical objects
- Rendering of the map image with consideration of needed image properties (size, number of colours, resolution)

The following section describes, how a generalisaiton service can be integrated in this portrayal model.

2.2 Framework

The generalisation engine is based on the Java framework of Deegree (Deegree, 2003). This provides standard tools for web mapping and accessing geographic data sources. The framework is the reference implementation of the OGC WMS 1.1.1 specifications. It is a pure java open-source implementation that is provided under a GNU Lesser General Public License (LGPL). This means it can be used in commercial software without royalty payment and without affecting the commercial licensing of the project in any way. The customisation of the architecture is shown in Figure 2. Items marked 'Deegree' are components from the framework. Deegree itself also uses two other LGPL Java frameworks, which will also be exploited further in the customisation. The JTS Topology Suite (Vivid Solution, 2003) provides a suite of tools for spatial analysis, essential for performing generalisation operations. The Batik toolkit (Apache, 2003) provides a framework for generating SVG content from Java graphics objects. For model generalisation the system will make use of Oracle's Java stored procedures capabilities and use the Oracle Spatial Java Class Library to manipulate Oracle geometry objects.

2.3 Generalisation process

There are three principal components to a generalisation process; model generalisation, organisation and interpretation, and view (graphic) generalisation – the terminology of this decomposition follows the model-view-controller paradigm from design pattern theory (Gamma et. al, 1995, Krasner et. al, 1988). The model generalisation component is responsible for adapting the map content to the required thematic and spatial resolution (Morgenstern and Schürer, 1999), e.g. by filtering, (re-)classifing and (re-)sampling data. This means model generalisation determines which classes, objects and attributes are relevant at the required resolution. It does not consider how the features will be symbolized in the final map. The view generalisation component considers symbolisation and graphical presentation of the map. It aims to provide a visualisation legible at the required cartographic scale and containing all the important information (Weibel and Dutton, 1998).

Distinguishing between model and view generalisation allows the treatment of content and presentation to be separated. Legibility constraints which result from symbolised presentation can have repercussions on the content selected. The reason is that symbolised objects often have to be visualized at larger size than their true footprint. This leads to areas in the map with high object density and limited readability. View generalisation solves such problems with selective reduction and replacement of content in such as way as to maintain specific aspects of the original set.

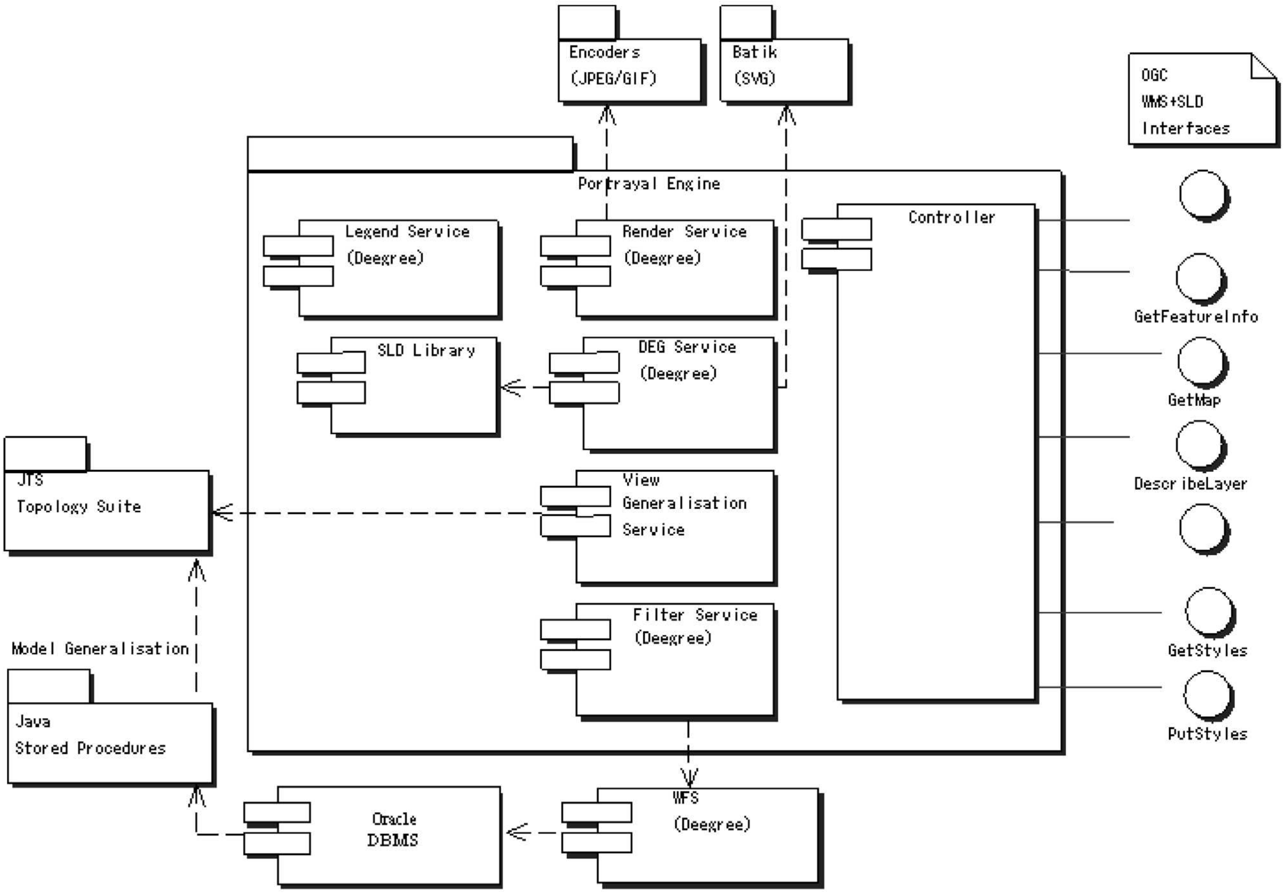


Fig. 2: Architecture designs for the generalisation engine

The organisation and interpretation component serves the purpose of providing a map that is "fit-for-purpose", i.e. that is relevant to the questions that it is intended to answer. Two roles are performed. First is organising the data into meaningful structures and groupings (e.g. patterns such as clusters and alignments which should be communicated in the answer). Second is to provide design directions as declarative statements of what should be preserved and enhanced about these organisations in general. Such statements are constructed using constraints or a parameterised interface which is used to control view generalisation algorithms (Edwardes et. al, 2003).

shows a high level view of the generalisation architecture. The view generalisation component is a middleware component created with Java classes. The model generalisation component is contained within the Oracle (2003) database and uses stored procedures written in Java. The use either pre-process or dynamically generate auxiliary data structures to prepare the data for a specified spatial and semantic resolution.

The design draws heavily on OGC standards and the decomposition of services and interfaces used by the OGC Web Map Server specifications (OGC, 2003a). It inserts a generalisation service which provides three functions, using independent sub-modules;

1) control of model generalisation - enabled through manipulations of filter requests (OGC, 2003b) and responses,
2) the organisation of data into geographically meaningful groups relevant to a task e.g. clusters, alignments etc. and the formulation of declarative statements to direct their generalisation, and 3) view generalisation of display elements based on symbology conflicts and design constraints.

3 Interface

3.1 Request

The engine presents an OGC Web Map Service interface. Here the most important operation is GetMap. This is called using an OGC WMS POST request (OGC, 2003c). This request contains all the information required for generalisation. That is, the resolution, the features that are to be rendered and the symbology that should be used to render them. The required feature types and symbology are

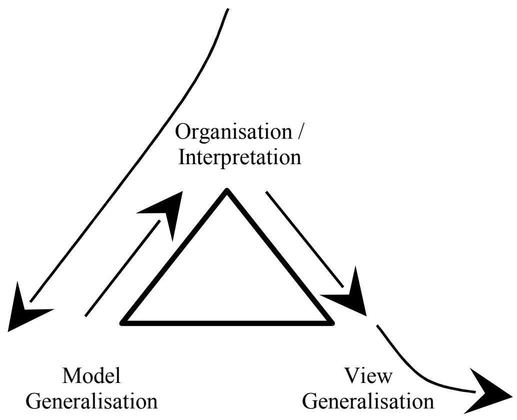


Fig.3: Generalisation process of dynamic generated maps

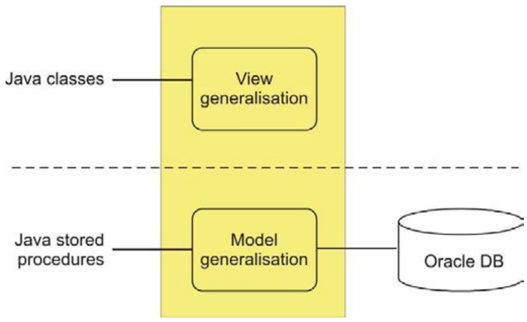


Fig. 4: High level view on generalisation architecture

contained within an OGC styled layer descriptor (SLD) (OGC, 2003d). The SLD associates a specific styling with a set of feature types contained in an associated Layer. The Layer defines the feature types either by their feature type name, by a database query described using the Filter Encoding Specification (OGC, 2003b), directly in GML (OGC, 2003e) (in which case the component is entirely standalone), or by reference to a named layer in the SLD library of the engine.

Below is an example of a WMS POST request taken from the SLD specification (OGC, 2003d).

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE GetMap SYSTEM "GetMap.dtd" >
<GetMap>
        <Format>
        <PNG/>
        </Format>
        <BoundingBox SRS="EPSG:4326" minx="0.0"
         miny="0.0" maxx="1.0" maxy="1.0" />
        <!--Embedded StyledLayerDescriptor starts here.->
        <StyledLayerDescriptor>
                <NamedLayer name="Rivers">
                        <NamedStyle name="CenterLine"/>
                </NamedLayer>
                <NamedLayer name="Roads">
                        <NamedStyle name="CenterLine"/>
                </NamedLayer>
                <NamedLayer name="Houses">
                        <NamedStyle name="Outline"/>
                </NamedLayer>
        </StyledLayerDescriptor>
        <!-- Embedded StyledLayerDescriptor ends here.-->
        <Width>400</Width>
        <Height>400</Height>
</GetMap>
```

3.2 Response

The generalisation engine responds in the standard way for a web map server, by delivering an image or url referencing the image on a web server cache. However for WebPark the service will be slightly different. The generalisation engine will act as a service for another web map server (from GEODAN). The GEODAN WMS will receive a request for a map from a client. It will then select the map layers it wants generalised (usually fore-ground layers), construct a POST request for these layers and send this to the generalisation engine. The engine will respond with SVG layers which will be integrated with any other (usually background) layers that it has prepared itself. Fig. 5 illustrates the round trip.

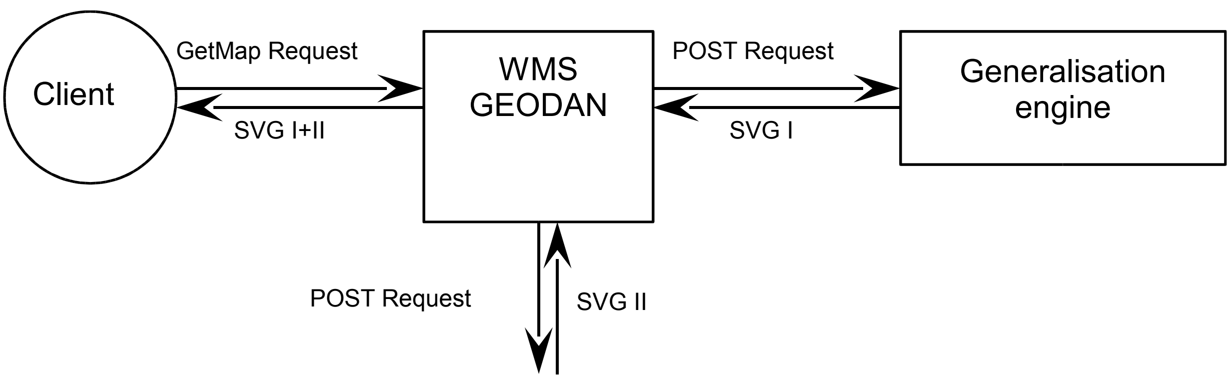


Fig. 5: The generalisation engine deployment

4 Example of use with generalisation

4.1 Generalisaton of point objects

In the context of the WebPark project, a Location Based Service for selection of suitable positions for observation of animals and plants was developed. The automatically generated maps were derived from observation data of the last year (2002). For the generalisation of point objects it is sensible to distinguish between constraints pertaining to absolute and relative position.

	absolute position	relative position
generalisation	• **selection / elimination**	• **selection / elimination** • **aggregation (combination and typification)**
examples	• **Points of interest** • **settlement as points** • **buildings in big scales**	• **animal observation data** • **signatures int thematic maps** • **buildings in small scales**

Tab. 1: Distinction between constraints pertaining to absolute and relative position

The information content of point objects from the second category consists, first of, all in their spatial distribution, reflected by different densities or appearing patterns. The aim of generalisation is to preserve these. Generalisation can be used here in a wider sense as a tool for data analysis. The important generalisation operator which will be applied is the typification. For the examples a hierarchical clustering method was used.

4.2 Clustering method

The hierarchical agglomerative clustering is a standard method in the area of information retrieval (Rijsbergen, 1979). Starting from a set where every cluster contains one element, they have to be unified, step by step, in pairs until a given number of clusters is reached, only one cluster is remaining or the distance between two clusters is bigger than a threshold.

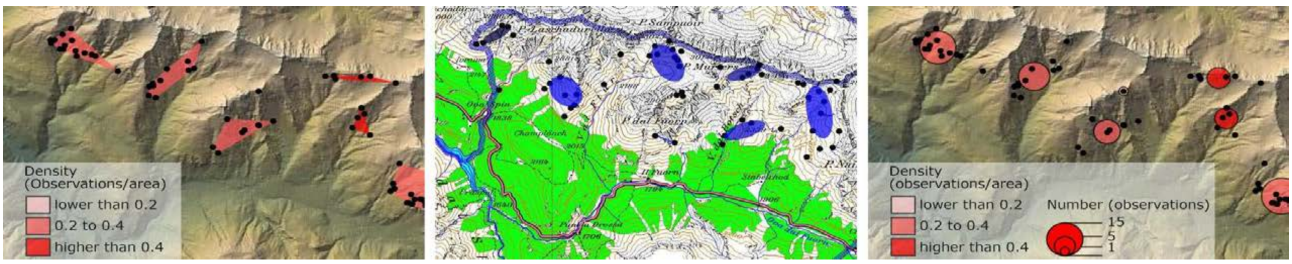
Fig. 6 a) gives the results of the hierarchical clustering method. Additionally, all animal observations are shown with black dots. The presentation in a) uses the convex hull of all observations belonging to the cluster. The disadvantage of this presentation is, that single points which are a bit far a way contributes over proportional to the size of the area. The density reflects the relation between the number of observations and size of the convex hull.

In Fig. 6 b) the presentation is done with help of standard deviation ellipses to give a quantitative impression of the spatial distribution of the observations. The major and minor axes of the ellipse provide a measure for maximal, respectively minimal, dispersion. For the presentation it is necessary to calculate the centre of gravity, the length of the major and minor axes, as well as the rotation angle. The standard deviation ellipse is less influenced by outliers than the convex hull.

Fig. 6 c) shows additionally the number of observations with help of circles. The radius of the circle is proportional to the number of observations belonging to the cluster. The density information is given through the graphic variable lightness.

4.3 Conclusion

The utilised hierarchical agglomerative clustering method is suitable for the automated point generalisation. Restrictions are given for the calculations with huge data volumes, because the calculation becomes quadratic with the number of observation, $O(N^2)$. The computing time with a standard PC (P4 processor, 1.6 GHz and 512 main memory) is 1s for 100 respective 52s for 500 point objects.



a. Convex hull for detected cluster *b. Ellipses with standard deviation* *c. Count proportional circles*

Fig. 6: Point generalisation with clustering methods

Further investigation is necessary for the automated determination of a suitable number of clusters. One possibility could be to look for the maximum of an evaluation graph (Salvador und Chan, 2003). The graph is calculated from the difference of the merge distances between the current and the last step in relation to the number of clusters.

Another task is related to an explicit consideration of background topographic information. This can either be considered with the distance measure for the clustering algorithm or by a presegmentation on the basis of background information. A practical extension would be the combination with a visibility analysis, whereby also the number of proceeded point objects can be reduced.

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Chorematic Focus Maps[1]

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Abstract

This contribution details the combination of two existing approaches on providing graphical route information in a cognitively adequate way: *Wayfinding choremes* and *focus maps*. The theory of wayfinding choremes originated from the leitmotif to reflect abstract mental concepts in map-like representations. It is therefore termed the *cognitive conceptual approach* to map design (Klippel, 2003) and stands in opposition to more frequently used *data driven approaches*. The second aspect of human cognition reflected in this paper is detailed in Zipf and Richter (2002). They introduced the concept of focus maps. A focus map is designed such that users' attention is drawn towards the region of interest. Different degrees of generalization and an effect of fading colors are used to funnel users' attention. The region of interest is displayed in full detail while the rest of the map is shown such that it is easily recognized as less important. The combination of these approaches reflects cognitive principles of information processing: the focus on pertinent information and the prototypical representation of functional relevant parts of a decision point.

1 Introduction

Every map reflects a conceptualizing activity put forth by a map maker or a group of map makers. The map maker, nowadays aided by all sorts of technical equipment or even 'himself' an artificial agent, has to make sense of the information available. Yet, the degree to which maps reflect mental conceptualizations varies. A topographic map or an automatically generated internet route map are not meant to reflect the imprecision of the world in our heads; rather they are meant to provide an exact depiction of the information that is available about the real world. In contrast, sketch maps are reflections of knowledge in our heads rather than precise depictions of the information about the environment. In between these classes of representations lies a whole spectrum of different kinds of maps, some more veridical, some more abstract. One important kind of maps are schematic maps, which are crafted as maps but intentionally distort spatial knowledge—just like sketch maps or like human knowledge is. The attractiveness of these maps—and the interest of cognitive science in them—is twofold: without any question schematic maps are perceptually easier to comprehend as they contain less visual clutter (e.g., Philips and Noyes, 1982) and focus more on a specific task at hand. Therefore, they are also referred to as task-specific maps (Freksa, 1999). Second, and more relevant for the article at hand, they are reflections of human mental concepts. This shows as we find similar knowledge representation characteristics in schematic maps and in naïve human spatial knowledge. A match between internal and external representations should therefore be easier with positive effects on the map reading process, especially by those map users not trained in the interaction with maps. There are detailed explanations why it is important to define appropriate schematizations and what the positive effects of schematic representations are (see, e.g., Clark, 1989; Tversky, 2003; Klippel, 2003).

Several approaches exist that aim at specifying representation theoretic aspects of schematic maps. We will briefly acknowledge two of them, one from cognitive psychology and one from artificial intelligence. The first is the toolkit approach by Tversky and Lee (1998, 1999). In their papers they analyzed sketch map drawings to elicit elements for a graphical toolkit for route directions as well as verbalizations for a corresponding verbal route direction toolkit. They propose a correspondence between these two toolkits and an underlying common conceptual structure from which both elements in the toolkits originate, i.e. verbal and graphical route directions are two different externalizations of the same mental concepts. The elements in their toolkits have the character of prototypes (see Figure 1).

The second approach we will briefly present, the one from artificial intelligence, is the aspectmap approach (Berendt et al., 1998): The basic idea of this approach is to construct maps to represent specific knowledge needed for a task at hand. This knowledge, the so called *aspects*, is extracted from existing data and is represented with a cognitively motivated level of abstraction. The aspectmap approach specifies different types of (spatial) knowledge: knowledge that needs to remain unchanged, knowledge that needs to be present but can be altered, and knowledge that can be omitted in the map. Accordingly, the aspects to be depicted are ranked in a depictional precedence (Barkowsky and Freksa, 1997) and, as a consequence, some aspects may get depicted such that they cannot be read off the map literally any more. To correctly use the map, the map reader's assumption about this depictional precedence, i.e. whether some information is depicted veridical or not, needs to match the actual precedence used. Otherwise, map reading may lead to overinterpretation, i.e. some aspect is taken for being represented veridical while it is not. Subway maps are a

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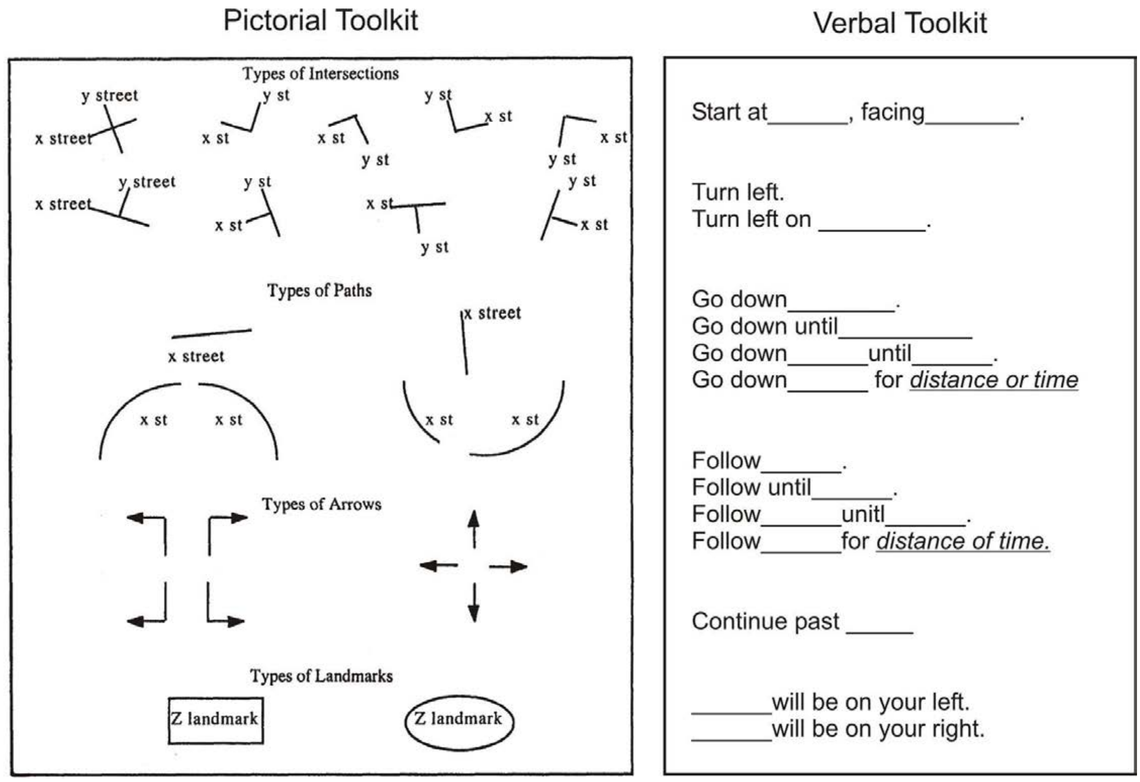

Fig. 1: Graphic and verbal direction toolkit by Tversky and Lee (1999, modified).

good example for this approach. While the direction and distance relations between stations along a line can be distorted, e.g., to fit in a qualitative eight sector direction model, and therefore cannot be read off the map literally, the ordering information between different subway lines needs to be preserved in order to keep the maps usable, and hence can be seen to be veridical.

2 The Wayfinding Choreme Approach

Wayfinding choremes are defined as mental conceptualizations of primitive functional wayfinding and route direction elements. Given their focus on functional aspects, i.e. the action that takes place in environmental structures, they reflect procedural knowledge, i.e. knowledge about how to interact with the world. In this sense wayfinding choremes are schemata and do not as such concern categorical knowledge about physical spatial objects (cf. e.g., Aristotle, trans. 1941; Neisser, 1976). Wayfinding choremes can be externalized, for example, graphically or verbally. The difference to the toolkit approach by Tversky and Lee (1998, 1999) and the aspectmap approach is that wayfinding choremes—especially graphical wayfinding choremes—focus on functional aspects (cf. Klippel, 2003). The approach integrates findings from cognitive psychology and artificial intelligence.

The wayfinding choreme theory got inspired by the idea of chorematic modeling, invented by the French Geographer R. Brunet (e.g., 1987). The term choreme is a composition of the root of the Greek word for space (*chor-*) and the suffix *–eme*; thereby, a relation to language is intended. Wayfinding choremes focus on wayfinding and route directions. Most pertinent for following a route is direction information at decision points on which the research efforts are therefore placed. In Klippel (2003) the empirical basis for wayfinding choremes, i.e. the mental conceptualization of functional primitives of route direction elements, is detailed. One major achievement is a clearer distinction between structural and functional elements of route information and how this distinction contributes to a better understanding of conceptualization processes. Most approaches concerned with the visualization of route information focus on structural aspects, i.e. they are concerned with the conceptualization or depiction of objects. In contrast, the wayfinding choreme theory aims at a functional characterization of route information, i.e. it focuses on actions that demarcate only parts of a physical spatial structure. The distinction is reflected in the following definitions and in Figure 2:

> **Structure –** denotes the layout of elements physically present in the spatial environment that are relevant for route directions and wayfinding. This comprises, for example, the number of branches at an intersection and the angles between those branches.
> **Function –** denotes the conceptualization of actions that take place in spatial environments. The functional conceptualizations demarcate parts of the environment, i.e. those parts of the structure necessary for the specification of the action to be performed.

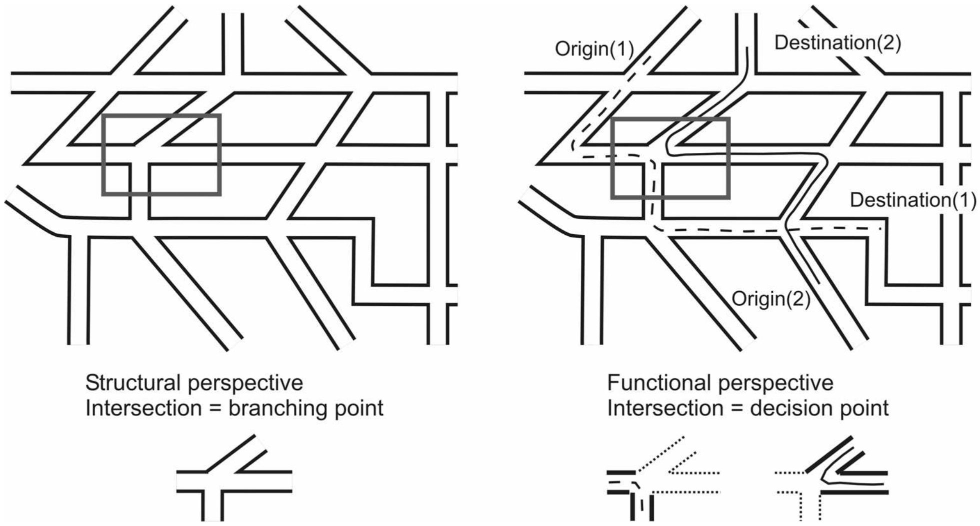

Fig. 2: Distinguishing between structural and functional aspects of route information.

An important goal of the wayfinding choreme theory is the combination of prototypical functional and veridical information. The action that is required at a decision point is communicated by a prototypical graphical instantiation. This prototypical action representation is then embedded in a veridical spatial situation.

These theoretical remarks will be explained in the following according to their graphical implications. Figure 3 shows the results for prototypical turning directions at decision points explicated in Klippel (2003). Participants adhere to the prototypicality of the turning actions, i.e. the functional aspects of decision points. It is important to note that they do not adhere to the prototypicality of the structure of the intersections. A seven direction model for turning actions has been confirmed by these experiments and is taken as a basis for the graphical representation of turning actions at decision points. The seven resulting wayfinding choremes are employed to schematically depict route information.

Given the set of wayfinding choremes for the functional parts of decision points, we will now turn to the remaining information at a decision point. The considerations of a wayfinding chorematic depiction are twofold: First, the action that has to be performed at a decision point has to be communicated clearly. This is done by graphic wayfinding choremes. Second, over-schematization can lead to wrong inferences. Therefore, an alternative strategy is chosen: a combination of veridical information, for recognition and pattern matching, and prototypical information, for the communication of the required action. Figure 4 explicates an example of a decision point. At this decision point the functional relevant parts are replaced by a wayfinding choreme (see Figure 3), whereas the remaining branches are kept veridical, i.e. their angular information is left unchanged.

Different to existing solutions and navigation systems, a wayfinding choreme based navigation assistance system focuses on the functional information for which prototypical graphical concepts can be determined. The conceptualization of an action that takes place at a decision point demarcates branches that are emphasized; branches that are not functionally involved are deemphasized, however, kept veridical to ensure that the corresponding intersection can be easily identified.

3 Focus maps

Focus maps as presented in Zipf and Richter (2002) are designed such that a user's attention is drawn towards the map part of interest. Clearly, this map part, the region of interest, depends on the task at hand; in case of wayfinding it is the area along the route to be taken. By focusing on this region, the user's mental processing of the map information is guided to the area of relevant information. The remaining parts of the depicted environment are shown in the map but are recognizable as irrelevant. They can still be used, for example, to orient oneself with respect to an area well known but not in focus. Hence, with focus maps a user's interpretation process gets inadvertently focused on the region of interest, which eases the map reading process as the amount of information to be processed is reduced.

The focusing effect is achieved by employing two techniques: a generalization to different degrees and fading colors. Map features in the region of interest are displayed veridical; generalization of these features is kept to a minimum. With increasing distance to this region, map features' degree of generalization increases, i.e. map features that are far off from the region of interest are simplified to a high degree. This is the first step in order to create a funnel towards the region of interest. The second step lies in the use of colors. Since in map making color is often used to denote a feature's class membership, it is not feasible to use totally different colors inside and outside the region of interest. But it is possible to use different shades of the same color category; bright and shiny colors for features inside the region of interest, dimmed and grayish ones for features outside of it. Again, with increasing distance the colors increasingly fade out. The combination of these two effects, increasing degree of generalization and fading out of colors, results in a kind of funnel that focuses a user's attention on the map part of interest.

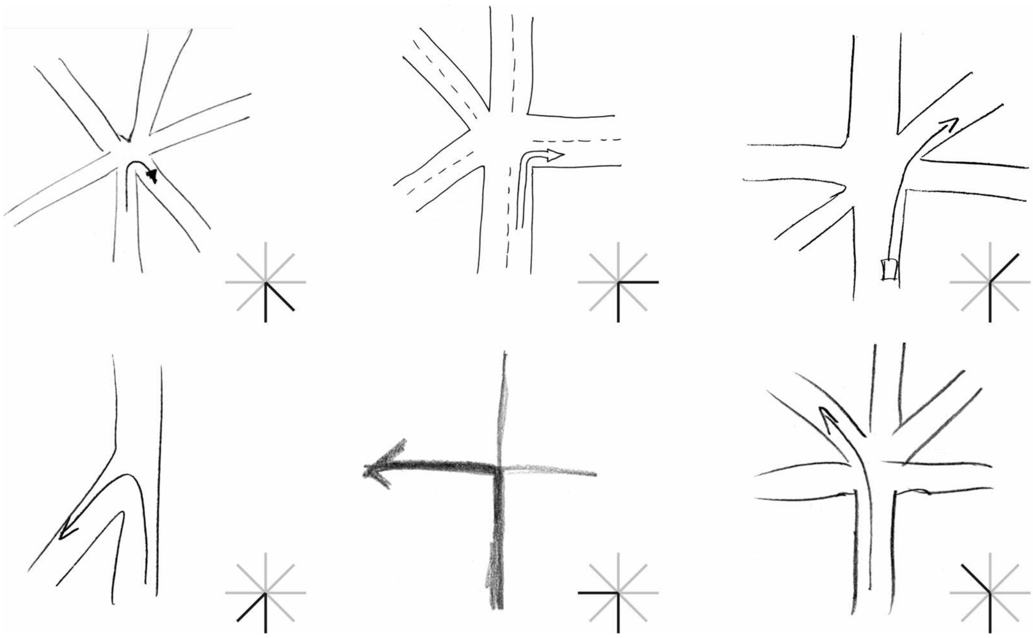

Fig. 3: The behavioral basis of wayfinding choremes (Klippel, 2003).

Figure 5 shows two focus maps of the city area of Heidelberg, Germany (Zipf and Richter, 2002). These maps display a static situation, i.e. they do not show a route. They are divided into several concentric areas; decreasing focus is not implemented as a continuous effect. The innermost area is in focus, this is the region of interest. In these examples it is in the center of the map. Outgoing from there, with each new area the amount of detail decreases and the colors used get dimmer and lighter: the depicted buildings at the edge of the map are almost white with a simplified geometry while the inner ones have a clearly darker color and much more detail.

4 Chorematic focus maps

The two presented approaches to map design can be combined, resulting in *chorematic focus maps*. From a representation theoretic point of view these maps are well suited as wayfinding assistance. Their design process comprises four steps: first, calculating the route to be taken, i.e. a connection between origin and destination. This determines the area that needs to be depicted on the map. Second, selecting aspects relevant for the task given. These aspects are used to construct a focus map in the third step. In a last step, functional relevant parts of the selected route, i.e. the branches of a decision point that will be used by a wayfinder, are replaced by the corresponding graphical wayfinding choreme (see Figure 3 and Figure 4).

Wayfinding choremes and focus maps complement each other ideally. Both approaches draw their motivation from cognitive principles of information processing. And even though one approach, wayfinding choremes, is cognitive-conceptual and highlights the relevant information by employing conceptual prototypes and the other, focus maps, is data driven and keeps the relevant

Fig. 4: Combining prototypical information (wayfinding choremes) and veridical information at decision points.

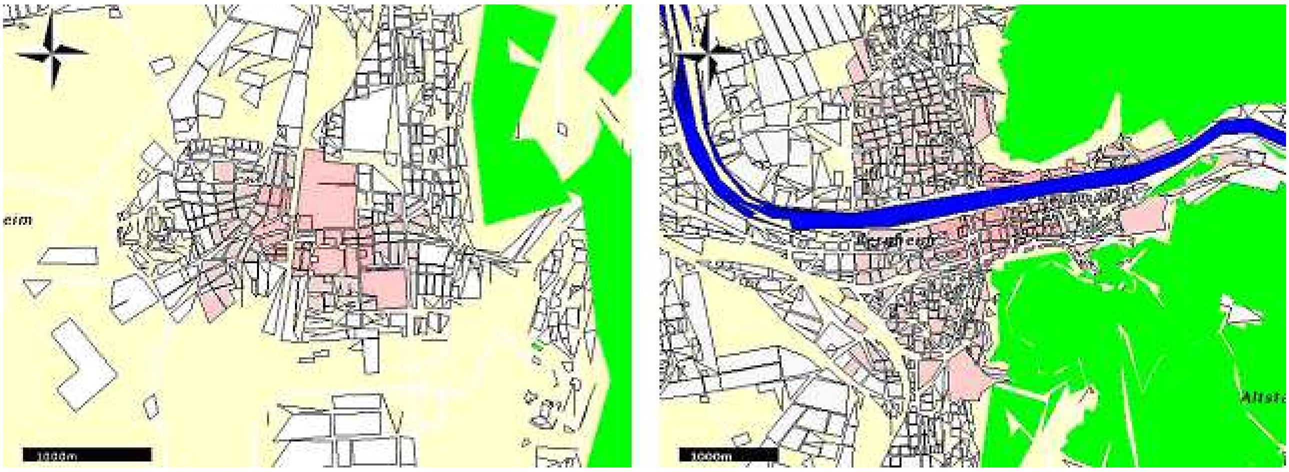

Fig. 5: Examples of focus maps (from Zipf and Richter, 2002).

information veridical but deemphasizes other information, their combination eases information processing significantly: On the one hand, with focus maps a user's attention is drawn towards the map's region of interest. This focuses the mental process, map reading, on the location of the relevant information, its *where part* so to speak. Graphical wayfinding choremes on the other hand emphasize the functional relevant parts of decision points. Additionally, further information remains veridical. By this procedure, the route and the corresponding actions to take stick out in the map and are easy to process. Wayfinding choremes emphasize the, so to speak, *what part* of the information. In combination, we have designed a map that allows a user to concentrate *on* the relevant information *in* the relevant part of the map; thus, the cognitive effort to process the information is drastically reduced, and map reading should become easier.

5 Future Research Directions

In its basic variant, focus maps display the region of interest in total, i.e. the complete route—or at least a significant part of it—is presented at once to the user who then needs to cope with all of it. In an electronic navigation system the approach can be extended to just presenting the next decision due, i.e. the next decision point to further ease chorematic focus maps' usage. In this case the region of interest is around a single decision point, which is shown in full detail with the functional relevant parts substituted by a wayfinding choreme. Thus, the focus shifts after each decision point from the decision point just passed to the next and the user's attention is drawn on the decision to come which further emphasizes a concentration on the presently relevant information.

As discussed, however, by several authors (e.g., Denis, 1997; Klippel, Tappe, and Habel, 2003), several decisions are often grouped into a single concept, for example 'turn left at the third intersection'. This new concept involves at three subsequent decision points two straight movements followed by a left turn. These *higher order route direction elements* (HORDE) (Klippel, 2003) reflect an omnipresent characteristic in spatial cognition, i.e. the grouping of basic elements into chunks (e.g., Miller, 1956; Allen and Kirasic, 1985). Wayfinding choremes allow for a straightforward specification of HORDE on a conceptual level by employing a grammatical notation, the *wayfinding choremes route grammar* (WCRG). Yet, graphically, HORDE need special treatment: either several decision points need to be focused on at once, or a decision point further ahead, one that, for example, requires the turn, needs to be in focus. A detailed examination of HORDE and possibilities to adequately depict them are ongoing research.

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Augmented Videos and Panoramas for Pedestrian Navigation

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Abstract

In order to support pedestrians in the tasks of orientation and wayfinding with mobile devices appropriate visualizations of their location, its surrounding, and background information are needed. In this paper we present two complementary concepts for the combination of realistic views and location specific information that can be implemented with current generation PDAs and next generation cellular phones. The first employs video clips that were taken along every path in a city which are augmented by location information. It is shown how multimedia clips consisting of videos and textual information can be stored and transferred using the SMIL standard from the W3C consortium. The second approach supports navigation by the overlay of virtual signposts in panoramic images taken for every decision point, i.e. street junctions, in a city. We argue that the location- and orientation-synchronized presentation of (previously recorded) realistic views in combination with location specific information is an intuitive complement to map based visualization on the one hand and less invasive and resource demanding than augmented reality systems with head mounted displays on the other hand.

1 Introduction

Where am I? What can I see and do here? What is important to know about the place? Where do I have to go to reach my target? These are the most important questions that pedestrian navigation systems (PNS) should help to answer for mobile users (cf. Malaka & Zipf 2000). Although verbal output from PNS can support a user in navigation, the visual presentation of the current location, its surrounding, and location specific information is most important for orientation and wayfinding. Generally, the displayed information in PNS are composed of: 1) the visual image or abstraction of the scene and its surrounding, 2) information about the place, and 3) route / navigation information, where 2) and 3) typically augment 1). Depending on the concrete realisation of 1)-3) the difficulties for a user to match the displayed

- scene with reality (finding his position and heading),
- location specific information with the objects depicted in the scene, and
- navigation information with the streets depicted in the scene

differ a lot. For instance, maps are abstractions of the real world and are well suited to give an overview of an area and for estimation of distances and areas. Nevertheless some cognitive effort is needed to determine the own orientation from looking at maps. When using augmented reality (AR) instead, matching the scene with reality is immediate, but it may be difficult to put location specific information at the right place due to positioning and orientation errors (Azuma 1997).

Thus, there are several design criteria and trade-offs for pedestrian navigation systems that visually support orientation and wayfinding (cf. Höllerer et al. 2001, Baus et al. 2002, Gartner 2003). We believe that the following aspects are crucial wrt. the effectiveness of orientation aid, user acceptance and feasibility regarding system requirements and data availability:

- Scene visualization should be 3d and as realistic as possible to provide enough visual cues and landmark information for quick recognition (cf. Kolbe 2002).
- The visualization of the scene should be synchronized with the user's current position and heading in order to facilitate immediate matching of the displayed image with the real view perceived by the user.
- Navigation and location specific information should be displayed in terms of augmentations to the displayed scene background. However, the placement of location specific information has to take into account the available precision of the position information and spatial data (see Höllerer et al. 2001, Gartner & Uhlirz 2001, Baus et al. 2002).
- Visualization should be tailored to the small displays of mobile information devices (MID) (cf. Gartner & Uhlirz 2001, Gartner 2003). For acceptance reasons an invasive (wrt. to unobstructed vision) display apparatus like head mounted displays (HMD) should be avoided.
- The system should need as few explicit world knowledge in terms of 2d and 3d spatial data as possible (e.g. no complete 3d city model). It should be examined to what extent spatial data from existing 2d navigation systems can be exploited.
- Since the system should work with current generation Personal Digital Assistants (PDAs) and next generation cellular phones (3G), the low computational power of these MIDs has to be considered (cf. Pospischil et al. 2002).

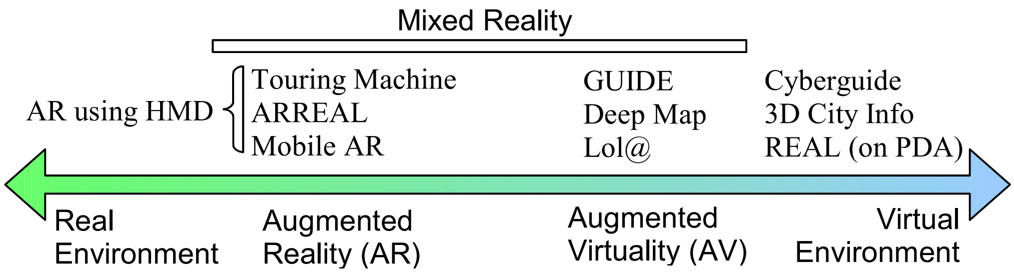

Fig. 1: Classification of PNS wrt. to the virtuality continuum (adapted from Milgram & Kishino 1994).

With these issues in mind we have developed two complementary visualization approaches for pedestrian navigation. The first concentrates on the visualization of the paths along streets and crossing places in cities, for which video clips are recorded in both walking directions and augmented by location specific information. The second focuses on street junctions and integrates panoramic images with navigation information for each junction of a city.

The rest of the paper is organised as follows: In section 2 we discuss related work. Section 3 describes our approach for augmented videos, including screenshots from a protoype implementation. In section 4 the concept for augmented panoramic images is explained and screenhots from another prototype are given. Finally, section 5 presents the conclusions and directions for future work.

2 Related Work

When reviewing literature on PNS it can be observed that most of todays concepts were developed in either of two research contexts; namely location based services (LBS) and outdoor augmented reality systems. This is reflected (at least) by their different visualization approaches, especially in the way how information about the current location and the surrounding is presented to users. Some prominent systems, that were developed in the LBS context, are Cyberguide (Abowd et al. 1997), GUIDE (Cheverst et al. 2000), Deep Map (Malaka & Zipf 2000), and Lol@ (Pospischil et al. 2002). In these systems the presentation of the user's location and its surrounding is mainly based on maps, which are displayed on the screen of a mobile information device. Further multimedia information like texts and photos about landmarks and points-of-interest are linked with signatures in the map. In outdoor AR systems like Touring Machine (Feiner et al. 1997), ARREAL (Baus et al. 2002), and Studierstube Mobile AR (Reitmayer & Schmalstieg 2003) users perceive the current location through head mounted displays (HMD) instead. Multimedia information about objects in the respective viewing area are presented as an overlay to the view of the real world.

Although both approaches differ substantially they have in common that they mix reality and virtuality to support orientation and wayfinding: the LBS approach by adding photos and movies of real objects to virtual presentations of reality (maps) and the AR approach by adding virtual objects and multimedia information to real scene views. In order to classify mixed reality applications we follow the line of (Milgram & Kishino 1994), who proposed to arrange the different approaches along the so-called *virtuality continuum*. Figure 1 reveals the big gap between the LBS approach (augmented virtuality) and AR systems (augmented reality), which we want to bridge using augmented videos and panoramas as explained in the next two sections.

Further relevant work concerns visual realism, i.e. the generation and usage of realistic views in virtual reality applications. Other PNS like 3D City Info (Rakkolainen & Vainio 2001) and IRREAL (on PDAs; Baus et al. 2002) use completely virtual presentations, i.e. 3d models to generate realistic views. However, complex and textured 3d city models are needed to reach a sufficient degree of visual realism for wayfinding (cf. Ruddle et al. 1998). An alternative approach is called *image based rendering* (IBR), where realistic views are synthesized from previously recorded photos and movies. Panoramic 360° images are one of the first and most prominent applications of IBR (Chen 1995). In recent years IBR techniques have extensively been applied for creating so-called *virtual walkthrough environments*, where users can move in realtime through a virtual space that is mainly synthesized from images and movies in a database (Lippman 1980, Chen 1995, Tanikawa et al. 1999, Kimber et al. 2001, Kolbe 2002). However, virtual walkthrough environments have not been applied in the context of mobile navigation assistance so far.

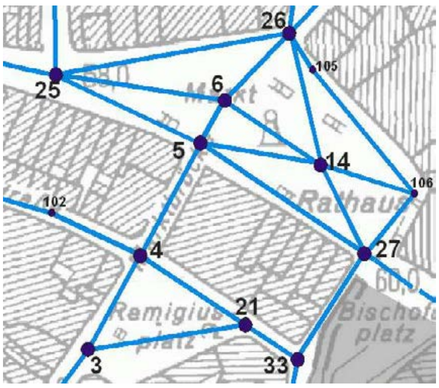

Fig. 2: Graph representation of places and streets in a pedestrian zone.

3 PNS using augmented videos

As stated above and is discussed in more detail in (Kolbe 2002), we want to provide visual support for orientation and wayfinding by combining realistic views with location specific information. Whereas outdoor AR systems already realize this concept, they have major drawbacks concerning the needed precision for position resp. orientation determination and hardware requirements. The usage of HMDs is

```
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            fit=″fill″ z-index=″1″/>
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    <region id=″houseno_left″ top=″242″ left=″0″ height=″18″ width=″25″/>
    <region id=″houseno_right″ top=″242″ left=″295″ height=″18″ width=″25″/>
    <region id=″label1″ top=″90″ left=″110″ height=″15″ width=″105″ z-index=″2″/>
  </head>
  <body>
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                  dur=″7.0s″ fill=″freeze″/>
      <textstream src=″019-020_links.rt″ dur=″7.0s″
                  region=″houseno_left″/>
      <textstream src=″019-020_rechts.rt″ dur=″7.0s″
                  region=″houseno_right″/>
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                 to=″215″ dur=″7.0s″ fill=″freeze″/>
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                 to=″40″ dur=″7.0s″ fill=″freeze″/>
      </textstream>
    </par>
  </body>
</smil>
```

see figure 4

Moving text label

Multimedia content for one video path

Fig. 3: Example for the definition of a multimedia clip for one directed walking path using SMIL 2.0. The head section defines the screen layout for the different media elements. Please note, that "label1" lies in the same area as "video", but is shown on top due to a higher z-index. The body element references and synchronizes five media elements: the walkthrough video clip, the street name, the current house numbers on both sides, and a text label.

very sensitive to orientation and position errors. Typically, small deviations already lead to inconsistent visualizations where the real view and its augmentations do not match, which quickly confuse the user.

To overcome this problem, we suggest to use previously recorded video clips of the paths in pedestrian areas. A walkthrough computer video can be considered a visual memory of the area along the route, because it is not restricted to linear replaying with constant frame rate in one time direction. Every video frame can be addressed and therefore be georeferenced individually. In contrast to holography, which memorizes the appearance of an object at a fixed position from all perspectives, walkthrough videos memorize the appearance of geographic locations in fixed perspective but arbitrary position along a trajectory. Since the videos are recorded before the system will be used, the georeferencing and synchronization of video and augmentations can be prepared off-line in advance (*Video AR:* cf. Azuma 1997, Gibson et al. 2002).

In order to obtain a complete visual representation of an area, each path is recorded on video in both walking directions. The paths are defined by the model of the respective area. Like in other PNS we model pedestrian zones by attributed graphs. Although pedestrians can walk freely over open ground, in most cases people move straight on prepared paths in the direction of their next target. Typically, a change of direction only takes place when following curved streets and at junctions. Therefore, junctions and intermediate points in a curve are represented by graph nodes and streets by graph edges. Places are modeled by 1) a ring of edges which connect all neighboured entrance points of the place and 2) edges from each entrance point to the others across the place. For big places further nodes and connecting edges are added within the surrounding polygon (see figure 2). Graph nodes are georeferenced and named. Edges are attributed by the street resp. place names and the house numbers with their positions on both sides. Furthermore, the location, the name, and the type of all points-of-interest are known. Further details on modeling (also of non-pedestrian zones) and route planning issues for PNS are given in (Kolbe 2002).

For the operation of the PNS a position sensor like (D)GPS and an orientation sensor like a magnetic compass, a gyroscope or a combination of both is needed in the MID (cf. Retscher & Skolaut 2003, Höllerer et al. 2001, Baus et al. 2002). While walking in the modeled area, the nearest point on the next graph edge to the user is continuously determined. Depending on the user's heading the video for either walking direction is selected. The frame of the video that is related to the current position then is presented to the user together with the augmentations. In contrast to AR using HMDs the scene views and their augmentations are always synchronized. Position errors only lead to differences between the real and the displayed scene view. If this error is small enough (less than 3m), it will be still easy for users to match the displayed view with their real view. However, this hypothesis has to be evaluated in future work.

The visual quality of the integration of location specific information with the background depends on the achievable precision of position resp. orientation information on the one hand and the quality of explicit world knowledge in terms of 3d models and coordinates of the objects depicted in the videos on the other hand. Thus, we distinguish two levels of possible augmentations to walkthrough videos which have increasing demands on precision: 1) Augmentation by annotations next to, i.e. above, below, or on either side of the movie clip. 2) Overlay of information within the movie area. For simplicity reasons we make the assumption in our current prototype, that the videos were filmed exactly along the graph edges and with constant velocity.

For the implementation one problem still had to be solved: how can videos and augmentations be integrated in advance and transferred to resp. stored in mobile devices? Above, the system should be usable on MIDs with low computational power. The solution lies in the application of the *Synchronized Media Integration Language SMIL* of the W3C consortium, a XML application which allows to integrate and relate different media with respect to a general presentation timeline (SMIL 2001, Kennedy & Slowinski 2001). SMIL browsers are available for PCs, PDAs, and cellular phones (see Real 2002). In the following we describe the structure of the SMIL representation of walkthrough videos that are augmented by location specific information (see figure 3).

The head section specifies the screen layout for the multimedia clip. It consists of four non-overlapping regions for the video, the street name, and the house numbers to the left and to the right (cf. figure 4). A fifth region lies in the same screen region as the video, but will be shown on top of the video due to its higher *z-index*. This region is intended to display a text label.

The body section defines within the <par> block a group of five media elements, that will be presented simultaneously with synchronized timing. The group consists of the video of the path from a start to an end node of the route graph, the textstream with the street name, the textstream with the house numbers for both sides, and a textstream with a label for points-of-interests. Textstreams are an extension of the RealOnePlayer to the SMIL standard, that allow to show resp. hide text portions at arbitrary positions and times (see Real 2002).

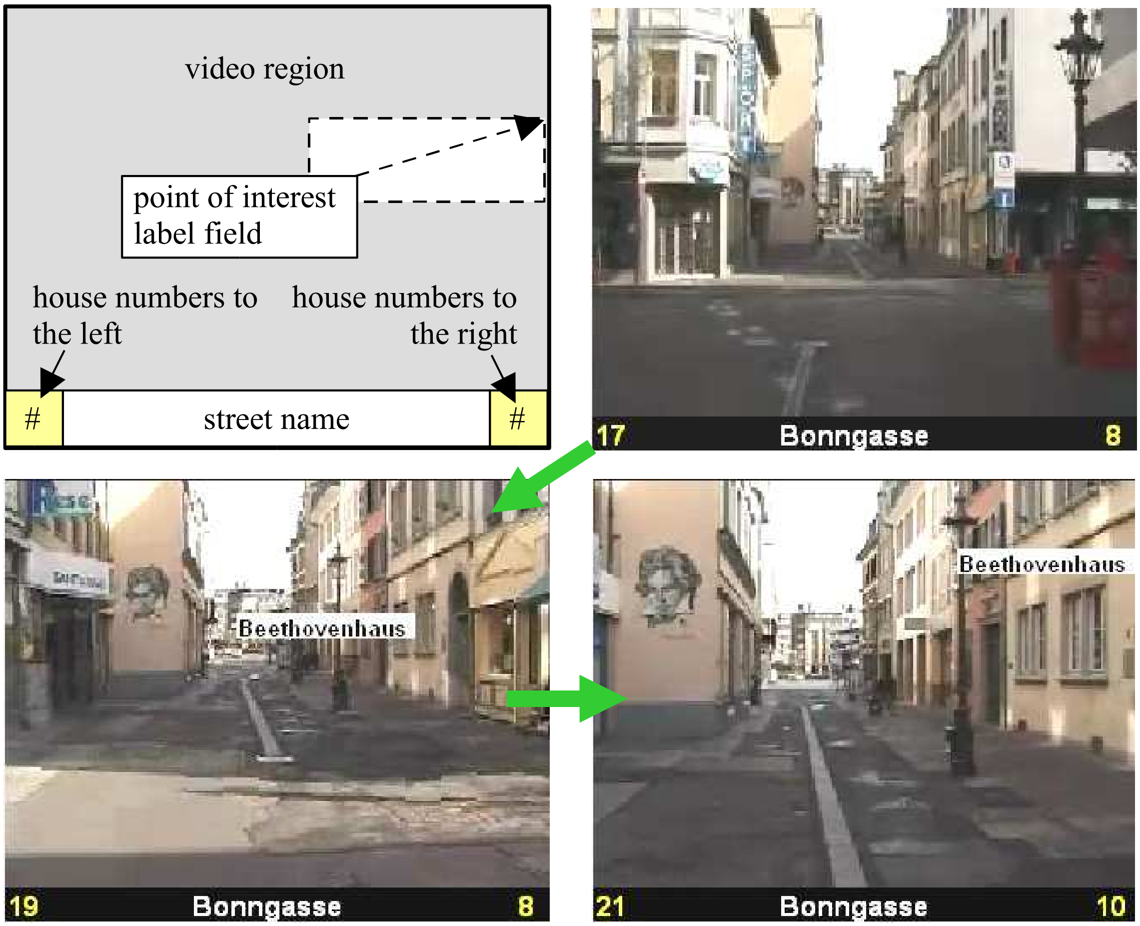

Fig. 4: Screen layout for and screenshots from the prototype for augmented video visualization using RealOnePlayer (Real 2002). The screenshots were taken at three points along the path to the "Beethovenhouse" in Bonn. Please note, that at a certain distance a label becomes visible which then moves within the video region.

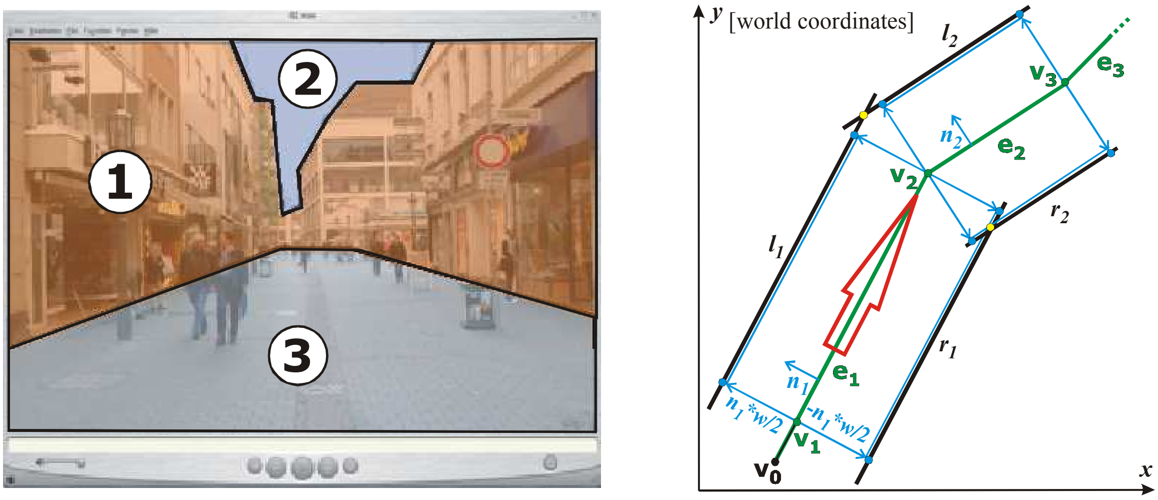

Fig. 5: Left: Principle components of a typical city scene view are 1) building areas, 2) sky, and 3) street areas. In order to minimize occlusions the location specific information like place names and waysigns are placed in the street area only. Right: Construction of the street polygons and generation of virtual waysigns in 3d object space by creation of left and right border lines from route graph edges e_1, e_2, e_3 and street width w.

The position of the label field is animated by two <animate> tags. It starts at *left,top=(110,90)* (as initialised in the head section) and moves during the clip's 7 seconds duration with constant velocity and linear interpolation to position *(215,40)*. By this mechanism label texts can be visually attached to objects depicted in the video like buildings and monuments: if the object comes nearer and moves to another screen position, the label moves accordingly. In general, we can derive from camera projection equations that linear interpolation is not sufficient, because the movement of depicted objects speeds up as the camera approaches them. SMIL2.0 offers spline animation and time manipulations (cf. SMIL 2001, Kennedy & Slowinski 2001) that would allow to reflect the acceleration of objects. However, since RealOnePlayer does not support these features (yet), we have not implemented it in the current version of the prototype.

If the route graph is attributed with house numbers and street names, the SMIL file and its referenced textstream files can be generated automatically for every graph edge in both walking directions. The duration of the <par> block is determined by the length of the corresponding path video. If labels should be placed and fitted automatically within the video area, the videos have to be georeferenced, i.e. extrinsic and intrinsic camera parameters have to be determined for each video frame. Above, 3d position information for the objects to be labeled have to be known. We are currently working on this issue and already got some promising results from experiments with automatic camera trackers (so-called *match movers*) like ICARUS (Gibson et al. 2002). In our prototype system all files for the modeled portion of Bonn city have been created manually.

Figure 4 shows screenshots from a virtual walkthrough with the prototype in the city center of Bonn. In the street "Bonngasse" the user approaches the Beethoven house, in which the famous composer was born and had lived for 22 years.

4 PNS using augmented panoramas

Our second concept for a PNS employs georeferenced panoramic images which are augmented by virtual signposts. Panoramic images memorize the visual appearance of the surrounding for a fixed location in all viewing directions (cf. Chen 1995). This makes them especially suited to support users when they are looking around at some point to find the way to their target. The idea is based on the observation that wayfinding support is especially needed at decision points, i.e. street junctions and places, where one of the

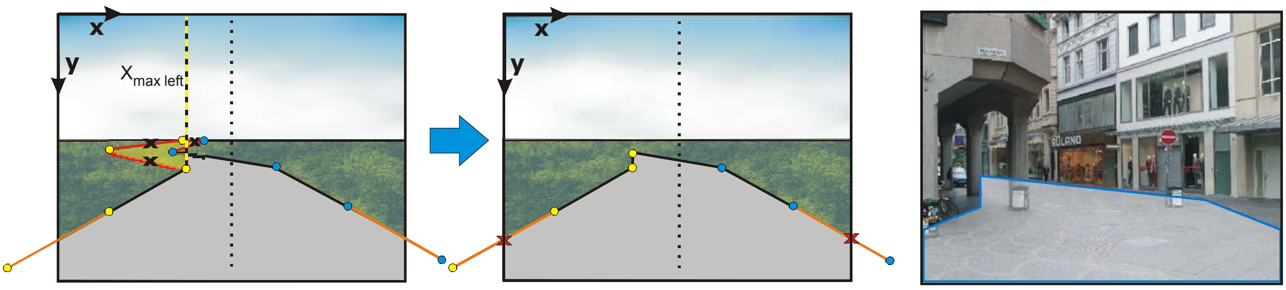

Fig. 6: Computation of the free labeling area by projection and truncation of street polygons. The left border of the street is truncated at the point where the projected x value begins to decrease. It is assumed that a building wall will occlude the rest of the path after the curve. Thus, the polygon is closed by a vertical line.

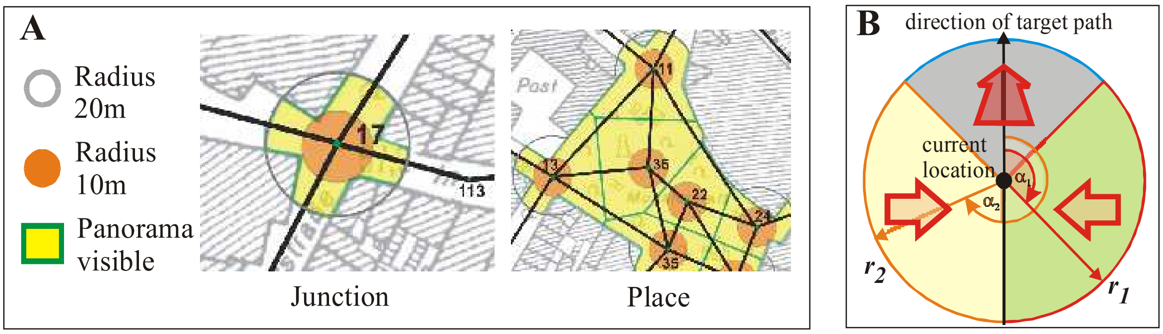

Fig. 7: A) Visibility areas for panoramas: If a user enters the 20m zone, the panorama will be displayed on the mobile device with a fixed direction to the target. Within the red zone (10m) the displayed portion of the panorama is synchronized with the users current viewing direction. B) Rotation dependent generation of signposts. When looking in target direction: 3d arrow; in other directions: simple 2d turn left resp. right signs.

different possible directions has to be chosen. Thus, for every junction of the route graph a 360° cylindrical panoramic image is captured, and the direction to north and the camera parameters are determined. Details on the generation of the panoramic images using a standard digital camera are given in (Middel 2003).

During system operation the user specifies his target (another graph node). Then the PNS continuously calculates the shortest path to the target. Like in the previous approach the MID needs to be equipped with a position and an orientation sensor. Everytime, the user

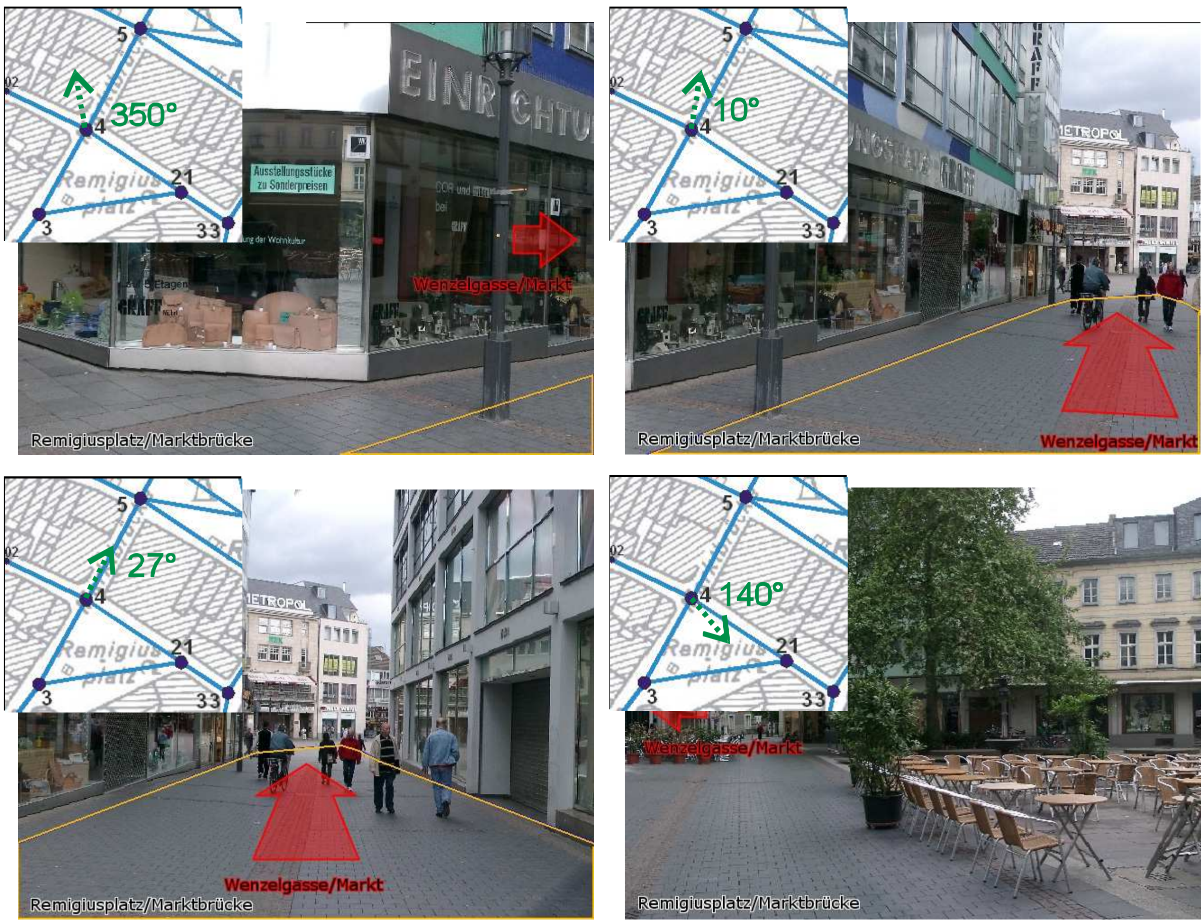

Fig. 8: Visualization of virtual signposts in different viewing directions at the same location.

is in the vicinity of a graph node, the corresponding panorama will be shown (cf. fig. 7A). The displayed portion of the panorama is always synchronized with the current heading of the user.
The following steps are processed for every change of the user's view. In order to augment panoramic views by virtual signposts, the first problem that has to be solved is the determination of areas in the projected views, in which signposts can be visualized without the occlusion of salient objects or other visual cues. This task is complicated by the lack of explicit knowledge about the world in terms of a 3d city model. In our system we assume that no 3d model is available and the edges of the route graph (cf. fig. 2) only have an additional attribute *street width*.

However, when looking at city views, one can distinguish three principal visual components: 1) building areas, 2) sky, and 3) street areas. Figure 5 shows on the left the partitioning of a city view into the three areas. Since most landmarks are found in area 1), the sky silhouette of area 2) is needed to support orientation, and the street information is the only available explicit world knowledge, we only use the street area. In order to determine the street area for the current view, the street borders for the shortest path are derived from the center line and street widths in 3d object space (see right side of fig. 5). Currently, we have not applied a digital terrain model (DTM) yet. Therefore, all heights are set to 0 in the prototype.

After the creation of the street borders, they are projected into the current panoramic view in order to compute the (2d) polygon that surrounds the visible street area in the image. In inner city areas the streets are typically bounded by buildings. Thus, the visibility of a street course ends at a curve and the projected street can be truncated accordingly. Figure 6 shows an example for the computation of the street area polygon where the street is truncated at the first left turn. Generally, several special cases for the truncation and closing of the street area polygon have to be differentiated. They are discussed in detail in (Middel 2003) and (Kolbe et al. 2004).

The placement of virtual signposts is done in two steps: At first, a marker is generated in (3d) object space several meters ahead of the current viewpoint on the centerline of the graph edge, which lies on the shortest path to the target (see right side of fig. 5). In the second step the marker is projected into the current view. If it lies completely within the free labeling area, i.e. the previously computed street polygon area, it will be displayed as an overlay to the current panoramic projection. This is normally the case, when the user is looking in the direction of the shortest path to the target. If the user looks in another direction, the projected marker typically does not fit into the free area or does not lie in the polygon at all. In this case, an arrow is shown on the left resp. right side of the image, telling the user to turn in the corresponding direction to find the correct heading to the target (see figure 7B).

Figure 8 shows screenshots from the prototype that were made during a virtual look-around at a junction in the city center of Bonn. Since in the first and the last image the projected marker does not fit into the labeling area (orange polygon), turn right resp. left signs are displayed instead.

5 Conclusions and future work

Augmented videos and panoramas provide intuitive support for wayfinding and orientation and complement traditional maps in pedestrian navigation systems. They are presented on the display of a mobile device which in contrast to a head mounted display is not invasive wrt. to the user's field of vision. The concepts put only small demands on the needed resources concerning position/orientation accuracy, explicit world knowledge, and computational power and thus can be implemented and used with current generation PDAs and third generation (3G) cellular phones. Furthermore, data acquisition is relatively cheap, because videos and panoramas can be recorded resp. generated using standard off-the-shelf hardware and software. In the MIT city scanning project a system for automated acquisition of georeferenced, panoramic images is already described (Teller et al. 2001). Whereas SMIL seems to be an appropriate framework for building multimedia clips for walkthrough videos, it has to be examined in the future how panoramic images could be handled resp. how both concepts can be integrated in general.

One drawback is that videos only memorize the world's appearance at the time of recording. Thus, changes in the recorded area will not be reflected and could lead to some confusion when the user tries to match video and reality. A related problem is day and night view. However, this can be overcome when videos and panoramas are recorded both for daytime and nighttime.

Cartographic challenges in future work concern the non-overlapping placement of simultaneously shown labels and signposts in object and image space (cf. Azuma & Furmanski 2003).

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Collaborative Augmented Reality for Outdoor Navigation and Information Browsing

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Abstract

Augmented reality (AR) can provide an excellent user interface for visualization in a mobile computing application. The user's view is augmented with location based information at the correct spatial location, thus providing an intuitive way of presenting such information. In this work we demonstrate the use of AR for collaborative navigation and information browsing tasks in an urban environment. A navigation function allows one or more users to roam through a city and guides them to selected destinations. Information browsing presents users with information about objects in their surrounding. Both functions feature support for collaboration. The developed system does not only concentrate on the user interface aspects but also provides a scalable infrastructure to support mobile applications. To this end we developed a 3-tier architecture to manage a common data model for a set of applications. It is inspired by current Internet application frameworks and consists of a central storage layer using a common data model, a transformation layer responsible for filtering and adapting the data to the requirements of a particular applications on request, and finally of the applications itself.

1 Introduction

Many researchers believe that augmented reality (AR) is an excellent user interface for mobile computing applications, because it allows intuitive information browsing of location referenced information. In AR the user's perception of the real world is enhanced by computer generated entities such as 3D objects and spatialized audio. The interaction with these entities happens in real-time to provide convincing feedback to the user and give the impression of natural interaction. Augmented reality as a user interface becomes particularly powerful when the computer has access to location based information so that it can merge the virtual entities with real world objects in a believable manner.

Two common applications for mobile computing and location based services are navigation and information browsing based on location. The work described in this paper demonstrates the potential of using augmented reality as a user interface for such tasks. A tourist guide scenario motivated the specification of the requirements of the prototype (see section). Our work integrates a number of advanced user interface features demonstrated in earlier research systems into a single coherent application. Moreover, it also supports collaborative work for human communication among several mobile users.

Such applications require a detailed model of the user's environment. The model needs to include geometric representation of the environment and also semantic and contextual elements. Compared to conventional location based systems, AR not only requires integration of a wider variety of data sources to build interesting applications, it also creates new types of content. Geometric models of real objects are not only used for visualization purposes, but for computing occlusions, rendering of shadows, interaction, and vision-based tracking of real objects.

The complexities of AR content resulted in limited demonstrators that only worked within a well defined environment. In order to scale the working environment to be comparable to a real environment as experienced by tourists, we also had to address the complex modeling and data handling needs of ubiquitous augmented reality applications. Consequently, we present the concept of a three-tier application architecture based on XML as the enabling technology (see section). A central XML-based database stores a common model used for all applications. Using common XML tools, data is transformed and imported from

Fig. 1: A user is roaming a historical location in the City of Vienna

different sources. Once in the database, the data can be maintained more easily and application or domain specific preprocessing operations can be applied. Then the data is transformed to a form directly useful to a single application. These transformations will often cull the model to return only those aspects of the data relevant to the application.

2 Related work

Navigation and information browsing are two common themes used for demonstrating wearable computing and mobile augmented reality. The Touring Machine by Feiner et al. (1997), the work described by Thomas et al. (1998), and the Context Compass by Suomela et al. (1992) show how pedestrian navigation can benefit from heads-up displays and AR interfaces. Information browsing was first demonstrated by Rekimoto (1997) with the Navicam and has since become a popular topic of AR applications. A notable example of a wearable tourist guide application is the GUIDE project described by Davies et al. (1999) that presents roaming tourists with location based information on Lancaster.

Augmented reality has also been identified as an important means of computer supported collaborative work (CSCW) as demonstrated by Billinghurst et al. (1996) in the Shared Space project. Collaboration between stationary and mobile users has been investigated by different groups in the MARS project (Höllerer et al., 1999) and Tinmith project by Piekarski et al. (1999). Mobile users could also create world models in the BARS project (Baillot et al., 2001) but only in well controlled indoor environments. Our work extends these attempts to collaboration between several mobile users in an outdoor setting.

All recent AR demonstrations work with small data sets that have typically been entered manually and do not require data warehousing. Related work by Julier et al. (2000) addresses the issue of selecting appropriate data for display, from a user's point of view rather than that of the application. Höllerer et al. (2001) describe a database and description logic used to store a model of the floor of a building which is annotated with meta-data for navigation target selection. The sentient computing project described by Addlesee et al. (2001) uses a CORBA run-time infrastructure to model a live environment as distributed software objects where locations and attributes of objects are updated permanently. Newman et al. (2001) describe a set of AR applications based on this infrastructure. Another important research project is the Nexus project described by Rothermel and Leonhardi (2001) which deals specifically with the problem of establishing a world model for location- and context-aware applications developing an efficient solution to providing location based data. In contrast, our work focuses on modeling the complex information needs of AR applications and providing powerful tools for using such complex data by simplifying the transformations of the general model into application specific data structures.

3 Tourist guide application

The needs and requirements of a tourist are a suitable starting point for testing location based applications. A tourist is typically a person with little or no knowledge of the environment. However, tourists have a strong interest in their environment and also want to navigate through their surroundings to visit different locations. Guided tours present also a common practice for tourists. In such a situation a single person navigates a group of people and presents information.

Consequently, we have chosen a tourist guide application for the City of Vienna as an example scenario for an augmented reality application that integrates a large amount of data from different sources. It provides a navigation aid that directs the user to a target location and an information browser that displays location referenced information icons that can be selected to present more detailed information in a variety of formats. Both functions support collaboration between multiple mobile users.

3.1 Augmented reality system

Our current setup uses a notebook computer with a 2GHz processor and an NVidia Quadro4Go graphics accelerator operating under Windows XP. It includes a wireless LAN network adapter to enable communication with a second mobile unit. A Trimble Pathfinder Pocket differential GPS receiver is used to determine the position of the system in outdoor applications. All the equipment is mounted to a backpack worn by the user. We use a Sony Glasstron optical-see-through stereoscopic color HMD fixed to a helmet as an output device. An InterSense InertiaCube2 orientation sensor and a PointGrey Research Firefly camera for fiducial tracking are mounted on the helmet (see Figure 1).

We use *Studierstube* (Schmalstieg et al., 2002) which is based on Open Inventor (OIV) (Strauss and Carey, 1992) as a software platform for developing AR applications. It provides a multi-user, multi-application environment, and supports a variety of display devices including stereoscopic HMDs. It also provides the means of 6DOF interaction, either with virtual objects or with user interface elements displayed in the user's field of view. Applications are developed as scene graphs that can be described with the declarative OIV file format. *Studierstube* is a very capable rapid prototyping system, but does not incorporate any database functions beyond a scene graph based runtime data structure.

Collaboration between different users requires distribution of the application's state among different setups. To simplify development of such distributed applications, we implemented an extension to Open Inventor – Distributed Open Inventor described by Hesina et al. (1999) – that provides shared memory semantics on the scene graph data structure. Changes to a distributed part of the scene

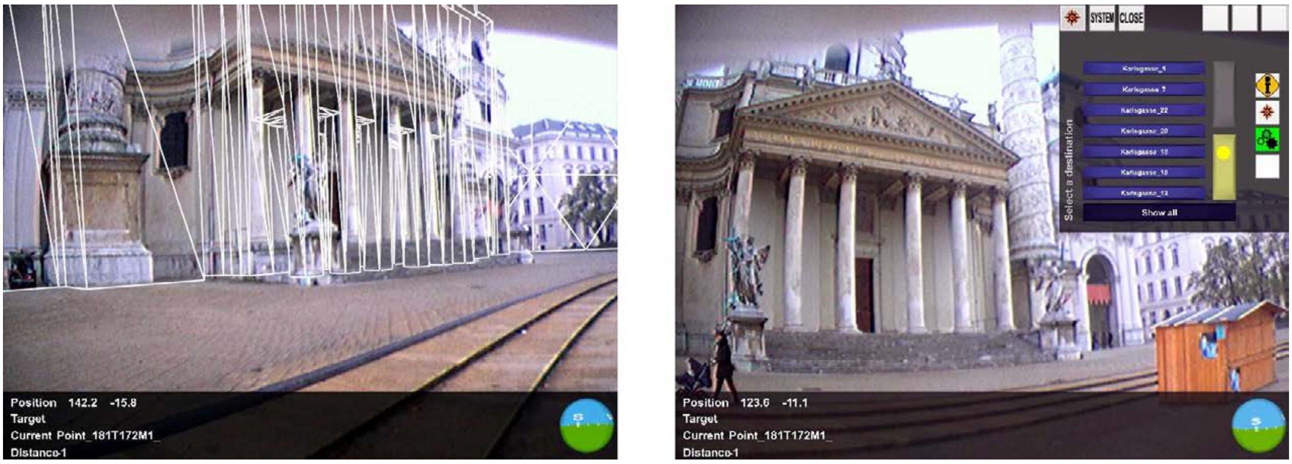

Fig. 2: a) An overlay of the building model over the real world.
b) 2D user interface components and HUD.

graph are transparently communicated to other instances of the application without exposing this process to the application programmer.

3.2 User interface

The system presents information to the user on the head mounted display. Such information is either presented as graphical objects rendered to fit into the natural environment or as text, images and 3D objects providing a heads-up display. The graphical objects are drawn to enhance and complement the user's perception of the natural environment. They can represent abstract information, alternative representations of real objects or highlighted real structures. The heads-up display is used to provide a graphical user interface consisting of typical 2D widgets such as buttons, lists, and text fields and to provide other status information. Figure 2 shows a typical view through the users display.

The user can control a cursor within the 2D user interface part in the upper right corner with a touchpad that is either worn on the belt or handheld. She can switch between different modes of the application such as navigation, information browsing and annotation. Each mode presents a number of individual panes to provide control of parameters and other options related to the current task. A general heads-up display (HUD) at the bottom of the view presents generic information such as the current location, selected target location, distance to the target and an orientation widget modeled after a compass.

3.3 Navigation

In navigation mode the user selects a specific target address or a desired target location of a certain type such as a supermarket or a pharmacy. The system then computes the shortest path in a known network of possible routes. It is interactive and reacts to the user's movements. It continuously re-computes the shortest path to the target if the user goes astray or decides to take another route.

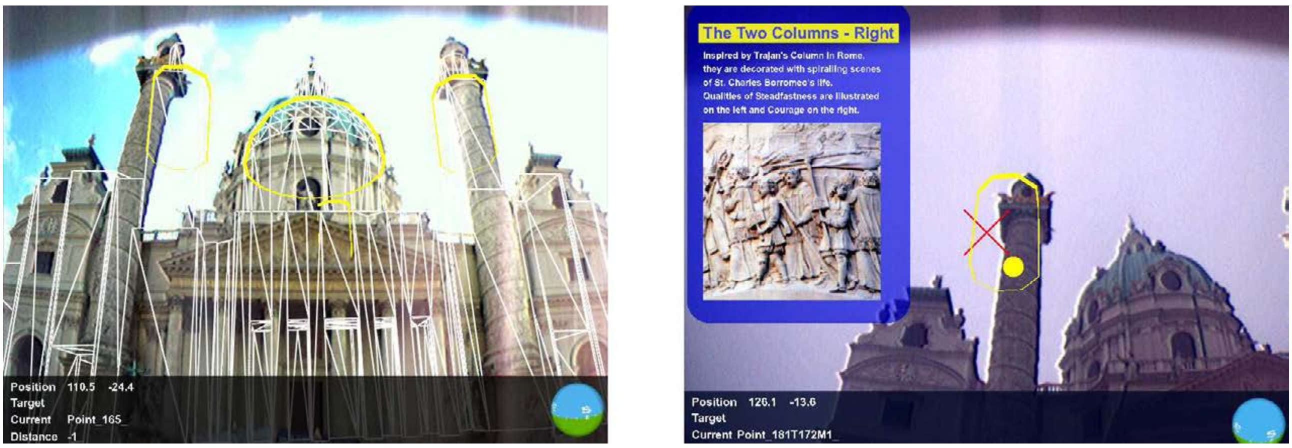

Fig. 3: a) Different parts of the building are highlighted to show possible additional information.
b) The user selects the column by looking at it and the content is displayed.

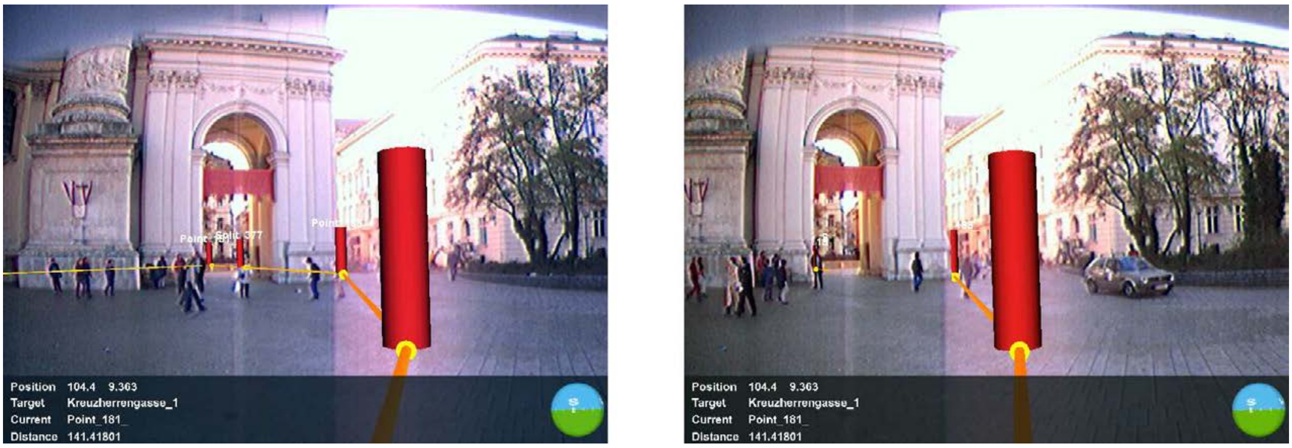

Fig. 4: a) A visualization of the path to the selected target without clipping on known objects.
b) The same path clipped at an object.

The information is displayed as a series of waypoints that are visualized as cylinders standing in the environment. These cylinders are connected by arrows to show the direction the user should move between the waypoints. Together they become a visible line through the environment that is easy to follow (see Fig. 4a). The user can enable an additional arrow that points directly from her current position to the next waypoint. Buildings can clip the displayed geometry to enable additional depth perception cues between the virtual information and the real world (see Fig. 4b). Finally, simple directional information is displayed, if the user is not able to perceive next waypoint because she is looking into the wrong direction.

If two or more users are present, a number of collaborative interactions are possible. The interface will present a list of all users that have joined the collaboration session. Every user can select another user and specify an interaction mode:

Follow. The user can decide to follow the selected user. The navigation display will update the target location to always coincide with the waypoint closest to the selected user.
Guide. The user can guide the selected user by setting the destination point of the selected user. The navigation system of the selected user will then behave as if that user had selected the target herself.
Meet. This mode supports to meet halfway with the selected user. The navigation system calculates the meeting point to be halfway between the two waypoints the users are closest to. Then the destinations of both users are set to this new target. Each user can still change the common target to a more suitable location if desired.

3.4 Information browsing

The information browsing mode presents the user with location based information. Location referenced information icons appear in her view and are selected by looking at them. They then present additional associated information. The application conveys historical and cultural information about sights in the City of Vienna.

The information icons can have any shape for display as well as for ray intersection. In the current application we use geometric representations of parts of buildings to annotate these with cultural information. The icons appear to the user as outlines of the building parts. A virtual ray is cast through the center of the display and intersected with the information icons. The first icon that is hit triggers the display of information that is associated with it (see Fig.4).

The information consists of images and text which were taken from a guide book. These are shown to the user in the heads-up-display. The user can also select a subset of the icons to be active and visible by choosing a set of keywords the icons should relate to. The reduction of visible icons avoids visual clutter.

The information browsing mode supports multiple users. Users can choose to share their selection of topics, or alternatively, tour guides can control the selection for a group of guided users. A user can also trigger the highlighted information on another user's display.

3.5 Annotation

In addition to pure browsing, users can also annotate the environment by placing virtual icons of different shapes and colors on structures and buildings in their surroundings (see Fig. 5). Again, a virtual ray is cast through the cross hair in the heads-up display and intersected with the geometry of the buildings. If an intersection is detected a yellow sphere is placed at the intersection point to visualize it. Then the user can place a predefined 3D icon at the intersection point. The icon is oriented parallel to the tangent surface

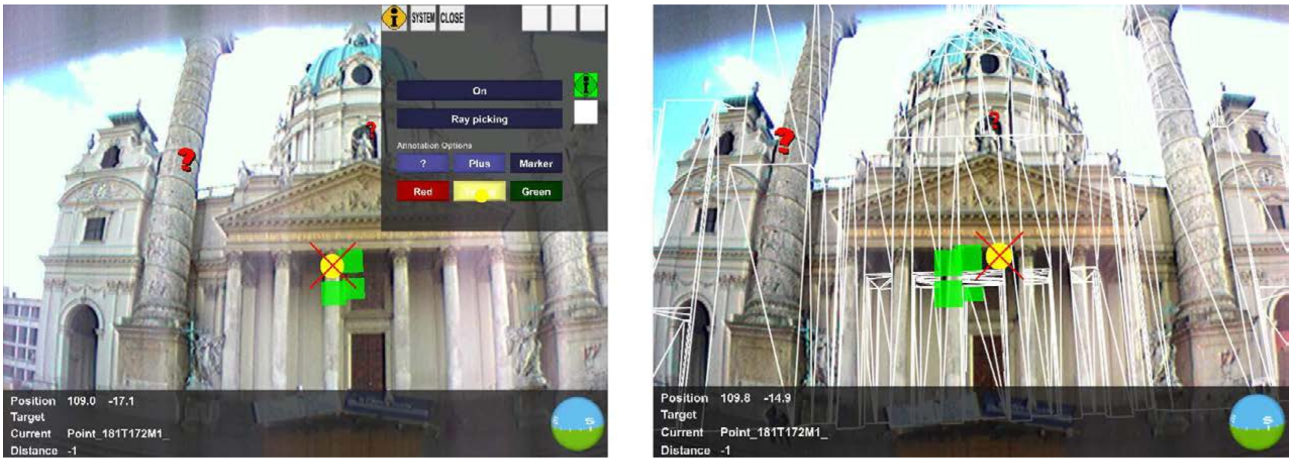

Fig. 5: a) Annotation options and icons.
b) The building geometry used for ray intersection is overlaid.

in the intersection point. The user can select between different predefined shapes and colors to use and can also choose which kinds of icons to display.

The virtual icons are shared between different users in a collaborative session and are annotated with the name of the user who created them. In this case a user can also include the name of the icons creator into the selection of visible icons.
The virtual markers can help to point out features on distant structures such as building facades. Users can attach and discern different meanings associated with markers by assigning different styles. They support collaborative work styles because they are shared information and can help users to communicate information about individual locations in the surrounding.

4 Data management

Any significant real-world application of mobile augmented reality will require a large model of location referenced data. While it may appear that a natural approach is to develop application specific data formats and management strategies, we have found that such an approach actually prevents reuse of the data and ultimately produces additional complexity in developing and maintaining the application. Therefore we developed a general model schema and a 3-tier architecture to maintain a central data store and application specific reuse through dedicated transformations. For a more detailed treatment of the data management concepts see Reitmayr and Schmalstieg (2003).

4.1 Three-tier architecture

The architectural concept is based on a typical 3-tier model. The first tier is a central database storing the overall model. The second tier mediates between database and application by converting the general model from the database into data structures native to the respective application. The applications themselves are the third tier and only deal with data structures in their own native format.

This architecture provides the usual advantages of the n-tier model. A common data model and store reduces the amount of redundancy in the data required for different applications and allows centralized and efficient management of this data. The middle layer separates the presentation issues from the actual data storage and the applications. Thus the applications can be developed using efficient data structures independent of the actual storage format. Moreover, the transformation can be adapted to changing data formats or processes without touching either the application or the storage back-end, because it is a distinct entity separated from both.

We built such an architecture based on XML technology, leveraging recent developments in the web development community where it is commonly deployed and directly supported in open-source or commercial products. The use of XML has a number of advantages for our task. An XML based model schema is powerful enough to capture the complex aspects of the data model. Transformation tools such as XSTL defined in Clark (1999) allow rapid prototyping and development of import, transformation and export tools to and from the data model. Parsers and generators exist for a wide range of programming languages, and allow applications and tools to use the most appropriate language for the task.

4.2 Modeling

At the heart of our architecture lies a data model that encompasses the requirements of all applications. Care was taken in keeping the model extensible so that new data could be integrated during the development. This data model is described by an XML schema.
The model is based on an object-oriented approach using a type hierarchy of entities. The root type is called *ObjectType* and contains an id and a generic annotation subelement that can be used to store any XML tree. All data types defined in the model are derived

from this type. The *SpatialObjectType* adds pose information and a geometrical representation to the super class. We further derive the *SpatialContainerType* that adds a children subelement to aggregate entities of type *ObjectType* for hierarchical composition.
From the three base types, we derive a number of application specific types that are used in the actual data files. The *Object*, *SpatialObject* and *SpatialContainer* elements are used for general purpose data and correspond directly to the base types. Applications can define additional types derived from the base types to provide more specific information. For example, the *Waypoint* element has a specific sub element to define neighboring waypoints connected by a path. Because elements refer back to their base type, an application can always provide a reasonable fallback behavior if it encounters an unknown derived application elements.

4.3 Data handling

Having defined a model and data format, there are a number of tasks and tools necessary to fill the database, transform and manipulate the data and finally make it available to the user through the development of appropriate applications. The typical tasks include import from other data formats, maintenance of the model and export to application specific data structures. In the last step transformations are applied to retrieve application data from storage and generate data structures for the applications. As described in section , applications are implemented as Open Inventor scene graphs. Each application uses a custom XSLT style sheet to directly generate the required scene graph and additional data structures from the general model.

The use of a separate step to transform the data into the application format has a number of advantages. It separates the general data format from the application specific data structures and provides an interface between both. It also provides a point for customizing the presentation independently of the application, similar to the way traditional cascading style sheets work for HTML. As the style sheet generates the actual graphical content, it can adapt it to different output requirements or profiles.

4.4 Data acquisition

The described application requires diverse data from a variety of sources. A 3D model of a part of Vienna was obtained from the cartography department of the city administration in 3D Studio Max format. This model was created as a reference model of Vienna, and is part of the official general map of the city (Dorffner and Zöchling, 2003). The department of Geoinformatics at Vienna University of Technology supplied us with a network of accessible routes for pedestrians, delivered in GML2 format defined in Cox et al. (2001), an XML based file format used in the geographic information systems (GIS) community. This model was derived from the general map of Vienna and is represented as an undirected graph. Each node in this graph is geo-referenced and used as a way point in the navigation model. For each building, a so-called address point was defined and included into the path network to be able to construct a path to this address.

Furthermore, annotation information such as businesses located at certain addresses was derived from the general map of Vienna. This information is connected to address points in the spatial database. Cultural information taken from a guide book was included at various places to provide more detailed data for a tourist application. Finally, we placed the icons as spatial representations of this information into our model.

5 Results

The described system was outfitted with data surrounding the area of Karlsplatz and adjacent building blocks down to Gußhausstraße in Vienna. The area of Karlsplatz proved to be a good testing ground because it is open enough to allow reception of GPS signals for positioning, has a somewhat complex network of foot paths through the Resselpark and a number of famous tourist attractions such as the Karlskirche are situated at its border. Finally, it is close enough to our institute to allow frequent visits for development and testing purposes. The images throughout the paper where captured during such test runs. We use a video see-through approach and render the image of the video camera into the background to simulate the experience of a real user.

During November 2003 we showed the prototype to a group of colleagues in an informal demonstration session. While they have been exposed to AR environments before, they did not know about the user interface of the tourist guide demonstrator. After an initial acclimation phase, users found the user interface of looking at objects and walking through the environment simple enough. The interaction with the 2D heads-up display interface was useable, but can be improved because the controls were not tailored specifically to the tasks.

The accuracy of the GPS positioning is not satisfying and the lack of precision leads to jumps in the graphics overlay. The blocking of satellites by high buildings prohibits the use of the system in the smaller side streets and close to buildings. Still it is the only technology available that provides the minimal required accuracy and robustness.

6 Conclusion and future work

The presented work tries to give an outlook into possible future user interfaces for location based services. Although many of the implemented user interface features have been demonstrated before, our work exceeds former work in two areas. Firstly, the collaboration features add another dimension to the possibilities of such systems by supporting groups of users in their tasks. While the features of the system are implemented, we need more tests of the collaborative aspects to determine useful and interesting extensions. Secondly, the integrated approach to handling the data required by a location based service allows the system to scale to realistic environments. The use of a flexible data model also simplifies extending the system with future applications that will have new requirements for data to be stored in the repository.

The application of a generic AR software framework such as *Studierstube* allowed us to leverage the graphical and interaction possibilities of modern 3D rendering libraries and simplified development to a great extend. Thus we did concentrate on the problems of scaling the data management and implementing collaborative features into the system. Moreover, we could enhance the user interface at every step during development because changes to the presentation and interaction can be implemented and tested within short turn around cycles. Still we did not fully explore the design possibilities because of the overwhelming number of options that presented themselves to us.

We plan to use DGPS in the future and distribute RTCM correction data over a GPRS connection from an Internet server to the mobile setups. Additionally a Kalman filter should reduce the noise in a static position while still reacting quickly to changes when the user is moving. Another interesting possibility is the use of velocity and direction information to auto-calibrate the orientation tracker. Under the assumption that the user is looking into the direction she is moving, we can update an error description of the orientation tracker from the direction information provided by the GPS receiver.

7 Acknowledgements

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USABILITY

User Expectations and Preferences regarding Location-based Services
- Results of a Survey -

Alexander Zipf und Matthias Jöst, Mainz

Abstract

How should Location Based Services (LBS) look like? What should they offer and in which form? This paper aims at answering some of these kinds of questions by presenting the results of a detailed survey recently undertaken in Heidelberg, Germany. A general section covers questions about the acceptance of different content types and services on mobile devices. Furthermore the preferences of various users for different communication channels and the willingness to pay for such services were investigated. Another section is dealing with special issues of – LBS, like questions about the users' behavior and its implications with respect to adaptive maps (e.g. alignment of the map) and proactive location-based tips (e.g. what actually means "Near" to users in what situation). The survey focuses on two specific user groups: pupils and students. As learned from SMS one can assume that these will be early adopters of such services. Our results provide a base to tailor services on mobile devices to the real needs of the users. But in particular in the area of adaptive mobile maps there are still a lot of open questions (Zipf 2003as) left for further studies. In particular there is a lack of mathematical quantifications of these results necessary for a formal model to be included in context adaptive map generating software as presented in (Zipf 2003b).

1 Introduction

After the flattening of the UMTS hype telecom providers need to search for mobile services, which are going to be accepted and heavily used by their clients. They have to achieve at least a partial return of investment for the tremendous endeavors undertaken to build the UMTS infrastructure. But what are the preferences and interests of future users of LBS? Apart from the economic reasons these are also a research question for the scientific community on ubiquitous computing. We think that a key success factor of mobile services is their ability to take the users with their preferences and context situations into account in order tailor these services to the users (Zipf 1998). Within several of our recent projects (DEEP MAP, CRUMPET, SMARTKOM) we developed LBS that do this by adapting the GIS-related services like maps (Zipf 2000, 2002), tours (Zipf & Röther 2000, Jöst & Stille 2002) or proactive location-based tips (Zipf & Aras 2001). But most of the parameters used today are based on simple heuristics and lack empirical evidence. For that reason it is crucial to evaluate system dealing with issues of mobility and human computing interaction not only under the clean and safe laboratory condition but also in real usage scenarios – outdoor – considering the various effects that might interfere (Schmidt-Belz *et al.* 2002, 2003). But not only need the system aspects to be evaluated under real conditions, also results of empirical studies conducted online might differ from results gained under outdoor conditions. That is of important and needs to be taken into account in particular for questions dealing with mobile services.

2 Setting of the Study

Recently we evaluated two systems build in our institute with users in Heidelberg, which is on of the most famous German cities that is attracting millions of foreign tourists a year. The study was conducted in two different settings. The first one was a detailed evaluation of one of the two systems followed by a questionnaire to examine systems aspects as well as general user preferences. The second one was a more comprehensive questionnaire focusing only on user preferences and mobile services. The presented results refer to general issues of location based services and not on specific aspects of our systems. Furthermore we focus on the results of two specific user groups, pupils and students.

	Number
Pupil [f]	8
Pupil [m]	13
Student [f]	47
Student [m]	63
	131

Tab. 1: Number of pupils and students by sex

As Tab.1 shows there were 131 participants of the study, predominantly students. This is due to the specific geographic situation in the city of Heidelberg where many university facilities are spread all over the old town.

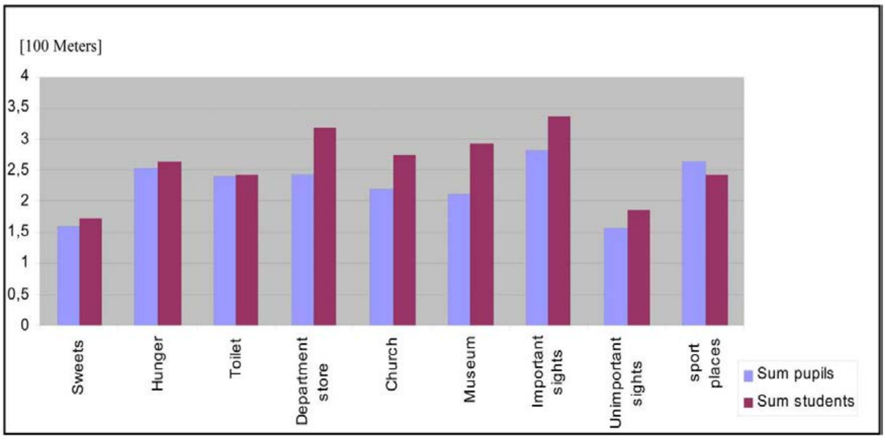

Fig. 1: Weighted average value of the distance for certain object types.

3 Defining the "region nearby" - on the meaning of „nearness" for LBS.

One question we are interested in, is: "*Which distance are users of location-based applications ready to walk at all?*" Typical usage scenarios of LBS are location-based tips or notifications, if users are in the proximity of a possibly interesting object. For example a business, that sends advertisement to users-near-by (if anybody at all is interested In such kind of services…), or tips for objects of interest on a sightseeing route of city tourists. Of course different persons evaluate such a distance depending upon their current situation (in the current context) and the kind of the object differently. In order to tailor the information offered by LBS to objects in the proximity we need to investigate the question what "Nearness" actually means for different types of users in different situations in terms that can be quantified in order to parameterize the service offered. Zipf and Aras (2002) explain how such information can be used for the generation of pro-active hints in a mobile city information system (CRUMPET). However in nearly all cases there is missing an empirical validation of the values used so far. This survey shall contribute to this question. When developing such LBS, that need to take the distance to objects into account, it would be a first and simple approach to use a simple circle with a certain distance as radius around the current user position. But as we know from GIS analyses, simple circular search buffers do not always correspond in optimal way to the actual conditions. Instead there exist boundary conditions influenced by topology and topography, which suggest that it appears to be more realistic, if the parameter "nearness region" is presented by a polygon, which is variable in form and size. Form and size of the same therefore should be dependent on several changeable context factors. Thus, a dependence on direction of motion and speed suggests a geometric form similar to an egg as query buffer. Different factors, which can affect the size and form of such a "nearness"-area, are presented in (Zipf 2002a). But up to now further statements are missing about the actual distance values that need to be used for this. In particular it is plausible to have different distances for different object types and users. This can be realized easily from a technical point of view, but how to actually fill in the values is still an open question.

Among others, we therefore asked for the maximum distance (in given intervals) that a user would walk in order to get to a certain service or point of interest, for example the next museum. This question however represents only a first step for answering the represented problem in detail, but due to the considerable length of the questionnaire further aspects could not be included. The result we gained gives us a first reference point for further, more focused analyses. Fig. 1 shows the average values of the distance estimates subdivided for pupils and students. Pupils and students showed significantly different preferences concerning the proximity of specialist shops, churches and museums.

However male did not differ considerably in their estimation of the proximity to the different objects from female. Since the entire problem obviously seems to be dependent from many context factors, it becomes clear that it also in the area of geographic information science important to analyze and to classify these various parameters (Zipf 1998). In such a context model for example the type of the object that can be visited, would be (only) one parameter of a more comprehensive context model combined with user profiles. First prototypes of such adaptive GI services are maps (Reichenbacher and Meng 2003, Zipf 2002b) or route planning (Joest and Stille 2002, Zipf and Röther 2001). More details on general context-aware information systems can for example be found in Chen and Kotz (2000).

4 Adaptive Map Display

A fundamental question for the acceptance of maps as navigation aid on mobile devices deals with the orientation of the maps. Through the recent improvements on processing power availability on mobile devices, such as pocket pc or handhelds, it is now possible to adapt maps dynamically to the individual spatial reference system of the user. This means to adjust them to the current viewing position of the user. Levine, Jankovic and Palij (Levine, *et al.* 1982) have presented results that indicate that humans construct their cognitive environment map according to the orientation of a drawn map. In such an egocentric reference system a mental rotation is no longer necessary.

In realistic situations during the navigation processes mental rotations where reduced through the physical rotation of the northwards oriented map into the movement direction. If such a manual reorientation is missing Shepard and Hurwitz (Shepard, Hurwitz 1984) have shown that a greater cognitive effort is necessary. To be more specific, the participants of their studies should decide whether a line should be continued to the left or the right. It appeared that the reaction time correlated directly with the diverge angel of the branching line to the upward targeted orientation. Shepard and Hurwitz gave the interpretation that the participants have to perform a mental rotation according to the given line.

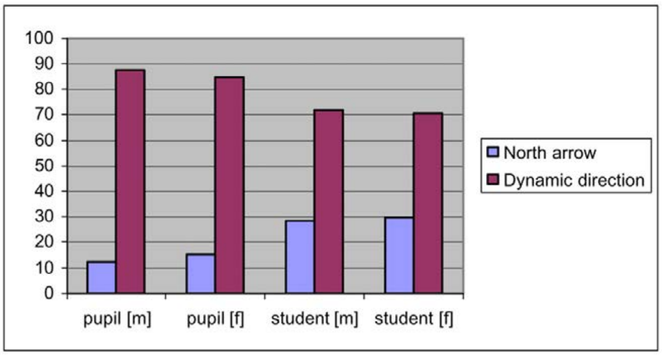

Fig. 2: Weighting for different map orientations by pupils and students

In their case the test persons were explicitly asked to adjust their egocentric reference system to the given stimulus and the taw was presented a certain period before to be judged line, the reaction time decreases. Through the fact that this happens only with the specific instructions Sephard and Hurwitz concluded that the adjustment process is exertive and will be done only if absolutely necessary.

But when we ask if there are differences between different types of users in their preferences of using north-bound north arrows or a dynamic alignment of the map one can find studies that give contradicting results. Most studies dealt with a gender-based distinction between user groups. But as the different results indicate this might not be the only– and in particular not the most important - factor influencing a preference on either north-bound orientation versus dynamic alignment. Our results indicate that the age of the person might also have an influence, but the number of participants and their selective age ranges do not yet allow final judgments. But we believe that in future studies this aspect needs to be investigated in a more comprehensive manner, taking several possible factors into account and checking them for correlation. In this study it could be shown that participants with maps that were not oriented accordingly had greater problems in orientation tasks than participants, which have gained their knowledge from interacting with their environment (Richardson *et al*. 1999). This certifies again the mental effort for the task to orient a map. Therefore the results seem to suggest that humans can use egocentric orientated maps more easily.

On the other hand maps oriented to the north might also be aligned to the movement direction manually and therefore offer the same possibilities than automatically reoriented maps. On the one hand such automatic oriented maps facilitate the navigation task to a given destination but on the other hand complicate the general overview if more than one destination should be represented on the map. That might be the case, for example if a user wants to remember the already visited sights by presenting them on the map simultaneously. In that case an orientation independent depiction should be chosen and a north oriented map is advantageous. Furthermore we have to consider the possibility that humans might navigate with dynamic oriented maps more easily, but still prefer the classic northwards oriented versions they are accustomed to for a long time.In order to answer this question the participants of our study had to answer which map orientation they prefer. It is important that the answer may not only be influenced by the cognitive effort that is necessary to do that, that may be gender dependent, as some research results indicate, but also how used and trained the personas are to perform this mental rotation, which might be influenced from their job, education, etc. Therefore we asked also other age groups than the students and pupils and indeed gained results that differed from those age groups. We examined by a chi-square test if the preference distribution in the different age and sex classes is different than the distribution in an age and sex independent grouping. While we do not consider these results to be representative through the small number of participants in some of the older age groups, the first results indicate the following direction that needs further confirmation by further studies. To summarize these first results male persons seem to prefer north-bound maps more or less through all age classes. But women change their preferences with age. While women prefer maps aligned to the walking direction in younger years, women of a higher age

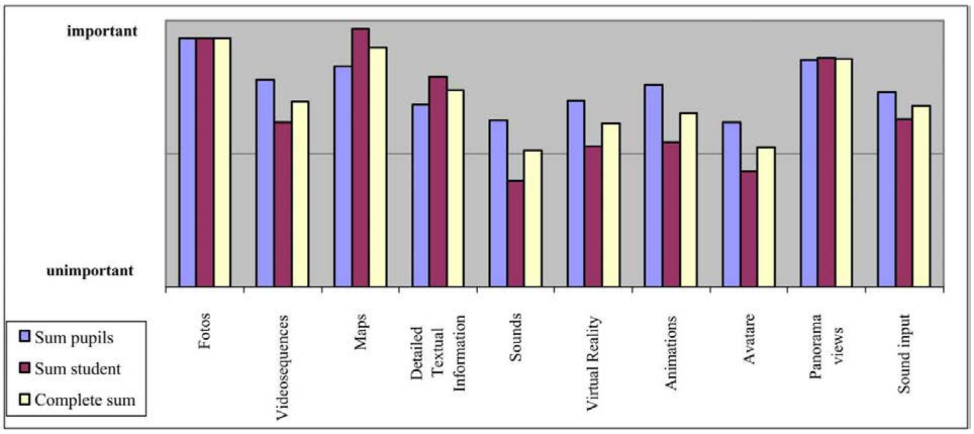

Fig. 3: Weighted types of content by pupils and students

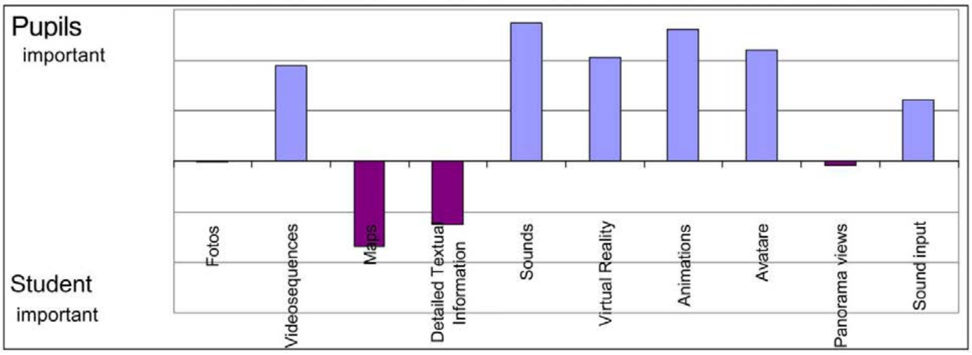

Fig. 4: Differences in the weighted types of content between pupils and students

prefer also north-bound maps. A first explanation might be, that this is due that they are longer accustomed to perform mental rotations and therefore do not need the help of the system that much. For the designers of adaptive map services this means, that it might be helpful to offer the alignment not only dependent from the gender, but also from the age of the user.

5 Rating of different Types of Content

Another aspect in our study investigates how users of different categories judge and weight various types of content. These types of content range from simple textual descriptions of interesting sights and locations in a city, to street maps, or even virtual reality models and animations of lifelike characters.

The general observation is, that for both test groups especially maps, images as photos or panorama views, followed by textual information about sights are of higher interest (see Fig. 4) whereas multimedia content such as sounds or virtual characters are in sum of lower interest. Additionally the interaction with the system by natural language was rated with less importance although especially such a multi-modal interaction might be well suited for mobile information systems.

Concerning the different multimedia contents a significant difference between both user groups can be shown according to their educational status. Students rated textual information with a higher importance than the pupils did and rated multimedia content with a lower importance. This trend could be explained with the assumption that pupils have a more playful behavior while using such technologies and that they are more used to virtual realities and animations through comic films and computer games.

6 Weighting of different services

Regarding the weighting of different information services to be offered by LBS, our results indicate that information about the public transportation and its departure-/arrival schedule plans are of great importance for pupils and students, besides to standard localization (Where am I?). But of course it is quite sure that both groups use less frequent cars due to the fact that they have no driving licenses or even do not own a car but in general one could estimate that the schedules for frequently used lines are well known by their users. For that circumstance the information about alternative routes to the requested destination might be of specific interest.

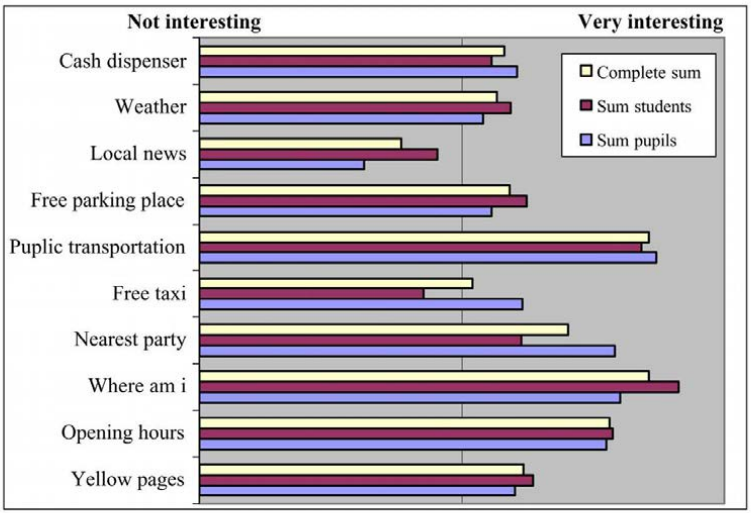

Fig. 5: Interest for different services

Beside the localization issue the results indicate that classical yellow pages information like the navigation to the nearest bakery or shoe shop is only of lower interest although these services are described as the classical ones for LBS.

In general our outcomes approve the results of Kölmel and Haberschneider (2002) in some aspects. But one can also find some interesting differences. For example the aspect “Where is the next party” (they call it ‘Event-Guide’) gained greater interest in our survey. This might be due to the specific age class of the participants of our study.

In a further step we asked the question about the preferences on the different means of communication that should be offered by LBS. As possible answers services were listed both from the mobile telephony domain and from the classical Internet domain. In both user groups the chat functionality is rated with less importance than SMS or eMail. SMS is a well-established service on mobile phones and recently eMail client are also more and more included into mobile devices. Due to the limited screen size on such devices and the cumbersome input via pen the chat functionality (where a speedy text input is crucial) is rated as inappropriate on mobile devices, such as PDA's.

As in the foreseeable future speech-to-text functionalities are likely to be implemented on mobile devices (Fenn 2003), chat functionality might then be of higher interest as well.

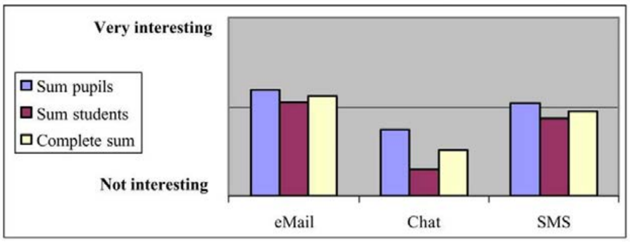

Fig. 6: Weighting of communication services on the mobile client

One of our most astonishing findings results from the question on the willingness to pay for different services. Significantly more pupils agree on paying for services (at maximum with 68% of all participants). For the students the pay willingness for services reached only 30% despite a possibly higher interest at the services itself. A reason for this observation might be founded in the situation that students often have less money to spend for their spare time activities than pupils have.

Although only 9,53 % of all German pupils in the age between 15 and 20 (Statistisches Bundesamt 2002) supplement their pocket money by jobbing, whereas 21,56% in the age 20 to 25 are doing so, is the financial situation quite different, because students often have to spend their money for living and not for pleasure.

7 Position Tracking by Service

In one of the final question the users were asked to rate the importance / potential interest to deliver position information to specific services such as emergency aid or mobile dating services.

The general observation is, that the provision of position information is not quite popular and that both groups are very apprehensive with respect to their privacy. For services that the users regard as unnecessary such as games, or that are controversial, such as kids monitoring, the readiness to publish the position information is very low. But some services are noted as useful, for example mobile city guide services, and for those the user is more likely to make his position available.

A general observation (see Fig. 8) is that female pupils and female students are more worried about their location privacy than their male counterparts. Our results are in contrast to the results of the empirical study undertaken by Ho and Kwok (Ho, Kwok 2003), which have found that users of mobile services are more concerned regarding the usefulness of services than on privacy issues. But in their study location as standalone parameter was unlevied

8 Summary and outlook

In this paper we examined some questions, which are relevant for the development of LBS and in particular adaptive services, based on empirical surveys. A lot of developments in the area of mobile systems were mostly technology-driven, i.e. new technical possibilities are realized, without considering the actual interests and desires of the users.

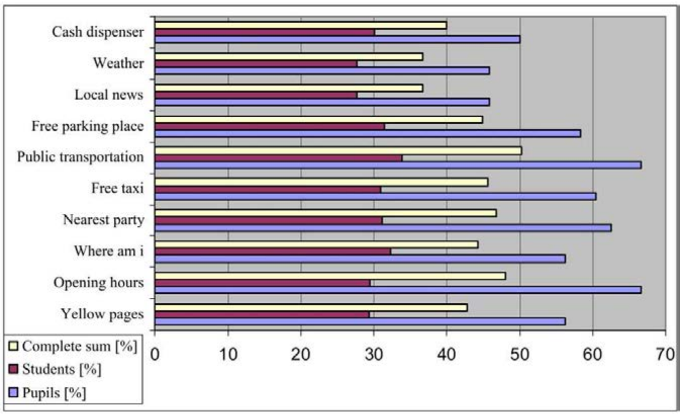

Fig. 7: Pay willingness for different services

The result of our survey suggests that there is a distinction between pupils and students, but not that much between women and men of this age for different services. With respect to map alignment, the direction of the map should also consider whether the navigation is being presented to a male or female user. However it is difficult to get valid statements about services, which are at the given time for the persons asked, often still quite abstract and unusual. If the users testing the system do not have sufficient time to become familiar with the new system and offered features one hast to expect only vague answers or results. Therefore we try to accomplish appropriate questionings parallel to

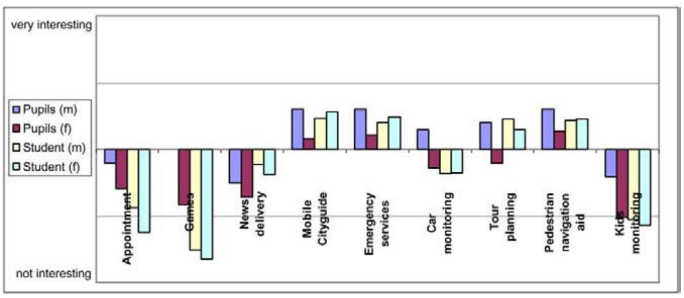

Fig. 8: Provision of position information for different services

the development of our prototypes, so that the users asked can develop a sensorial supported understanding concerning the addressed system properties.

Nevertheless, such investigations do give first indications on preferences of certain groups of users. Enichlmair and Staufer-Steinnocher (2002) underline that in particular the data presented are important for the success of mobile services. We ask the further question which services need to be prepared and optimized for whom (Zipf 2002b). This content adaptation is of course connected with additional costs. The importance of cost benefit analyses for LBS is stressed by Schilcher *et al*. (2002). If personal interests are considered in the adaptation process, naturally further questions of security and privacy need to be considered with mobile systems in particular (Hoffmann 2002).

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A user-centred research approach to designing useful geospatial representations for LBS

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Abstract

With the introduction of interactive computing, cartographic research and development shifted in focus from the paper map to digital geospatial information tools, increasingly linked to the Internet. A new phase is upon us, facilitated by advances in mobile technologies that have enabled the relative benefits of these two cartographic resources to be combined, into online digital mobile maps and Location-Based Services (LBS). Inevitably, a number of unique infrastructure and contextual constraints are posed by this composite cartographic medium, prompting research that has been largely focussed on the technology involved. We argue that whilst such an approach can be valuable, it must also be supplemented by user-focused studies in order to ensure the usefulness of geospatial services (i.e. in terms of both utility & usability) and thus the commercial success of LBS.

Researchers in the field of Human-Computer Interaction (HCI) have recognised the need to address user issues relating to LBS, however there has been limited focus on the component geospatial representations. Cartographic researchers, on the other hand, have concentrated on developing representations within LBS that support users' geospatial tasks; however their results have been constrained by a general lack of user involvement. In response, we propose a user-centred approach to address specific concerns of effectively representing, presenting and enabling interaction with often-complex geospatial information via LBS. We contend that by following a User-Centred Design (UCD) methodology, rich data will be generated regarding user needs, abilities, goals and tasks relating to geospatial information use in a mobile context. This paper discusses the user-centred research strategies selected for a study, including User Profiling, Contextual Task Analysis and Evaluation.

1 Introduction

Cartography continues to evolve, adopting and adapting technological innovations and new media. Representing an important paradigm shift, the Internet has been closely linked to the future of cartographic research and development, not least in its capacity for faster delivery and increased distribution of geospatial information, but also the possibilities it offers through multimedia and interactivity (Peterson 1999). Until recently, research in Internet Cartography has concentrated on theory and applications relating to geospatial information services delivered via stationary, desktop computers and fixed-line Internet connections. A new concept has emerged, however, brought about by the advancement of highly portable devices and the 'mobile Internet', itself supported by improvements in wireless telecommunications.

1.1 Online digital mobile mapping benefits

The concept of online digital mobile maps (encompassing graphic and non-graphic forms of geospatial representation, and herein referred to as Digital Mobile Maps (DMMs)) embodies a merging of the two widespread cartographic media – the desktop Web and the paper map – combining advantages from each. Firstly, the high mobility of the devices (e.g. mobile phones, handheld computers) and networks used to deliver DMMs makes them equally as convenient to use as paper maps, i.e. "easily portable and can be consulted anywhere" (Brown, Emmer & van den Worm 2001, p.61). Secondly, mobile Internet connections ensure that the geospatial and other information being represented is always as current and as accurate as the underlying data, and the possibilities for interactivity and multimedia have the potential to offer alternative views of the data (Peterson 1999). Finally, where real-time positioning of the user is available (e.g. via GPS coordinates), context can be incorporated into the representations in order to increase their relevance to the current situation.

1.2 Cartographic constraints

For all of the perceived benefits, the combination of new technologies and dynamic environments characterising DMM delivery brings forth additional challenges for cartographers. Indeed, just as the introduction of interactive computing required new developments in cartographic theory and methodology (Dransch 2001), the field of *TeleCartography* (Gartner & Uhlirz 2002) has emerged to respond to the constraints of the mobile Internet medium. Table1 divides the limitations affecting DMMs into two major categories: technical infrastructure and context of use, listing the main factors relevant to each.

TECHNICAL INFRASTRUCTURE	CONTEXT OF USE
Display	**Situation**
• Small screen size [D] • Limited resolution [D] • Low (if any) colour range [D]	• Location • Time
Interaction	**Environment / surroundings**
• Limited input opportunities [D] • Restricted output capabilities [D]	• Dynamic settings
Performance	**User characteristics**
• Slow connections [N] • High latencies [N] • Limited storage [D, N] • Restricted processing power [D, N]	• Goals • Tasks • Interests • Abilities

D – Device related; N – Network related

Tab. 1: Limitations of DMMs (adapted from Urquhart et al*. 2003).*

There are three main constraints generated by the factors presented in the table. Firstly, the device-related characteristics encompassed by *display* and *interaction* necessarily restrict the amount of information that can be represented and presented to a user at any one time. Secondly, the device and network issues relating to *performance* place limitations on how much data can reasonably be delivered to, and processed by, a single device. Finally, the uniqueness of every potential *user*, their constantly changing *situation* and the attentional demands of their dynamic *environment*, together make it important and difficult to present only the information that is genuinely of interest, given the user's immediate situation.

2 Research objectives

The wireless industry has long purported services making use of location information as a 'killer application', which will provide returns on their widespread investment in third generation communication networks (Hamai 2001; Reichenbacher 2001). As such, there has been a great deal of industry activity in the realm of 'mobile Location-Based Services' (herein referred to as LBS) which are defined for this research as: *wireless services that use the location of a portable device to deliver applications which exploit pertinent geospatial information about a user's surrounding environment, their proximity to other entities in space (eg. people, places), and/or distant entities (eg. future destinations)*.

DMMs constitute a major part of the LBS user interface, often being the primary means of geospatial information output and, in some cases, also a means of input for the service. It may be argued, however, that more consideration has thus far been paid to developing the technology underlying LBS, with less emphasis on LBS and DMM usefulness, particularly in terms of the user characteristics defined in . This is the key motivation for this research, which aims to respond to a number of general and specific calls for research into:

- the impact of new media (mapping) displays, the interaction of users with them and users' reactions to them (Fairbairn et al. 2001);
- developing approaches for matching (new) cartographic representation forms to tasks and use contexts (Fairbairn et al. 2001), in a mobile environment (Reichenbacher 2001);
- effective representations for mobile communication devices, considering their restricted graphical capabilities (Fairbairn et al. 2001); and
- understanding how to design effective interfaces for mobile mapping services (Cartwright et al. 2001).

Essentially, this research will investigate techniques for representing, presenting and interacting with often-complex geospatial information so as to ensure the usefulness of DMMs within LBS for the study's targeted end users. Specific research objectives in this respect are to:

- identify users' geospatial information needs (dependent on their goals, tasks, interests and abilities) in a dynamic mobile environment; and
- develop a number of geospatial representation, presentation and interaction techniques, that are deemed useful by specific LBS target users.

This research has the added dimension of being supported by an Australian Research Council (ARC) Linkage scholarship, and as such it involves the collaboration of academia with Australian industry. The industry partner for the research – Webraska Mobile Technologies – understandably has a commercial interest in the outcomes and in this respect is concerned with maximising the usefulness, and thus the acceptance of their own LBS, through the research. An additional objective for this purpose is to:

- develop guidelines and a methodology that will ensure useful DMMs and LBS, in the future.

3 Background

3.1 The concept of usefulness

Before continuing it is necessary to define the term *usefulness*, an integral component of the research. Whilst there are numerous characterisations of usefulness and seemingly no general consensus on its definition, we have chosen to take the lead of Nielsen (1993), who defines it from a software design perspective as "the issue of whether the system can be used to achieve a desired goal" (p.24), comprising the two complementary concepts of utility and usability (after Grudin 1992). According to Nielsen, *utility* is "the question of whether the functionality of the system in principle can do what is needed" (1993, p.25), which is echoed by Rubin's assessment of usefulness as the motivation behind system use: "if a system is easy to use, easy to learn, and even satisfying to use, but does not achieve the specific goals of a specific user, it will not be used" (1994, p.18).

The International Organization for Standards formally defines *usability*, in the context of human-computer interfaces, as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use", where:

- Effectiveness is the accuracy and completeness with which users achieve specified goals;
- Efficiency concerns the resources expended in relation to the accuracy and completeness with which users achieve goals; and
- Satisfaction relates to freedom from discomfort, and positive attitudes toward the use of the product (ISO 9241-11 in Jokela et al. 2003, p.54).

These concepts are of paramount importance to the acceptance of LBS, for which there are currently high levels of consumer interest (ACA 2002; Wrolstad 2002). If users cannot use the services to (a) achieve their goals, and (b) do so with efficiency, effectiveness and satisfaction, they will not adopt them. Since DMMs constitute a major part of the LBS interface, their utility and usability in particular must be ensured.

3.2 Evolving attitudes

In a research sense, technology-centred development – focussing on applying new technology and investigating technical issues in its application (Cartwright et al. 2001) – can be a major facilitator of innovation, often enabling new technologies and concepts that may never have been arrived at by other means. With all of the advances it enables however, at some point researchers and developers must stop and take a step back, since the "build and they will come" and "one tool fits all" attitudes that are typical of technology-driven development will not guarantee the success of new products (MacEachren & Kraak 2001, p.9; Gould & Lewis 1985).

As Dransch (2001) identifies, cartographic research has long been dominated by issues of technique (e.g. the possibilities for interaction) and data (e.g. what can be done with it), rather than user needs. She goes on to recommend that future studies in this area should support both map-making and map-using and target the specific tasks the maps are used for as well as how they are used. MacEachren & Kraak (2001) support this view, highlighting a need to integrate work on human spatial cognition with technological development, and address user differences. Applying these concepts to DMM products, Winter, Pontikakis & Raubal (2001) call for research into issues of human spatial cognition, user interface design, data quality and spatial analysis with respect to supporting task-specific user interaction. Finally, in more general terms, Slocum et al. (2001) propose a research agenda dealing with the development of a methodology based on a user-centred approach for evaluating the usability of alternative geovisualization (i.e. geospatial representation, presentation and interaction) techniques.

3.3 Existing research

In the realm of mobile Internet services, developers and researchers have begun to realise the benefits of making utility and usability a focus of development, in order to design products that meet users' needs and expectations. WAP (Wireless Application Protocol) services are a prime example of the failure of technology-driven development, with studies uncovering numerous usability problems leading to user rejection of the services (Ramsay & Nielsen 2000). Building on such experiences, others have endeavoured to improve new mobile Internet services by conducting research early in the product development lifecycle, in order to understand user requirements and thus design for them from the outset (Helyar 2002).

Specific research in the area of LBS has also turned to usefulness. Much activity in this respect comes from the field of Human-Computer Interaction (HCI), which categorises LBS under the broader topic of 'context-aware' computing (Cheverst et al. 2000). A number of studies have sought to define user needs for location-aware services (Kaasinen 2003), and projects such as GUIDE (Cheverst et al. 2000) and HIPS (Broadbent & Marti 1997) have employed techniques for ensuring systems that meet users' goals and are easy to use. These projects have however been mainly concerned with issues of overall system appearance, functionality, information content and methods of interaction, with little or no emphasis on the appropriateness of the component DMM representations, with one notable exception (Chincholle et al. 2002). Taking a different approach, researchers within cartography have been working to specifically develop representations for LBS that will support users' geospatial tasks. Particular attention has been paid to map design (Uhlirz 2001; Wintges 2002), with some treatment of non-map geospatial information presentation (Brunner-Friedrich & Nothegger 2002). Whilst these studies are certainly revealing, it may be argued that the resulting representations/services are bound by the same constraints as technology-centred development (a review of the related literature suggests that the design work was not based on an assessment of user needs, nor have the results been evaluated), and thus their usefulness cannot be assured.

This research program will build on current cartographic research relating to DMMs and LBS by taking an approach more in line with that of HCI researchers. This has led to the selection of User-Centred Design as the overarching methodology for the research.

4 User-Centred Design

User-Centred Design (UCD) is a philosophy employed in computer systems design, having developed under the premise that in order to ensure the usefulness (and thus commercial success) of a system, all design activities should position the end user as their focus so that the final product is easy to use and ultimately meets their needs (Gould & Lewis 1985). The term UCD is often used interchangeably with terms such as *human factors engineering*, *ergonomics* and *usability engineering* (Rubin 1994), creating confusion for newcomers to the area. Ehrlich & Rohn (1994) distinguish, however, that while UCD refers to the "overall endeavour of making products easier to use" (p.74) the other labels, in particular Usability Engineering (UE), refer to the particular techniques and activities employed to satisfy UCD aims. In any case, a UCD approach addresses the fundamental questions: '*How do I understand the user?*' and '*How do I ensure this understanding is reflected in my system?*' (Holtzblatt & Beyer 1993, p.93).

The principles and techniques of UCD originated from the early works of researchers Gould and Lewis (1985) and Norman and Draper (1986), with the former proposing three basic principles, which endure today: (1) an early focus on understanding users and their tasks; (2) empirical measurement of product usage by representative users; and (3) an iterative cycle of design, test and measure and redesign. Since then these ideas have been elaborated and embodied within a standard (ISO 13407 in Jokela et al. 2003), with numerous UE activities/techniques now employed as common practice in the field of software engineering (Butler 1996; Mayhew 1999; Nielsen 1992). Whilst not an exhaustive list, Tab. 3 (Section) identifies and describes a range of key UE activities, along with various associated techniques.

4.1 Relationship to Social Research

Apart from its software engineering origins, the ideals of UCD are grounded in a number of social science disciplines, most notably cognitive psychology (the study of human perception and cognition), experimental psychology (the use of empirical methods to measure and study human behaviour) and ethnography (the study, analysis, interpretation and description of unfamiliar cultures) (Mayhew 1999). In general, UCD aligns closely with the field of social science – concerned with the study of peoples' beliefs, behaviours, interactions and institutions (Neuman 1997) – which is particularly noticeable in terms of the correlation between specific UE techniques and social research data collection methods, as will become apparent. In the social sciences, methods of data collection are categorised into traditional research approaches, namely 'quantitative' and 'qualitative', which are distinguished by their styles of research, the particular techniques they employ and the form of the data collected. A basic comparison of the two approaches is provided in , with the following sections briefly defining each and discussing their relative benefits and limitations.

QUANTITATIVE	QUALITATIVE
Measure objective facts	Construct social reality, cultural meaning
Focus on variables	Focus on interactive processes, events
Reliability is key	Authenticity is key
Value free	Values are present and explicit
Independent of context [#]	Situationally constrained
Many cases, participants	Few cases, participants
Statistical analysis	Thematic analysis
Researcher is detached	Researcher is involved

[#] Not strictly always the case in quantitative research (e.g. usability testing in context).

Tab. 2: Quantitative vs. Qualitative Research Approaches (adapted from Neuman 1997, p.14).

4.1.1 Quantitative research

Adopted from the natural sciences, social quantitative research generally involves the objective collection of data in order to test a theory or hypothesis, using specific variables. Measurements are systematic, producing precise, quantitative information about the social reality involved. More specifically, quantitative methods involve the collection and analysis of statistical data using predetermined, standardised instruments such as surveys and experiments (Neuman 1997; Creswell 2003).

The nature of quantitative research, with its rigorous measurement techniques, generally involving large numbers of participants, brings advantages such as simple comparison and statistical aggregation of the data and thus the ability to generalise findings to the larger population. It may be argued, however, that by categorising the social data into predetermined categories, and hence harbouring preconceptions, the varying perspectives and experiences of people under quantitative study can never be adequately understood (Patton 2002).

4.1.2 Qualitative research

Qualitative research strategies and methods were developed within the social sciences as specific tools to aid in the study of social and cultural phenomena, grounded in the perspectives of the people involved (Myers 1997). Becoming more common in the field of cartography (Suchan & Brewer 2000), qualitative research represents an exploratory approach to studying social issues and involves the development of themes for organising the rich, descriptive information through strategies such as ethnography, grounded theory, case study, phenomenology and narrative (Creswell 2003; Neuman 1997). Qualitative research commonly involves observations of participants in the field (hence the term 'field study') as well as interviews, questionnaires, documents, texts and researcher impressions and reactions (Myers 1997). The data are necessarily descriptive and consist of words (e.g. quotations), observations and document excerpts (Patton 2002; Suchan & Brewer 2000).

The depth and detail with which issues are studied through qualitative research offers advantages in terms of increasing the understanding of individual cases and situations. Additionally, the unconstrained approach of qualitative research enables participants' own categories to be captured and used when describing the data. The small numbers of participants and cases involved, however, reduces the ability to generalise findings. Moreover the sheer volume of qualitative data and its lack of standardisation can make analysis a daunting and difficult undertaking (Patton 2002).

4.1.3 Mixed methods research

The respective advantages and disadvantages of quantitative and qualitative approaches elicit differing levels of importance, depending on the problem at hand. In some areas of study, quantitative research will clearly dominate qualitative research as the approach of choice, and vice versa. In many cases however, a *mixed methods* approach is taken, combining techniques from both qualitative and quantitative research, in order to ensure meaningful and comprehensive results. Mixing methods not only serves to reduce the respective limitations and bias of each approach, it also enables the results of each technique to be used to inform subsequent techniques (Creswell 2003). This is essentially how UCD operates, with the combination of various UE techniques enabling the collection and analysis of both quantitative and qualitative data (often simultaneously). This is particularly important to the specification of usability goals (refer to Tab. 3), towards which design activities proceed and against which resulting designs are iteratively evaluated (Mayhew 1999).

5 Research Plan

Experts in the field of UCD acknowledge that it is not always feasible to employ every UE activity and technique, due to time, budget and other resource constraints (Mayhew 1999). They therefore suggest that a smaller subset can be sufficient to achieve the required aims, provided that Gould & Lewis' (1985) base principles (see Section 4) are adhered to (Nielsen 1992). Accordingly, the goals and scope of the research were considered in order to identify a set of UE activities to be employed for the research. Tab. 3 details the activities selected for the research, along with some of the techniques available for each.

The plan for the research, incorporating the above activities is presented in Fig. 1. The remainder of this section provides specific discussion of the three key UCD activities involved – User Profiling, Contextual Task Analysis and Evaluation – in terms of their position within UCD and the UE techniques selected, as well as their relationship to specific qualitative and quantitative social research methods.

5.1 User Profiling

As with other computer-based interfaces, it is perilous to suggest that a single style of DMM, employed within LBS, can be developed to suit every user type. With reference to geovisualization in general, Fairbairn et al. (2001) identify that individual users tend to react differently to alternative representations of the same geospatial data, depending on their preferences, experiences and abilities. Applying this to DMMs, in order to evolve design guidelines/models the possible range of target user characteristics must first be understood (i.e. "know the user"), which will enable both general and specific user requirements to be established for the ongoing research (Nielsen 1992, p.14). The first stage of this process is to be accomplished through the activity of User Profiling, which aims to define the target user population.

LBS can take on numerous forms and thus appeal to a wide variety of users (Niedzwiadek 2002). Short of designing DMMs for the 'entire population', it was deemed necessary to restrict the target user population by concentrating on a particular application area. Following discussions with the industry partner and background research, the application area of 'leisure-based travel' was selected, and further delineated as travel to distant, often unfamiliar, locations within Australia, which is undertaken on a regular basis (Urquhart et al. 2003). In the absence of a readily available set of individuals whose activities fit this description, an existing and more generic user group has been selected for the research, consisting of (Australian) general public users of online directory services. This user group will be employed to identify and profile individuals who are potential users of a 'leisure-based travel' LBS. The User Profiling stage of the research is therefore deemed to have two purposes. Firstly, it will be used to screen members of the existing user group and thus identify those relevant to the selected application area. Secondly, it will help to obtain a current description of the selected target users in terms of psychological (e.g. attitude, motivation), knowledge and experience (e.g. task experience, geospatial skills and abilities), goal and task (e.g. frequency of travel, task structure) and physical characteristics (e.g. colour blindness) (Mayhew 1999).

	Activity	Aim / Description	Techniques
Pre-Design Phase	***Know the user***		
	User Profiling	To develop a description of the type of users who will ultimately be using the system, in terms of their relevant demographics, abilities and experience.	Questionnaires, interviews
	Contextual Task Analysis	To understand the users' goals, approaches to tasks, information needs, etc. in their actual 'work' environment, and to identify any weaknesses in the current situation.	Contextual inquiry, task modelling
	Setting usability goals		
	Usability Goal Setting	To define qualitative (e.g. learnability and satisfaction) and quantitative (e.g. error rates) usability goals for use as acceptance criteria during evaluation activities.	Analysis of User Profiles & Contextual Task Analysis
Design & Development Phase	***Guidelines and heuristic analysis***		
	Platform Capabilities / Constraints	To study the capabilities and constraints of the selected technology platform, relevant to the design.	Document review, interviews
	General Design Principles	To identify all relevant design principles and guidelines.	Document review, interviews
	Participatory design – Empirical testing – Iterative design		
	Design	To produce a design incorporating presentation and interaction rules, displays and navigational pathways.	Application of previous analyses
	Prototype development	To incorporate the design into a form that will support its evaluation, refinement and validation.	Prototyping (low to high fidelity)
	Iterative Prototype Evaluation	To iteratively evaluate, refine and validate the design, involving tests with real users and representative tasks.	Usability testing, usability inspection

Tab. 3: UE activities relevant to the research (adapted from Mayhew 1999; Nielsen 1992).

The two most common data collection techniques for User Profiling are *interviews* with parties knowledgeable about the user population and/or *questionnaires* distributed to actual users. The latter has been chosen, due to the relative ease of data collection and the fact that more qualitative, in-depth user information will be gathered with the help of interviewing during the subsequent Contextual Task Analysis activity (see Section 5.2).

Although traditionally a quantitative approach to research, questionnaires can be considered as either quantitative, qualitative or both. The use of closed questions (i.e. with predetermined response categories) enables the collection of data that can be quantified, whilst the use of open-ended questions (prompting descriptive, opinion-based responses) allows for qualitative analysis of the results (Patton 2002). While both styles have been employed for this stage of the research, the questionnaire is not a standardised instrument and thus the results cannot be generalised reliably (i.e. quantitative analysis is not possible). This is not considered an issue however, as the questionnaire analysis will not be used to make generalisations about the larger population. Instead it will help to define the characteristics of the target users who are the focus of this study, whilst qualitatively developing high-level themes (for input into later stages) regarding geospatial information use and DMM design requirements, in the context of LBS for leisure-based travel.

5.2 Contextual Task Analysis

In addition to defining the target user group, a designer also needs to *understand* the users – in our case in terms of their current geospatial goals, their approaches to relevant tasks, their geospatial information needs and any problems with current methods during their travels – in order for the design to adequately support them (Gould & Lewis 1985; Nielsen 1992). This is the second stage of getting to know the user and may be accomplished through a 'Contextual Task Analysis' (the process of obtaining a user-centred model of tasks as they are currently performed (Mayhew 1999)), the activities of which parallel the 'Contextual Design' activities of Contextual Inquiry and task modelling (Holtzblatt & Beyer 1993). We have chosen to adopt this approach, extending the task modelling process to include models of how users *would like* to complete tasks and how the *design* will ultimately provide for task completion.

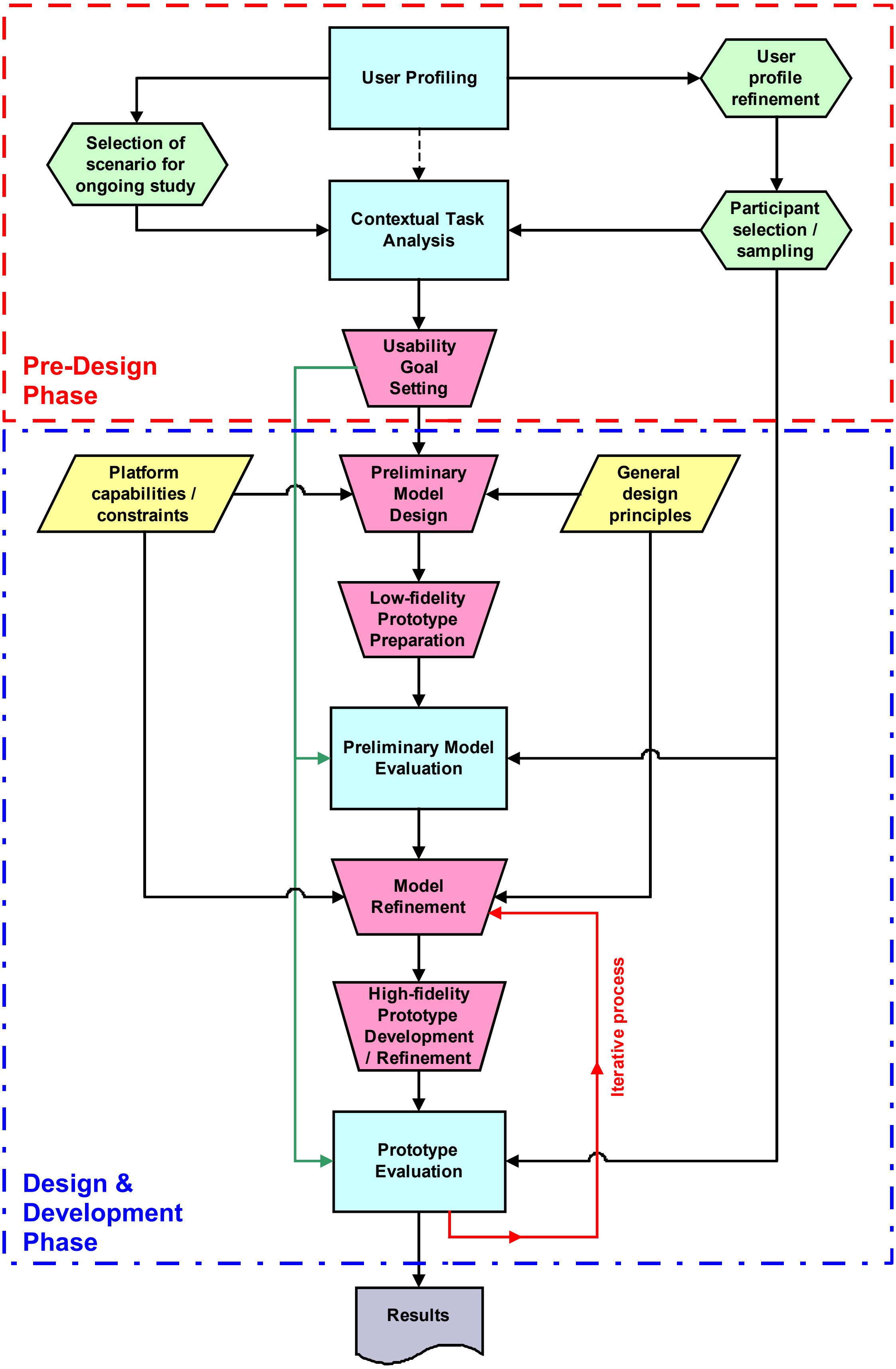

Fig. 1: Flow diagram of the research activities.

Contextual Inquiry is the main data collection activity planned for the Contextual Task Analysis. Put simply, it involves observing and interviewing users in the 'real' world whilst they undertake 'real' tasks (i.e. in *context*) (Raven & Flanders 1996), with the relationship created being one of 'master' (user; teaches while doing) and 'apprentice' (designer; learns by observing/questioning) (Beyer & Holzblatt 1995). This field research method was largely adapted from ethnography, which developed within anthropology as a qualitative social research strategy for gaining insight into the life experiences of different cultural groups, and is characterised by researchers immersing themselves in the field for extended periods of time in order to "investigate, study, analyse, interpret and describe unfamiliar cultures" (Blomberg 1995; Mayhew 1999, p.3). Its adaptation and simplification for Contextual Inquiry has resulted from calls within the HCI and system design communities for design that incorporates a deeper understanding of the unique culture of a given user group, their environment of 'work' and their current work practices (Blomberg 1995; Mayhew 1999).

We will employ Contextual Inquiry to obtain detailed information about target users' needs, decisions and actions, which they may otherwise have difficulty articulating (Holtzblatt & Beyer 1993). As emphasised by Raven & Flanders (1996), the inquiry must be based on a focus and ours will be clearly directed toward collecting data relating to user goals and tasks that rely on the access and use of geospatial information. The sporadic nature of leisure-based travel will make it difficult to observe/interview users undertaking actual work and thus a modified process of 'artifact walkthrough' will be employed for the Contextual Inquiry (Raven & Flanders 1996). In this respect, users will be asked to 'recreate' a travel-based activity, using the artifacts (or tools) that they would normally use, in order to stimulate their recollection of past travel experiences. The use of a representative scenario for users to follow (developed from the User Profiling data) will aid this process, as well as serving to limit scope. Scenarios can help to keep the design process "focused on the needs and concerns of users" (Carroll 2000, p.45) and thus it is anticipated that the scenario employed for the Contextual Inquiry (intentionally broad and flexible) will be utilised throughout the remainder of the UCD process, being refined and elaborated as the research progresses. A final point of consideration comes from Slocum et al. (2001), who warn that simply observing users undertaking tasks with current tools is insufficient to gain insight on what might be possible, since those tools may not correspond with the possibilities for online digital mobile mapping. In lieu of this, upon completion of observed tasks users will be questioned about how they would expect/desire a LBS to help attain their goals.

The second stage of Contextual Task Analysis comprises the development of task models for use in the subsequent design activities. In this respect, the data from the users involved in the Contextual Inquiry (contained within videotape and field notes) will be analysed and a number of high-level themes evolved, relating to the users' goals when approaching the scenario, the tasks they undertake in order to do so, the geospatial information they require throughout, the decisions they make, common problems encountered and any implications or suggestions for DMM design. It is envisaged that Affinity Diagrams (a series of 'sticky' notes detailing important findings, which are rearranged on a wall into clusters of similar items) will help in organising the data according to themes and thus providing insight into the users' needs and tasks (Holtzblatt & Beyer 1993; Raven & Flanders 1996). Moreover, the development of formal sequence models, representing the order of actions employed (and desired) by users in completing the scenario, will enable a detailed definition of which tasks the design must support (Holtzblatt & Beyer 1993).

5.3 Evaluation

Perhaps the most prominent message to be gained from the UCD literature is the need for iterative design and *evaluation*. The impetus for this is that through ongoing evaluation during the development lifecycle, conceptual models and design ideas can be continuously tested, validated and modified, ensuring a rigorous design process and thus less expenditure of effort in ensuring usability once development is complete (Gould & Lewis 1985; Mayhew 1999). There are two principle types of evaluation for UCD, namely *empirical usability testing* and *usability inspection methods* (Butler 1996).

Usability testing involves the collection of data relating to a set of usability parameters (e.g. learnability, user satisfaction, error rates) during observations of target users interacting with the design (e.g. via a prototype) to perform representative tasks (Butler 1996; Rubin 1994). Usability inspection methods are less formal techniques for identifying usability problems, involving 'inspection' of the design by various evaluators including usability specialists, human factors experts, designers, developers and users (Nielsen & Mack 1994). Research has shown that usability testing can uncover usability problems that are overlooked by inspection methods and vice versa (Jeffries et al. 1991). This has lead Nielsen & Mack (1994) and others to suggest that optimal results may be achieved through a combination of methods, with the different types of evaluation having relative importance to different stages of a design project (Butler 1996). In light of this, two types of evaluation are planned for the research: (1) a usability inspection, early in the design phase; and (2) iterative usability testing toward the end of development.

Pluralistic walkthrough (Bias 1991; Nielsen & Mack 1994) has been selected above other usability inspection methods for this research. The primary reason for this is that pluralistic walkthrough involves representative users in the inspection process, unlike the other methods. With this in mind, since the aim of this research is to produce DMMs that are considered useful by the *target users*, based on their evaluation of alternative representation techniques, other inspection techniques[1] were generally deemed unsuitable. The pluralistic walkthrough for the study will follow the evolution of a number of preliminary design models from the established user task models. The aim of this evaluation is to obtain rapid and early feedback on the usability of the various DMM models (i.e. the design), mainly relating to qualitative usability goals defined during a previous activity (see *Usability Goal Setting* in Tab. 3). To this end a 'focus' group will be assembled comprising target users, a human factors expert and a cartographic expert, as well as the

[1] Including: heuristic evaluation, guideline review, consistency inspection, standards inspection, cognitive walkthrough, formal usability inspection and feature inspection. Refer to Nielsen & Mack (1994) for more detail.

principal investigator (developer). Together the participants will step through a sequence of tasks comprising the selected scenario (via a low-fidelity, paper-based prototype), discussing perceived problems with the usability of each component representation and possible design solutions. The main advantages of this process are that valuable collaborative and subjective design feedback will be obtained quickly, and any revisions can be easily implemented since no major commitments or resource investments have yet been made toward particular designs (Bias 1991; Mayhew 1999).

The usability testing will be more formal, involving a high-fidelity prototype – essentially an operational LBS demonstrating the refined DMM design (incorporating alternative representation models), which resulted from the previous evaluation. This activity will be more rigorous than the walkthrough evaluation, involving the collection of empirical observation data in order to measure and compare the usability of the DMM models, evaluating them against the quantitative and qualitative usability goals defined previously. The evaluations will be conducted on an individual basis, involving target users, and will be iterated following related refinements of the design (as far as time permits). Although it is impossible to test *real* situations of use (Rubin 1994), the testing will attempt to represent actual use as far as is practical, employing the adopted scenario 'outside the laboratory' and thus asking users to complete representative tasks using the prototype in the 'real world'. This concept of *field study* is considered highly relevant to HCI research involving mobile systems, since "Mobility is very difficult to emulate in a laboratory setting, as is the dynamism of changing context." (Kjeldskov & Graham 2003, p.326).

Nielsen & Levy (1994) contend that "usability is a general concept that cannot be measured but is related to several usability parameters that *can* be measured" (p.67), and that the collection of subjective data, is equally as valuable for informing the usability of a system. For the two usability evaluations, subjective data (incorporating user opinions, preferences and behaviours) will be collected and qualitative methods of analysis used to evolve themes, patterns, understandings and insights relating to usability problems with the models, and thus techniques for improving them. Moreover, the collection of objective (i.e. performance) data during the second evaluation phase will enable quantification of some of the issues involved. In summary, it is envisaged that, by feeding subjective and objective user evaluation data back into the design on an iterative basis, models for the representation of geospatial information that are useful for the target users will be achieved.

6 Conclusion

In this paper we have demonstrated a need for ensuring useful DMMs within LBS and have proposed a methodology that is aimed at addressing this need. In doing so we have argued that, while technology-centred research and development is valuable, it must be supplemented by user-centred studies in order to enable the development of useful (and successful) online digital mobile mapping services. Although this view is supported by the cartographic and LBS literature, a review of existing research has indicated a general lack of user involvement in the design of DMMs to date. It is for such reasons that UCD has been selected as the overarching methodology for the study, incorporating a mixture of qualitative and quantitative social research techniques that place the user as the focus of design activities. A review of available UCD techniques has been undertaken, with three key activities adopted for the research – User Profiling, Contextual Task Analysis and Evaluation – incorporating the development, refinement and application of a representative LBS usage scenario. Ultimately, by applying the proposed methods within the framework of UCD, we hope to achieve our aims of creating useful geospatial representations within LBS for the defined user group and identifying specific user issues that may form the basis of future research programs in the area.

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Improving the Usability of Mobile Maps by Means of Adaption

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Abstract

An early usability evaluation of mobile maps was performed in an EC-funded project "Geospatial info-mobility service by real-time data-integration and generalisation" (GiMoDig). The purpose of the project is to improve accessibility and interoperability of national topographic databases for mobile use. In user-centred product creation an early evaluation of the product is regarded important for resulting in good usability of the end product. The early user test results were utilized to develop principles for context-aware topographic maps and a suitable UI for the GiMoDig service. A set of mobile contexts relevant for navigation was identified based on the field tests on mobile maps in Nuuksio National Park, Finland. Regarding mobile map services, the most important context of use is currently the location of an user. However, other context elements worthy of attention identified in the test included system, purpose of use, time, physical surroundings, navigational history, orientation, user, and cultural and social elements. Some of these elements were implemented and further elaborated in the paper. The implementations on a PDA device were carried out with a Mobile SVG viewer called eSVG. Although, currently the performance issues for SVG visualizations on PDA seem to be a bottleneck, the examples show how adaptive maps would better meet the demands of the users. However, as normally in the iterative process of user-centred design, the implementations presented here will also be evaluated, and experiences used in the second round of user-centred design cycle.

1 Introduction

There are already a few commercial applications for maps in mobile devices, in which the maps are displayed on the screen of a Personal Digital Assistant (PDA), cell phone or other devices with small displays. Most of the applications are for car navigation purposes, but there exist also products for off-road navigation for cyclists or walkers (Navman GPS 3300 Terrain; Outdoor Navigator; TomTom CityMaps; Falk City Guide; MapWay; 2003). Mainly all of the services so far provide the maps only in raster format, but there are also vector formats emerging, mainly because of the higher quality visualisation and interaction possibilities.

Mobile applications have lead to the rise of usability studies on map design and visualisation. The map in a mobile device can be treated as a Graphical User Interface (GUI), and therefore the methods used in Human Computer Interaction (HCI) can also be brought to cartography. There are also other cartographic research projects on mobile guides, which consider the usability issues in their product development, e.g. WebPark (Edwardes et al., 2003) and LOL@ (Pospischil et al., 2002).

The usability of the applications can be evaluated by many different methods, and the evaluation can be done either by the project developers or by bringing the users into contact with the product. It seems that getting the users involved with the development of mobile applications is the best way to provide the most suitable products for the market at the end of the project development cycle (Bornträger et al., 2003; Schmidt-Belz et al., 2003; Heidmann et al., 2003; Melchior, 2003).

In general, there is an emergent need for more intelligent user interfaces and one of possible approaches to be considered is the context awareness of the systems. According to a previous study by the authors this applies also to the small display maps – embedding context awareness into the maps could also increase the usability of mobile map applications (Nivala and Sarjakoski, 2003).

In this paper we present the first examples of the maps that are adapted to some of the context elements. The following section starts by a description of the background for the implementation work and then we continue by demonstrating our experiments on the GiMoDig GUI and adaptive maps. The conclusions are given after remarks on the future implementations.

2 Implementation background

2.1 XML-based architecture

The studies presented in the paper are a part of the EC-funded project "Geospatial info-mobility service by real-time data-integration and generalisation" (GiMoDig, 2003). The overall purpose of the GiMoDig research and development project is to improve accessibility and interoperability of national topographic databases. The project will result in a prototype system providing

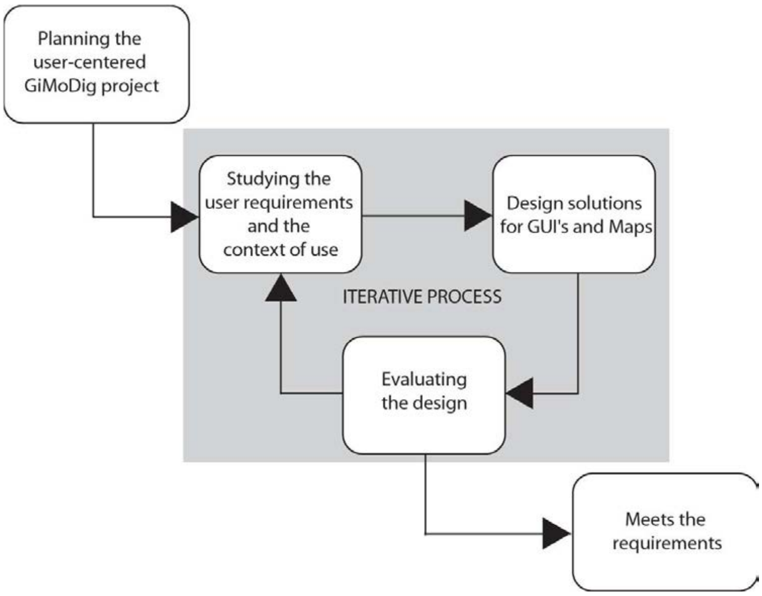

Fig.1: User-centred design cycle in GiMoDig project (adapted from the ISO 13407 standard, 1999).

geospatial service across the participating countries consisting of Finland, Sweden, Denmark and Germany (Sarjakoski et al., 2002a;b). The system is based on the use of Extensible Markup Language (XML) – technology, the Web Map Server (WMS), Web Feature Service (WFS) and Open Location Services (OpenLS) by Open GIS Consortium (OGC, 2004). The prototype architecture and principles are described in detail by Sarjakoski and Lehto (2003) and Lehto (2003), and also by Lehto and Sarjakoski (2004).

2.2 GiMoDig field-testing

The user-centred design cycle for the GiMoDig project is illustrated in Figure 1. The study started by collecting information about the user requirements (Jakobsson, 2002). Field-testing was one of the methods used as described in detail by Nivala et al. (2003). The goal of the study was to examine the usability of present topographic maps in mobile devices, to derive user requirements and to identify design principles for adaptive maps to be displayed in the GiMoDig GUI.

A group of appropriate test users was brought to the Nuuksio National Park, where they were asked to complete predefined test tasks using topographic maps shown on a Personal Digital Assistant (PDA) (Compaq's Pocket PC) with Genimap's Navigator LT software. The mobile raster maps used in the evaluation were derived from the Topographic Database of the National Land Survey of Finland. Two observers monitored the users during the evaluation, and interviewed them when the users were performing the tasks with the aid of mobile maps.

One of the central outcomes of the results was that the main benefit of the mobile map services was seen to be combining additional data and presenting it on the top of the topographic map data. The users' obvious need for additional information showed that there is a clear need for integrating data from various sources. Separate topographic datasets are not enough from the users' point of view: users need meaningful maps that have right information in right place at right time. The most interesting test result for the field test study was identifying the different context elements around the user during the mobile usage situation (Nivala and Sarjakoski, 2003). It was noticed, that the actual environment of the mobile user essentially affects the use of maps.

The aim of the current paper is to describe the preliminary client implementations, which were created during the first iterative round in user-centred design cycle based on the field-testing results.

2.3 Mobile contexts

The map is always strongly related to usage situations in which the user tries to find his/her way in an unfamiliar environment. As described above, based on our earlier experiences from the user tests, there seems to be a clear need for context awareness in topographic maps in mobile devices (Sarjakoski and Nivala, 2003). The location of the user is the most obvious context information needed. According to the study by Nivala and Sarjakoski (2003), also several other context elements seem to be relevant for the use of topographic maps in mobile devices: user properties, purpose of the use, time, orientation of the user, system properties of the device, physical surrounding, navigation history, and cultural and social situation. In Figure 2 the different contexts relevant for mobile map usage situation are illustrated.

In the centre of everything is the user: *Who is he? What is the way of the transportation he is using? How old is he? Does he have some physical constraints?* The purpose of the use is also important: *Is the user just wandering around in entertainment purposes, or is he going fishing?* His location, and direction of the movement are also relevant, as well as the physical surrounding around him: *Is the weather sunny? Are there many hills on the way to his target? In which kind of cultural environment does he exist? What is his social situation at the time?* And finally: *What kind of mobile device does he have?*

The surrounding context defines, what kind of map the user wants and needs. The user should not feel frustrated or stupid when trying to understand the map. The user needs maps at different scales, and the maps should provide comprehensive information in various formats to various types of devices. Even a small change in map content and adaptation to the surrounding contexts can improve the usability of the map and make the user satisfied.

Due to these facts the map service providers face a challenge to generate and maintain mobile map services. In order to gain experience on benefits of maps adapted to the user's context, an effort was made to implement some context-aware maps.

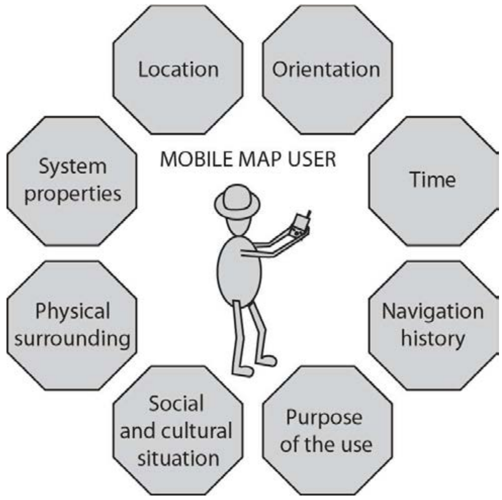

Fig. 2: Surrounding context of the mobile map user is composed of different elements.

2.4 SVG for the GUI

The Scalable Vector Graphics (SVG) was used as a tool for implementing the client user interface and the adaptive maps on a PDA. The PDA used was Compaq's IPac 5500. SVG offers some benefits over other graphics formats. Since SVG is an XML- application it fits very well to the XML-based server technology (Sarjakoski and Lehto, 2003). Being a vector graphics format, it is flexible on the client, e.g. for zooming. The flexibility is further strengthened by its scripting capability, making it possible to create active, "clickable" maps (Lehto and Sarjakoski, 2001; Reichenbacher, 2003).

Our implementations on a PDA device were carried out with a Mobile SVG viewer called Embedded Scalable Vector Graphics (eSVG, 2003) from Embedding.net, belonging to EXOR International Inc. The eSVG is a SVG viewing software developed especially for the mobile environment and has support for Java-scripts. In addition, it can be used as an Active X-component from Visual Basic. In our client application the SVG functionalities are controlled by Java-scripts. A SVG- image consists of a set of elements, which can be manipulated interactively as described above.

2.5 Scope of the preliminary implementation

The client sends a request from the PDA to the GiMoDig server, which returns the requested map area. The topographic information is delivered from the National Mapping Agencies' (NMAs') geo-databases in real-time through the GiMoDig server to the client PDA. In the server the data is processed into a Euref-based coordinate system and expressed according to the Global Schema of the GiMoDig (Illert and Afflerbach, 2003). The map objects (or layers) to be shown on the map can be selected by the client application. For each adapted map these selections are predefined as a part of map views. At the time writing this article the user had a possibility to choose only among a set of predefined test areas. Also, in the implementation discussed here, the intelligence for adapting the maps for specific usage situations was built up in the client application. One particular limitation regarding the preliminary implementation was a simple test database on the client for the points of interest (POIs).

3 Preliminary GUI and adaptive maps

3. 1 Personalization of the service

The current GiMoDig user interface implementation includes the personalization of the following features: Identity, Activities, Time, Place and Device, Figure 3. These features response to the studies on mobile contexts described above: user properties, purpose of the use, time, orientation and location of the user, system properties of the device, physical surrounding, navigation history, and cultural and social situation. However, the user is not forced to define the user preferences if she/he so wishes; in that case the application defines the default parameters automatically. Since the GiMoDig service is a prototype system resulting from a research and development project, many of the features to be implemented aim only for demonstrating the capability of such a system and rather show the direction of possible further development.

Identity
The possibility to personalize the service according to the identity of the user includes: the choice of the language and the choice of the age group. The choice of the language reflects to the language of the user interface itself; in our case the languages of the participating countries are included in addition to English. The choice of the age group in turn reflects to the requested map's layout.

Fig. 3: Personalization of the GiMoDig service on a PDA.

In our example in Figure 4 we have chosen English as a language and the age group 0-17 years for presentation layout. The following Figure 4 shows the selection menu for the Identity.

Activities
The activities here refer to the use cases in favor for the user. She/he has a possibility to choose among a set of use cases, which are hierarchically organized. In our example the main activities include: Public services, Outdoors, Restaurants and shops, Tourism and traveling and Expert use. After the user has made her/his selection, the Activity-menu is automatically personalized according the user's favors and shows only her/his own Activities.

Time
The user has the possibility to define the season and time of the day, according to which map information she/he is interested to be displayed. If no specific user preferences are given the default time is always the current time.

Place
The user's location in the center of the delivered map is used as a default for the displayed map. However, also other areas might be of interest for the user. Additionally, an expert user has a possibility to define the coordinates for the area of interest.

Device
At the time witting this article it was only possible for the user to get the displayed map on a PDA. For the demonstration purposes the user will be later able to choose among a set of devices. However, the type of the device could be set by the system automatically in the final client application.

3. 2 Adaptive seasonal maps

In order to illustrate how the system responses to the user depending on the personalization and context of use, we first describe an example of possible user scenario and then continue by showing how the adapted maps are changed.

A user scenario
In our example a teenage boy is visiting the Nuuksio National Park in Finland. It's Sunday morning in June and the boy wonders how to spend his time there, while forced by his parents to spend at least two hours in fresh air after spending all the Saturday with video games. As a comfort his parents have given him a PDA with the GiMoDig service. Our teenager thoughts, that he might find the nearest cottage to by some soft drinks and defines his activity to be "Outdoors" on the GiMoDig service. The system shows a map with available outdoor activities around the location of the teenager. The map shows also that there is only one possible rest place within a short distance. By clicking the red cottage on the displayed map, the teenager notices that the rest place is open today between 8-16. "Brilliant! I'll go there and spend the two hours there". While walking he wonders what would have happened if his parents would have taken him to the park in wintertime instead. "Would there have been any routes at all? Would I have to have to crawl in the snow for get any drinks?" Because of curiosity he defines the wintertime season for the GiMoDig service and for his horror notices, that the rest place is only open during summer times. "I would have been frozen in less than 5 minutes! They would have been so sorry for wanting me to have more fresh air…" He also notices, that some of the routes used by hikers during summertime are used by skiers during winter. There are also additional routes for only skiing. There is also a jigger visualized on top of the lake and that brings the first good ideas to his attention: "Wow, can they really do that also within these co-ordinates? Actually, wouldn't it be nice to take some friends with me and to come over here some time, do some fishing and bake the fishes on those campfire place? Hmmm…" And he continues his walking, and it can be assumed that perhaps he has a little bit less negative thinking about "getting the fresh air" as earlier…

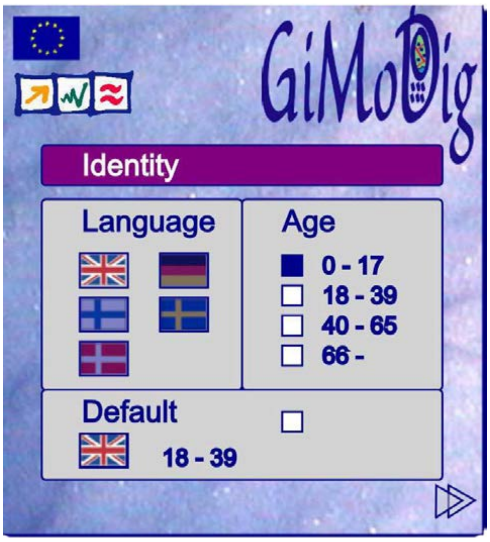

Fig. 4: The identity menu shown as a screen shot.

In Figure 5 the user has received adapted maps responding to the user preference "Time". The options "Summer"/ "Winter" with the current time are used, as well as the "Activity": "Outdoors". When the user clicks the symbol of cottage, he gets additional information for the current moment "Rest place open 8-16".

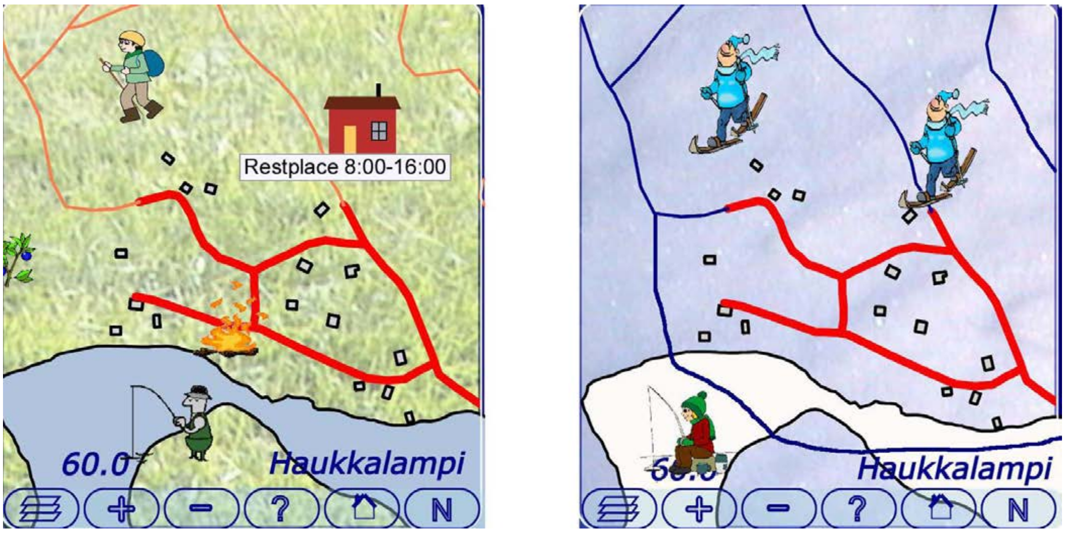

Fig. 5: The adapted seasonal hiking and skiing maps for a user in age group 0-17.

Map layout

In the first phase of the GiMoDig project studies on small display cartography were made (Nissen et al. 2002). In the seasonal maps shown in Figure 5 further experiments regarding the map layout are done. We have used a kind of photo realistic presentation: the topographic map data received from the server is shown in vector format (SVG), together with the POI symbols on the top of the background raster image (for the winter map “snow”, and for the summer map “grass”). It can also be seen how the information on the same Activity map “Outdoors” changes while the season is changed (context “Time”). In the summer map to the left the hiking tracks are shown, while in winter map to the right the user is only interested in the skiing tracks. The tracks for hiking and skiing are partly differing from each other. The map is adapted for the time of the year - fishing in wintertime is possible also in the hole on the ice-covered lake and the skiing tracks can be found on the ice also. Since the maps are aimed for the youngest user group in our example, we demonstrate how the impact of “having fun” is aimed to reflect to the map layout. This shows the importance of designing the future map symbology: much more efforts have to be made in order to provide the user with such a presentation that would attract him among a lot of alternatives. For example, a game like presentation would please the young generation and they might become more interested to use map services in general. However, to approve this assumption new user tests are needed. The older users for instance, would have high demands on the visibility of the map symbols.

3.3 Considerations for future implementation

In our first experiments, only a simple test database for the POI data was used. For the further development we are implementing the POI database on the GiMoDig server. Since the available POI data on the market only consist of a very limited number of additional information, the contents for our POI database must be gathered manually, and will be available on our test areas for a limited number of use cases.

The intelligence to derive the adapted layout was implemented on our client in the presented GUI version. This part will be moved into the server side, and will consist of definitions of several map views regarding the map contents, generalisation level and layout of the adapted maps.

Although the SVG images need a lot of processing power, at the same time the SVG is an interesting tool for implementing high quality maps. However, we are also examining other tools for the implementation.

4 Conclusions

The actual environment of the mobile user essentially affects the use and requirements of the small display maps. The users require different maps for different purposes and for different situations, contexts. The adaptation of map presentation and content according to the usage situation could greatly improve the usability of mobile topographic maps.

In the paper we introduced the first experiments on adapting the map to some contexts. The implementations cover some test areas and only in few usage situations. The contexts implemented included Identity (user properties), Activity (purpose of the use), Time (season, time of the day), Place (orientation and location of the user) and Device (system properties of the device). However, due to the iterative process of user-centred design, the implementations presented here will be also evaluated, and the results will in turn be used for the next round implementation of of the client application for user-centred design.

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Privacy, Web Map Access and User Confidence

William Cartwright, Melbourne

Abstract

Using the Web and Mobile devices for locational information provides users with access to a plethora of geospatial resources or an immediate at-location service. We have become attuned to using the Web as a 'first-stop' virtual shop for all things geographical. And, the Mobile Internet, accessed through the use of mobile telephones or enhanced Personal Digital Assistants (PDAs), enables us to bring map artifacts, commerce and information resources to us, wherever we require the service. Our whole approach to finding and using cartographic artefacts has changed. But, it is argued, at a price – the loss of privacy.

Consider accessing 'free' geographical information using the Web. Prior to actually downloading data, services or digital products we are usually obliged to provide certain details of ourselves. This can range from general profession/country information to those of a more specific nature. With mobile telephone use the service provider knows, fairly precisely, where we are and who we are when a location-based service is requested and subsequently delivered. We have sacrificed privacy for almost instant access to digitally-delivered information.

This paper addresses the issue of privacy related to the use of Web-delivered and mobile telephone-provided geographical information. Firstly, it looks at the general issue of privacy and how it effects the delivery of information using contemporary communications systems. Then it looks at the loss of privacy that has occurred when ‚new' communication systems are introduced. Then it considers how service providers have compromised privacy with online and wireless systems. It then covers aspects of security and privacy initiatives. Finally, it comments on problems with developing technology and some of the privacy and security issues that need to be addressed by the geospatial science industry involved in the delivery of Location Based Services (LBS).

1 Introduction

The extent and the use of the Internet have now matured to a point that users see it as an everyday commodity or communications device. Education has embraced it for content delivery, face-to-face lecture support and as a tool for students to keep in touch with academics and peers, and to conduct day-to-day administrative and general queries. Industry uses it as a tool for facilitating more effective logistical approaches. Commerce uses it as a means for linking their services. And, business views it as a conduit for marketing, selling and delivering (digital) products.

In a fairly recent report, *The UCLA Internet Report - "Surveying the Digital Future"* (UCLA, 2003), the extent about how the Internet has been embraced can be seen. This UCLA report, coordinated by the UCLA Center for Communication Policy, is a year-to-year study of the impact of the Internet on social, political and economic behaviour of users and non-users of the Internet. In general, the report noted that:

- Internet access remained generally stable from 2001 to 2002 and online hours increased, as did the use of the Internet at home;
- Use of the Internet spans all age groups;
- The Internet was seen as an important source of information (in 2002 over 60% of all users surveyed considered the Internet to be a very important or extremely important source of information);
- The Internet had widened the number of people that respondents communicated with;
- Use of the Internet for making purchases online had declined, but the average number of purchases made this way had increased; and
- There were growing numbers of people use the Internet for business purposes, from emails to business-to-business and business-to-customer transactions.

However, there were some concerns:

- Firstly, the number of users who believed that information on the Internet was reliable and accurate continued to decline in 2003 (just over 50% of users thought that the Internet was reliable and accurate – a decline from both 2001 and 2002; and more than a third of the users thought that only about half the information on the Internet was reliable and accurate);
- Secondly, there were concerns about using credit cards online, especially related to hackers and "too many unknowns";
- Thirdly, approximately 45% of respondents who used email at work reported that their email was monitored by their employers, as well as their general use of the Web;

- Finally, users interviewed were concerned about Internet privacy, especially related to buying online (there were high levels of concern about this, but it had declined from responses received in surveys previously conducted in 2001 and 2002).

Use of the Internet has grown tremendously, but its use is relatively new, and there are major issues of concern related to security and privacy. It is argued that with the Mobile Internet these issues are compounded when the receiver/transmitter (a cellular telephone or an Internet-enabled Personal Digital Assistant (PDA)) is included in the formula. Those provisioning users with map products and services related to the 'Location-Based Services' phenomena must be aware of the potential personal risks associated with 'someone else' knowing where users are at any given time, their movement history and their activities linked to them being at a certain location. This paper addresses the issue of privacy related to the use of the Mobile Internet and the responsibility we, as providers or facilitators of geospatial information delivery via the Web or by providing support for LBS projects, have to ensure that a user's privacy is not compromised and that adequate privacy and security standards are developed for this sector of the industry. In so doing, the paper will address personal and security issues related to other communication provision devices and systems and then propose issues that we need to address.

2 Privacy

Monmonier (2003) covered the issue of privacy and the Internet and coined the term “”locational privacy” (p. 99). In this book chapter he addressed the issues related to the use of the Internet and GPS-enabled mobile appliances. Related to 'tracking' users, the chapter focussed on 'known' tracking, where law surveillance agencies and organisations could follow the movements of known criminals and automobiles, individuals could subscribe to 'child-tracking' or keeping tabs on elderly parents (Monmonier, 2003). The approach of this paper differs to that of Monmonier, insofar as it addresses the unknown (to the user) surveillance possible with LBS (Location-Based Services) and the confidential or private information we, as users, readily offer to providers of services and goods in return for speedy delivery, online transactions or services and information delivered directly to our desk-bound or mobile device.

For example, loss of privacy was a trade-off for the US Federal Communications Commission's decree that all providers of mobile telephone services needed to be able to locate a caller in an emergency to the nearest 125 metres (Monmonier, 2003, from Divis, 2000). This was in response to findings that showed that US 911 (emergency) dispatchers had reported that many callers to their facilities in emergency situations did not know where they were. However, technical problems have stalled the introduction of services that can provide the required positional accuracy.

3 What happened with non-Web products?

If we consider the Web to be just a two-way communication device, then we can draw some parallels with other, historical two-way communication systems and consider what the user sacrificed for 'making contact'. These are the post, the telephone and Teletex/Videotex.

A private postal service was established in Europe in 1305 by the Taxis family. Much later, in 1659, the London 'Penny Post' was available and in 1840 the first postage stamps were sold throughout England. (From www.localhistory.scit.wlv.ac.uk/ plaques/LichfieldStreet.htm: „Sir Rowland Hill proposed that letters should be charged by weight, not distance and that the sender should pay the postage. The scheme went before Parliament in 1837 and an Act of Parliament gave the Royal Assent in 1839. From January 10th, 1840, a letter not exceeding half an ounce could be sent to any part of the country for one penny.“). The one penny stamp used is shown in figure 1.

Fig.1: ‚Penny Black' stamp . Source: http://homepages.ihug.co.nz/~awoodley/Letter5.html

By 1897 postmen delivered mail to every home in England, and the postman became a familiar figure on the streets of England (figure 2).

Door-to-door communication with words written onto paper with ink, which was then folded, sealed, stamped, delivered and the message read. All the user needed was the name and address of the recipient and a one penny stamp. And, to make things more effective, perhaps a return name and mailing address was added to the back of the envelope. The user sacrificed their personal 'location' information so as to use an efficient person-to-person communication system. They could be 'plotted' to the nearest postcode, and then further 'zoomed' into by their actual address. And, this information could be linked to ownership records, purchases delivered to this address etc. The information could be further enhanced by linking the address to census information, providing more information on the family unit, its earning power, preferences etc. For an efficient communication system that used paper and the written word some privacy was sacrificed.

Bell invented the telephone in 1876, providing a person-to-person communication system that used sound (the human voice) to communicate, rather than words, as was the case of mail. Soon telephone lines spread across the USA, in 1902 a Trans-Pacific telephone connected Canada and Australia, in 1914 the first transcontinental telephone call was made, in 1915 a speech was given across the Atlantic using radio-telephone. As this system initially relied on operators (figure 3) to connect individual users who sometimes shared telephone lines (party lines), their conversation could be 'listened-in' by operators or other party line users. Privacy was again sacrificed for 'instant' voice communication. This was improved somewhat in 1919 when telephone users could dial numbers themselves.

The telephone was a personal communications system success and in 1967 there were already 200 million telephones worldwide (half of them in the USA). Privacy was encroached either legally or illegally by 'wiretapping', allowing law enforcement agencies or interlopers to secretly break-in to private telephone conversations. Countries brought in to effect various anti wiretap laws that were usually updated to take-in changes brought about by technology. In 1968 the USA introduced Title III, the wiretap law designed to legislate what could and couldn't be done with telephone conversations.

Television became an information resource through the use of teletext in its many forms. In 1974 the BBC introduced its *Teletext* service. Its potential was exhibited with a nationwide two-way system when *Minitel*, France Telecom's Web service was introduced. France Telecom launched the system in February 1984 and it consisted of a low-cost dedicated terminal in the home or office or as an anonymous kiosk charging system. It provided a range of services through the use of coarse text and graphics (compared to today's standards) on colour television screens, and amongst its information pages it included the French telephone directory and airline schedules. Users with a telephone connection were able to use the screen and keyboard (see figure 4) for two-way communication.

Fig.2: Englissh postman . Source: http://www.lombardmaps.com/cat/prints/costumes/postman.jpg

It was an instant success and at its peak it had 15 million clients in France. Commercial users loved it, and it was used to sell goods, and have clients billed for these goods and services via their France Telecom account. What almost brought the system undone was the pedalling of sex services, and the payment for these services via the same France Telecom bill used for *bona fide* services - something that almost mirrors the Web with the proliferation of pornography and sex sites that have grown to an alarming number. Looking at the problems of privacy and security – users' names were available, as were their telephone number, telephone account details, etc. There was a trade-off of privacy for immediate access to information and services.

4 Going on-line with the Internet

In his book, *Being Digital* (1995) Negroponte outlined the differences in communications that were introduced by the Internet, and particularly the Web. He called this paradigm shift "Moving bits rather than moving atoms". We now take for granted this global system that provides us with access to information from almost anywhere in the world. The simple use of email illustrates how digital global communication changed the way information transfer and privacy was viewed. An on-going debate has been conducted in the USA regarding the amount of control government should have over encryption and the 1994 Communications Assistance for Law Enforcement Act (CALEA) to preserve law enforcement's access to communications. The Act required that telecommunications common carriers had to ensure that their systems could satisfy law enforcement electronic surveillance requests (Berman, 1997).

Also, early in the use of the Web privacy and access became issues. In 1994 many countries restricted or banned satellite dishes to reduce Western influence. And in 1996 restrictions on Internet search engines use in China, Germany, Saudi Arabia, Singapore and New Zealand were introduced. In a 2001 review of 750 commercial Web sites conducted by Consumers International, a worldwide federation of 263 consumer organisations, it was found that two-thirds of the sites examined had collected personal information about visitors to their site. 60% of the sites lacked a privacy statement. Only 9% of European sites asked for permission to sell customer-provided information, 20% asked for approval before adding users to mailing lists and 15% of the sites gathered information in ways that were invisible to the user. Some sites transferred customers' credit card information over unsecured connections (Evers, 2001).

Fig.3: Telephone operator using a manual exchange. Source: www.rockfoundation.org/

For mapping, users do need to be aware what the limitations are when they use a site and what possible consequences might result. For example, the actual location of individual Web site users is able to be tracked. Quova, Digital

Fig.4: Minitel 'kiosk'. Source: http://www.ust.hk/~webiway/content/France/history.html

Envoy, NetGeo and InfoSplit, offer 'geolocation services' (The Economist, 2003). Their databases link IP addresses to particular computers, and then the location (country, organisation and the actual location of the computer) can be ascertained.

Logging-on to a site by MapQuest to find a map of a city is handled in the same manner as locating and using a governmental mapping or atlas site. But, the consequences may be somewhat different. Take for example MCCIS, a Military Maritime Command and Control System that has been developed and maintained for members of the North Atlantic Treaty Organization (NATO). MCCIS electronically processes data from multiple sources, displays data in various command and control applications, and allows the user to manipulate this data. The MCCIS assists strategic and tactical commanders and their staffs in the decision making process.

Civilian users are able to log-on to the site for information. When viewing the data users need to read the privacy policy, which states:
USE OF THIS COMPUTER SYSTEM CONSTITUTES AN EXPRESS CONSENT TO MONITORING AT ALL TIMES.

"This Computer System and all related equipment are to be used for the communication, transmission, processing, and storage of official North Atlantic Treaty Organization or other authorized information only. All North Atlantic Treaty Organization compute systems are subject to monitoring at all times. If monitoring of any North Atlantic Treaty Organization Computer System reveals possible violation of applicable laws, all relevant information may be provided to law enforcement official"
(http://cliffie.nosc.mil/~NAUG/manusr/index.html).

The maps and information are available to all and sundry, but certain rights have to be ‚signed away' to access and use this information.

5 Going wireless

The first cellular mobile telephone network was introduced in Japan in 1979. Since then the coverage and the use of mobile devices has grown tremendously. We have small, portable devices that keep us in contact, constantly and instantly. But we can be 'overheard' accidentally or deliberately. There exist numerous devices to eavesdrop on mobile telephone conversations. And, as Berman (1997, p. 4) points out *"Cellular eavesdroppers are invading the privacy not only of the person who is using a cellular phone, but also of anybody else who is in on the conversation using an ordinary landline telephone."*

In the USA the Electronic Communications Privacy Act (ECPA) was introduced in 1986 and in 1994 the Communications Assistance for Law Enforcement Act (CALEA) (Berman, 1997). CALEA extended legislation to cover email and mobile telephone conversations. According to Berman (1997, p. 3) *this "...gave an important degree of credibility to those communications media when they were in their infancy, contributing to the dramatic growth that they both have undergone"*. The Act of 1986 made it a federal crime to intercept mobile telephone conversations and to manufacture, sell, assemble, possess or advertise any device that could be used to intercept conversations. However, the anti-terrorism Act of 1996 repealed the provision (Pub. L. 04 –132, section 731)) (Berman, 1997).

The Federal Bureau of Investigation (FBI) has pushed to be able to physically track users of mobile telephones. However, the events of 9-11 have changed what is seen as essential information to be kept private. The US has proposed the "Location Privacy Protection Act 2001 to forbid telephone providers from providing information without consent. And, the Wireless Location Industry Association provided self-regulation guidelines whereby users are able to either 'opt-in' or 'opt-out' of the release of positional information (Monmonier, 2003).

Another 'wireless' application is the availability of Wi-Fi (Wireless Fidelity), which provides immediate wireless access to the Internet. The availability of Wi-Fi services is being 'logged' or 'mapped' by various groups, and one in particular has been called the WorldWide WarDrive. This mapping project has revealed the extent of Wi-Fi access points (25,000 access points were mapped in 2002) (Jardin, 2003). The University of Kansas (www.ittc.ku.edu/wlan) also provides information about sites and signal strengths. An example of their information provided as part of the Wireless Network Visualization Project is shown in figure 5.

Websites, such as *wifinder.com* and *80211hotspots.com*, are used as global directories of Wi-Fi base-stations, and sites are located by entering a postcode or a particular address (The Economist, 2003). There is a perceived need to publicise WEP (Wired Equivalent Privacy) and the use of encryption tools when using these network access facilities (Wired News, 2003c). Consider the problems

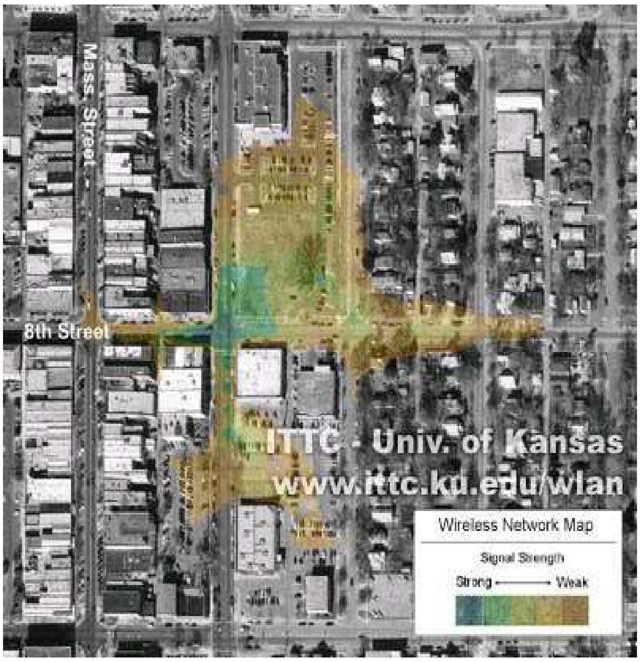

Fig.5: Example image of the signal from a single wireless access point in downtown Lawrence, Kansas. Source: http://www.ittc.ku.edu/wlan/

that could be encountered if a mapping package depends upon accessing, say, *Bluetooth* via Wi-Fi if proper and integrated security systems are not in place.
Wireless is now seen as part of the Internet, and not distinct. It is increasingly being used as a 'gateway' to resources provided via the Internet and it demands the same degree of security and privacy infrastructure and checks as does 'wired' Internet nodes. Conversations are not the only communication that needs protection, it is also the very data that is being sent or received by the mobile device and the database from which it requests that information or where information from activities like banking transactions, field surveys, etc. are lodged. Even what was considered to be 'unbreakable' security was expounded by Berman (1997, p. 5) as an example of what could go wrong with digital transactions, and he reported: "*In one series of transactions in 1994, an international group of criminals penetrated Citicorp's computerized electronic transfer system and moved about 12 million from legitimate customer accounts to their own accounts around rhe world*." For the geospatial sciences, as many contemporary practices employ mobile devices to 'upload' the results of surveys, sometimes into official repositories like government cadastres this is an important point to consider. The very link that makes almost 'immediate' updates from field parties possible may also be the means of 'breaking-in' or corrupting these legal repositories of data. If Citibank's security was compromised, how safe would a land data repository be?

As a final note to this section, Berman's address to the House Committee on Commerce in 1997 (Berman, 1997) concluded with a request that Congress should ensure that wireless data transfers should be brought explicitly within the Electronic Communications Privacy Act.

6 Wireless and location

Currently mobile telephones have reached almost saturation point in terms of everyday use. However, using these devices to access geospatial information has not yet been properly exploited. As the information delivery infrastructure is already in place, and the fact that the graphics displays on telephone devices are always being improved, they offer the potential for delivering usable geoinformation graphics and support information like sound, or a series of SMS (Short Messaging Service) textual 'prompts' to assist navigation.

The 'voice' about privacy issues was quiet when the location of a cellular telephone user could only be located to the nearest cell, and even this location might be vague during times of intense phone use, where users might be 'switched' to another, less crowded cell. Obviously the accuracy of the location varied between urban areas and rural areas and from country to country, where the saturation of mobile telephone transmission towers might be different. European and Japanese companies were the first to market solutions based on these imprecise location technologies, using the cell ID (jlocationservices.com, 2000). Accuracy requirements are context and application-specific – emergency services and navigation requiring the highest degree of accuracy and weather and general information the least (Gisler, 2001). The US's e911 initiative provided for mobile telephones to be shipped with GPS locators (Landgrave, 2003).

The location of users can be enhanced by relative attenuation – using two or more transmitter sites to triangulate a users position. Here the signal strength and the direction from which it reaches a particular tower can be used to more accurately position a user. But, the position was still too imprecise for the deployment of Location Based Services that depended upon more accurate positioning. Hence the interest in GPS-enabled mobile phones. At the end of 2001 only 120,000 handsets in the USA (out of a total of some 130,000,000 handsets) featured location capacity. In 2002 GSM handsets used observed time difference (E-OTD) to be able to locate 9-1-1 callers. By the end of 2002 most CDMA units in the USA incorporated assisted GPS (A-GPS), a satellite/land station location system. It is predicted that 95% of all handsets sold in the USA by 2005 will be location-enabled. The handsets meet the E9-1-1 requirements and they are seen to be the devices that will act as a catalyst for developing and adopting LBS (jlocationservices.com, 2000). But, this does pose a problem in cities, where the majority of customers reside. In the USA, the company Qualcomm provides *gpsOne* technology, which combines a GPS receiver with ranging information from local base-stations. This provides accuracy to within a few metres. However, being a proprietary system extensive uptake has stalled. Java-enabled handsets are seen as a solution to proprietary ownership problems (The Economist, 2003).

7 Business interest in LBS

If we look generally at GPS, the 'industry' has been excited at the opportunity that ‚location' provides for new business. In 2000 the GPS market was seen to be worth US$8 billion annually according to the US Commerce Department. And, this was projected to double to US$16 billion by 2003 (*ZDNet Australia*, 2000). These figures relate to the 'main stream' GPS market, and it does not consider the LBS market. With the introduction of mobile telephones with GPS capabilities business looked forward to applications in business, especially for workers in potentially dangerous situations (*ZDNet Australia*, 2002).

Location services, sometimes referred to as L-commerce, has seen European operators struggling to create LBS revenue models. Short Message Services (SMS) was seen as providing the most dependable revenues from location services over the next several years (Gisler, 2001). E-OTD location measurement was seen as the basis of high-value services. 'Assisted GPS location solutions looked-upon favourably by 'location services' company Snaptrack and telco Sprint, who have conducted a joint case study. The industry sees that the biggest potential money earner is mobile location entertainment, especially amongst teenagers (Gisler, 2001). But, Swedeberg, from Ericsson Radio Systems has noted that the immediate industry needs are in the areas of technological standardisation and security and integrity in the system (Gisler, 2001).

A fairly recent example is the Zingo cab service in London (www.zingotaxi.co.uk) that provides a direct connection to available taxis to subscribers (see Home Page in figure 6). Users call Zingo from a pre-registered mobile telephone, then Zingo's location technology – Cellular and GPS for the user, and GPS for the taxi – links the customer with the nearest available taxi (Zingo, 2003). The system pinpoints the potential passenger's location by locking on to the location of the mobile 'phone The system operates using the UKs Vodafone, O_2, Orange, Virgin and Three cellular telephone systems. It works automatically with O_2 and Vodafone. In April 2003 there were 400 cabs using this system, with 'several thousand' planned (Rubens, 2003). There are already some concerns about privacy. Comments solicited about Ruben's story in the BBC News 'feedback' section saw correspondents concerned about Zingo's privacy statement – *"... by calling the Zingo hailing number you give your consent to the use of your information as described above"*. But an issue was raised about how the mobile service providers, the 'partners' in this service, would use this information, or how they would release or sell this information. It was noted by another respondent that recording of pick-up and drop-off points, a process that is assumed to be part of Zingo's service, would not be allowed under the UK's Data Protection Act unless a user specifically signed-up for it (Rubens, 2003).

Looking specifically at the revenue models for some companies, they generally charge a monthly service fee £200 per operator (which includes 500 requests) (EPL Communications Limited, a UK- based LBS company that provides single point of access services for European cross network LBS services). These costs are charged as pre-paid services or contract. Other UK operators have different models, for example O2 (UK) £0.075 per request, Vodafone (UK) £0.088 per request, T-Mobile (UK) £0.095 per request and Orange (UK) £0.085 per request (EPL Communications Limited, 2003). The actual amount charged for each individual request for a location 'response' is quite small, but multiply this by individual operator requests and multiply this again by the many customers that use this service, then the true revenue potential can be realised. And this is for a relatively 'hands-free' (wrt the operator) service that operates 24 hours per day, 7 days per week!

8 Privacy concerns

Information and access to information is now an important commodity and an every-day need. As information is now stored digitally, we have a love/hate relationship with the systems that store our information, but control us with the same information. Our very existence, and the proof that we do exist relies on the integrity of digital data repositories that store information about us. To illustrate the importance of digitally stored data to achieving our daily goals the movie *The Net* (starring Sandra Bullock) illustrated how we rely on this information to prove who we are and to determine what we are allowed to do and the things that we can access. In the movie her (digital) identity was stolen by removing her personal digital data. It proved to be impossible to establish who she was and what she owned or had access to.

There are some concerns about how 'tracking' information will be used by employers and service providers. For example, Landgrave (2003) reported that a court in Virginia, USA, have already decided that a company providing commercial services must

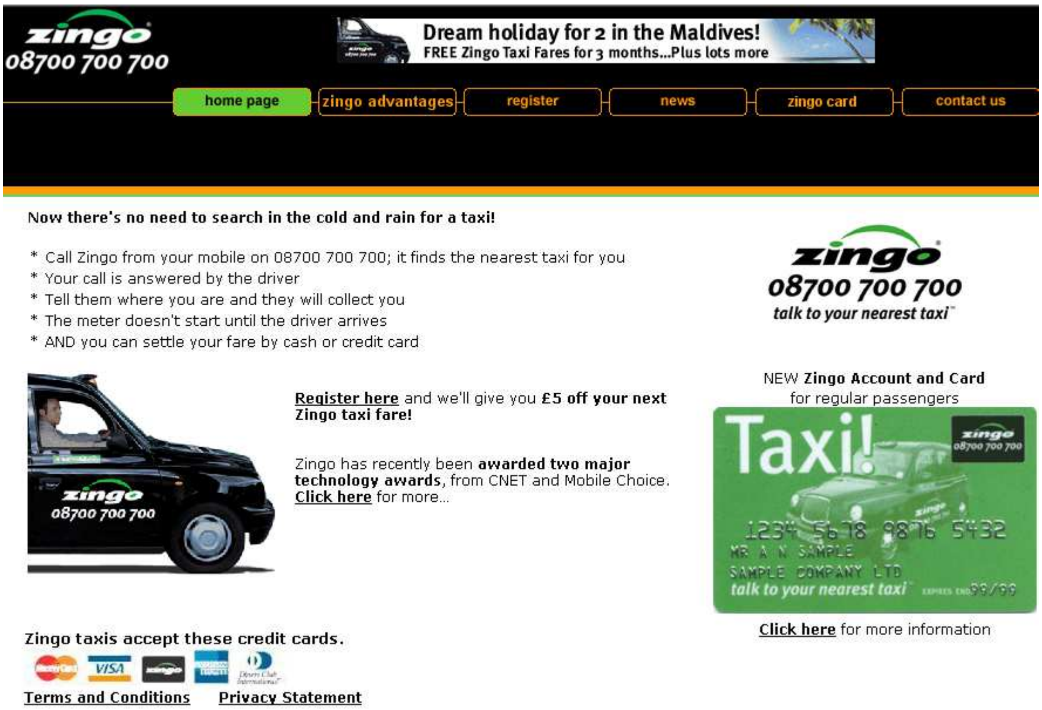

Fig.6: Zingo. Source: http://www.zingotaxi.co.uk/

provide notification before using GPS services. He cites the case about how one rental car firm installed devices in its cars. One renter, who saw an "excessive speeding" charge on his bill later found that the company had used the GPS device to track the hirer's driving speed – without informing the renter. As the company had failed to inform the renter of this condition (and the associated device fitted to the vehicle) they lost a related court case.

9 Security and privacy initiatives

It has been noted that enterprises have resisted adopting wireless LANs due to the immaturity of management standards and security. As security means confidence in a system and confidence means increased business, providers of information services via wireless LANs are keen to 'bed-down' formal security methods and practices. As building a complex LAN to provide converged media that includes voice, video and data, requires a complex approach, single vendor and third party solutions like wireless gateways are tipped to be the means by which this will happen (ZDNet Australia, 2003c).

Security and privacy initiatives have taken two distinct paths: 1. Self-regulation; and 2. Legislation. Generally the self-regulation path has been followed by US companies and the Legislation path by European concerns. However, the US is developing a number of legislation papers related to privacy and data protection related to LBS, especially through the Federal Trade Commission (Gisler, 2001). These classifications can also be split into private verses governmental security and controls.

Self-regulation generally is conducted and implemented by individual companies or by consortia of companies. This involves the development of and the introduction of privacy policies and procedures. For example, US firm EPL Communications Limited require providers to pre-register subscriber mobile numbers in advance, enabling subscribers to opt-out of tracking service. An 'on/off' service allows users to select their required level of assistance and to suspend individual applications from being able to locate them (EPL Communications Limited, 2003).

The Cellular Telecommunications Industry Association (CTIA) of the USA has taken a position on privacy and consumers and advocates the following:

- Inform each customer about the collection and use of location information;
- Provide the customer with a meaningful opportunity to consent to the collection of locational information before it is used;
- Ensure the security and integrity of any data and give the customer reasonable access to it; and
- Provide uniform rules and privacy expectation (www.wow-com.com)

The Wireless Location Industry Association state that members should:

- Notify subscribers hoe location information may be used;
- Offer reasonable options regarding the generation, use and disclosure to third parties of location data;
- Make every reasonable effort to ensure that location data is accurate;
- Retained location data should be secured (www.wliaonline.org).

And, Privacy Times (www.privacytimes.com) see the importance of:

- Anonymity;
- Opt-in;
- Default: no tracking;
- Purpose and use specification;
- Access/correction; and
- Security/enforcement.

These examples provide what can be considered to be 'motherhood' statements – good on websites, but they are so non-specific to be almost impossible to be used to ensure real privacy. Self-regulation and software controls are required. However, the problem with self-regulation is that individual companies want their security standard to be adopted as the standard. For example, Cisco and Microsoft push PEAP and Funk software and some others wish to see TTLS as the standard. Funk's TTLS has one advantage over PEAP – scalability, providing the ability to deliver secure information to many clients and this information can be restricted via time of day access used by providers like Nortel, 3Com, Checkpoint and others (ZDNet Australia, 2003b). It has been predicted that PEAP will emerge as the *defacto* standard for the Institute of Electrical and Electronics Engineers (IEEE) 802.1x standard for wireless user authentication (ZDNet Australia, 2003c). In the absence of the approved IEEE standard Microsoft, Cisco and the Wi-Fi alliance are promoting the introduction of Wi-Fi Protected Access (WPA) for use while the proposed standard progresses (ZDNet Australia, 2003c). The standard should be ready in 2004 (ZDNet Australia, 2003d) and it is predicted that it will be integrated and deployed as part of handhelds and client services during 2004 (ZDNet Australia, 2003e). This is an important standard, as there is a growing use of 802.11b or Wi-Fi technology to find the nearest internet-access point. To illustrate this popularity T-Mobile is installing such services in Starbuck's coffee shops that provide wireless access.

The European Commission's working group on data protection developed a proposal relating specifically to mobile location privacy issues. Elsewhere, other countries are developing/implementing legislation to protect privacy. For example, Korea's Ministry of Information and Communication recently drafted a Bill to regulate LBS for cellular phone services (Deok-hyun, 2003).

But, few solutions can prevent malicious and inadvertent attacks. And there exist few tools to detect and remove rogue wireless networks. Firewalls and encryption are still seen as the best protection still (ZDNet Australia, 2003c). Even when 802.1x is introduced it will only protect by authenticating users and devices at the 'edge' of the network and information being transmitted will still need to be encrypted. This will also hold if *Bluetooth* becomes widely deployed and used (ZDNet Australia, 2003e).

Threats arise from both governmental and private surveillance (Berman, 1997) and methods must be employed to provide the public assurance that every possible means has been used to guard their security. Along with this is the need to ensure that consumers are adequately informed about what software is being placed on their machines (eg cookies) and how to 'turn on' their own 'privacy' button (something like that proposed by Calacanis, 2000).

10 Problems with developing technology:

We live with being always photographed by security cameras; we know and accept that credit card providers know how much we earn, where we live, how much we spend, how often, and where; and we may use smart cards (called e-tags in Australia) that record nodes of our journey on tollways, recording where we were, at what time and date we were there and the car we were driving. Digital surveillance and transaction 'machines' track our every move, and what could 'they' learn about us if this information was linked and analysed? (And, is it linked and analysed?).

Pricewaterhouse Coopers released its annual Technology Forecast for 2000 that made projections that wireless data transmission, smart appliances and computers integrated into building infrastructure will be emerging trends. It reported that within five years households would have combined computing power of more than 100 gigabytes in ordinary appliances and combined PCs, DVDs and television sets. The technology prediction illustrates the massive impact that the applications of new technologies, new communication systems and New Media will have in the near future. Digital television has the ability to record or 'track' a users preference and thus viewing habits. Broadcasters are able to build databases and then use it for 'focussed' advertising and special programming or purchase offers. Marketing wants this type of information because, according to Wunderson of marketing data provider I-Behaviour Inc.: *"Past behaviour is the single strongest indicator of future behaviour"* (Thibodeau, 2001, p. 1). It has been predicted that by the end of the decade 40% of adults and 75% of teenagers will have always-on, wearable computing and communications capabilities (Lais, 2001). But, with this 'rush' to adopt technological solutions we have accepted 'privacy invasions'.

Zimmerman, the creator of the PGP encryption product (the first widely adopted strong encryption program for protecting files and emails), sees that technologically-driven improvements on surveillance cameras pose a threat to civil liberties (ZDNet Australia, 2003a). How do we manage them when there are literally millions of CCTV cameras recording our everyday activities? Consider for example the speed at which pictures of the hijackers using an ATM pre 9-11 were made available after the event. Digital credit card transactions and focussed search on ATMs in nearby locations led to rapid information discovery, access and dissemenation.

A technology that some have labelled as 'spyware' is being introduced by manufacturers, wholesalers and retailers to identify the 'location' of products, from manufacture, to transportation, to warehousing, to point-of-sale. This is Radio Frequency Identification (RFID), transponders that manufacturers are embedding into products from whitegoods to clothing (by weaving the transponder into the labels of clothing) (Baard, 2003a). Already companies in the USA and Europe, like Wal-Mart, Tesco, Proctor and Gamble and Gillette, are using the tags. Wal-Mart have insisted that its 100 largest suppliers must tag their warehouse pallets and containers by 2005 and their other 12,000 suppliers by 2006 (Baard, 2003c). The retailer is conducting tests in selected stores, sometimes with customers being unaware that they were being tracked. There is much concern that the combination of radio tag data and the information obtained from store loyalty cards could be coupled to create comprehensive customer profiles (Wired News, 2003a). In Australia the warning bells have began to ring. Sneddon, national coordinator of the privacy practice at law firm Clayton Utz has stated that devices like these expose "holes in existing Australian privacy legislation" (Australian Technology and Business Magazine, 2003).

Ubiquitous computing is of much interest to computer technologists and also cartographers. Ubiquitous computing has been named as the ‚third wave' in computing, or „...the age of *calm technology*, when technology recedes into the background of our lives" by the father of ubiquitouss computing, the late Mark Weiser (Weiser, 1996). Weiser (1996) has described it more fully as:

„Inspired by the social scientists, philosophers, and anthropologists at PARC, we have been trying to take a radical look at what computing and networking ought to be like. We believe that people live through their practices and tacit knowledge so that the most powerful things are those that are effectively invisible in use. This is a challenge that affects all of computer science. Our preliminary approach: Activate the world. Provide hundreds of wireless computing devices per person per office, of all scales (from 1" displays to wall sized). This has required new work in operating systems, user interfaces, networks, wireless, displays, and many other areas. We call our work "ubiquitous computing". This is different from PDA's, dynabooks, or information at your fingertips. It is invisible, everywhere computing that does not live on a personal device of any sort, but is in the woodwork everywhere."

We now see this type of computing in the form of handheld PCs, mobile phones, wireless sensors, radio tags and Wi-Fi (Baard, 2003b). Designers of ubiquitous systems envision seeding private and public places with sensors and transmitters that are embedded into objects and hidden from view, providing for the deployment of things like ‚Audio Tags', which plays an infrared sensor-triggered message once a person is within a pre-determined proximity (Wired News, 2003e). And there is ‚Assisted Cognition', AI and pervasive systems that can support a patient's failing cognitive skills. For example, in Milwaukie, Oregon, the Oatfield Estate operated by Elite Care use a combination of electronic badges, infared detectors and load-sensing beds to track its elderly guests (Baard, 2002). But, there are also many privacy issues to address. Computers 'hidden' in everyday tools will collect personal information about habits, health, employment, etc. The perceived 'convenience' can be outweighed by loss of privacy. As Lais (2001) noted, the US federal government has already passed laws such as the Health Insurance Portability and Accountability Act, requiring health care organisations to safeguard patient information. But there is still some confusion about how this will actually operate and how privacy related to an individual's medical records will actually be protected (Jones, 2001)

11 Privacy issues

There are numerous privacy issues related to the use of new electronic devices for capturing storing, processing and representing information, including geospatial information. There are issues that we must address to ensure that we protect the users of what we provide. The list below is a starting point for discussion of the range of privacy concerns that we, as information providers must address. Some of the issues are:

- How do service providers and their partners use subscriber information, and locations visited?
- Do service providers provide this information to other companies/ And, do they sell this information?
- Can a service provider 'log' where individuals travel? A fairly simple process with companies like Zingo, who would have a record of pick-up and drop-off locations, linked to times of day and dates. Although, without the use of LBS taxi companies could already do this if they wish.
- The use of cookies and the difficulty 'general' users of the Web would have to know if cookies were being used at all, and how to set their browser to reject cookies is a big problem. (Even some government sites in the US, where the Clinton administration restricted the use of cookies, were found to use unsanctioned cookies in 2001 (a total of 64 sites) (CNN.com, 2001)).
- The combination of GPS and the ubiquity of wireless communications provides the ability to track anyone, from anywhere to anywhere. How do we protect an individual's rights when their every movement can be tracked and recorded?

- If a user of a LBS system crosses and international border, carrying a device with pre-recorded data, and able to access extra data from another country, what are the legal ramifications of these activities? (The U.S. ‚safe harbour' laws (approved in 2000), designed to protect U.S. compaies from lawsuits over how they treat personal information in other countries may provide a starting point here. But, laws are not yet clerely defined on legal juristiction in cyberspace (Lawson, 2001)).
- In some instances, contractors employed to manage the operations of a site, and where tracking systems are used, then in some instances the contractor legally owns the information gathered (CNN.com, 2001). How do we deal with the problem of having to use provider companies to deliver our geospatial products, when we may have no control of their records related to customer tracking?
- The results from a U.S. Federal Trade Commission (FTC) study about how companies exchenge personal data showed how some companies share data to provide a more detailed ‚picture' of customers (Thibodeau, 2001). Since many mapping products provided on-line may be a conglomerate ‚picture' painted from accessing numerous data repositories and using various links, how can we stop the providers of the components that may make up our delivered product, related to a location-based request, ‚owing' information collected during electronic ‚procedures' that form the product request, the product itself and product delivery.
- If LBS service providers can track our movement from CCTV camera to CCTV camera, a complete, and annotated (with CCTV pictures) record of activities can be assembled. How do we address this as information providers?

12 Conclusion

When undertaling a literature review for this paper, the more I read the more I became convinced about the privacy minefield that we need to negotiate with LBS. With the advent of ‚modern' communications systems we have had to sacrifice privacy to ensure access to information and to use information devices. This is no different with wireless communications and the Mobile Internet. To ensure consumer confidence and product/delivery credibility we must address privacy and security issues and make them part of our agenda for future research and development. The profession, and professionals working in this sector of the geospatial sciences industry need to view privacy and security as key ingredients of future successful products and services. Consumer confidence in what we provide will be a key ‚make-or-break' factor in the provision of LBS.

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Positioning

Combined GPS-Galileo positioning for Location Based Services in urban environment

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Abstract

Position determination is one of the key-elements of Location Based Services (LBS). One popular approach to positioning for LBS is using a Global Navigation Satellite System (GNSS). With such a system, three-dimensional positioning is available anywhere on, and above the Earth, in principle without any local or regional infrastructure. On the other hand, as satellite based radio positioning relies on relatively weak signals, indoor positioning is a hard job, in particular without any aids. Also urban environment can pose a serious challenge to satellite based radio positioning. In this contribution, the availability of today's GPS positioning is analyzed using a three-dimensional model of the town of Delft in the Netherlands.

This contribution starts with a demonstration of the range of position accuracy using today's Global Positioning System (GPS). Different modes of kinematic and real-time positioning will be shown using a trial with a boat on the Schie-canal between Delft and Rotterdam. Standard GPS single point positioning with a simple handheld receiver offers 5-10 meter accuracy. With corrective information received from a geostationary satellite, the European Geostationary Navigation Overlay Service (EGNOS) comes down to the 1-meter level. Global Differential GPS, with a dual-frequency user receiver, reaches decimeter level accuracy, but currently only after a considerable initialization period.

Although accuracy is one of the main issues regarding GNSS, it is clear that availability is another point of concern with the LBS context. If you cannot rely on your positioning device all the time, the usage of the service will be limited. Therefore it is of great importance that within five years from now, the European Galileo system is expected to get into orbit, next to the US GPS. Doubling the satellite constellation is expected to be beneficial to position availability. The impact of the advent of Galileo on this aspect is analyzed as well, using the same urban environment.

1 Introduction

Position determination is one of the key-elements of Location Based Services (LBS). A Global Navigation Satellite System (GNSS) is an attractive way for worldwide positioning. Two importance aspects of such a positioning component in an LBS application are accuracy and availability. Depending on the mode of GNSS positioning the accuracy may range from 10 meter to a few centimeters. The availability is in particular of importance in urban environments. Due to obstructions of satellite signals by buildings, the ability to determine one's position is known to drop significantly in cities.

In the next section this paper first presents an overview of the accuracies that can be achieved with different modes of GPS positioning. Section three briefly discusses the LBS markets that are emerging with the advent of the Galileo positioning system. The availability of GNSS systems in urban environments is analyzed in section four. Using the (planned) orbit information of both GPS and Galileo satellites and a detailed 3D city model it is investigated to what extent the availability of GNSS positioning will improve once GPS and Galileo can be utilized simultaneously.

2 Positioning with GPS

This section intends to give a partial overview of the current range of GPS positioning modes. With a focus on position-*accuracy*, practical results are shown for standalone GPS, Wide Area Differential GPS (WADGPS) with EGNOS, and Global Differential GPS, the latter offering decimeter accuracy, in real-time, seamless all over the world.

The results shown - for the different modes of positioning – pertain to *real-time* operation (contrary to long site occupation times and post-processing of measurements). The results follow either from processing just a single epoch of measurements, or are the actual output of a recursive-processing scheme (for instance a running Kalman filter).

Kinematic experiment

All examples shown in the sequel are the results of a kinematic positioning experiment carried out by the Mathematical Geodesy and Positioning section in Spring 2003, with a small boat on the Schie-canal between Delft and Rotterdam in the Netherlands.

Fig.1: The small boat, with several GPS receivers and antennas on-board, all collecting measurements simultaneously, was cruising the Schie-canal forth and back for an almost 3-hours period. The boat is depicted here at the little village De Zweth.

For each of the examples in the following, GPS range measurements have been taken during the same 3 hours time span, at a 1 second interval. Generally, between 5 to 8 GPS satellites were used for the position solution. For all receiver antennas on board, a so-called ground truth trajectory was established with centimeter accuracy, using both classical survey measurements on the boat - after the experiment - when it was moored again at the quay in Delft, and, high-precision GPS position solutions for three of the (high-end) receivers. The latter solutions were computed from dual-frequency precise carrier-phase measurements, with cycle ambiguities fixed, in differential mode using a nearby reference site (at 3-5 km distance).

Position accuracy measures
The position solutions obtained in the various cases are differenced with accurately known reference positions (ground truth trajectory). Subsequently, the 95^{th} percentile value is determined empirically for the position differences, over the full time span, in each coordinate direction (each time in a local North-East-Height system); 95% of the position samples are within the values given. The 95^{th} percentiles refer to the horizontal position error (North and East component together) and to the (absolute) vertical position error. For an introduction to position accuracy and its measures, the reader is referred to (Tiberius 2003).

2.1 Standalone GPS

Based on pseudorange code measurements of a single receiver, the position can be determined anywhere on Earth. Only the satellite signals are needed. The satellite position and clock error are obtained from the broadcast navigation message. This mode of positioning is referred to as single point positioning, or absolute positioning (sometimes also as point positioning). No auxiliary means are needed, as with Differential GPS.

In the kinematic test with the boat, a simple commercial handheld receiver was used (a Garmin GPS76 with a small external GA-27C antenna). Figure 2 shows the position error in all three components as a function of time. In particular the Height component is severely biased (mean is – 6 meter). The accuracy lies in the 5-10 meter range, see Tab.1.

mode	horizontal	vertical
standalone GPS	6.20	11.52
WADGPS	1.19	2.34
Global DGPS	0.34	0.60

Tab.1: Position accuracy of standalone GPS positioning, Wide Area Differential GPS positioning with EGNOS and Global Differential GPS. Given are 95^{th} percentiles in meters.

For more information about the standalone GPS positioning results, see (Le and Tiberius 2003).

2.2 Wide Area Differential GPS: EGNOS

Augmentation systems to GPS can improve the accuracy of standalone positioning. The European Geostationary Navigation Overlay Service (EGNOS) will, in the near future, as a Wide Area Differential GPS, cover the whole of Europe. Similarly, the FAA is developing the Wide Area Augmentation System (WAAS) in the US. Positioning with EGNOS is based on Differential GPS, but instead of a single reference station, an integrated *network* of reference stations is deployed. The correction signal is broadcast from geostationary satellites. The user needs in principle additional equipment to receive the EGNOS signal, though there are already (relatively simple and cheap) handheld receivers on the market, which are WAAS (and EGNOS) capable.

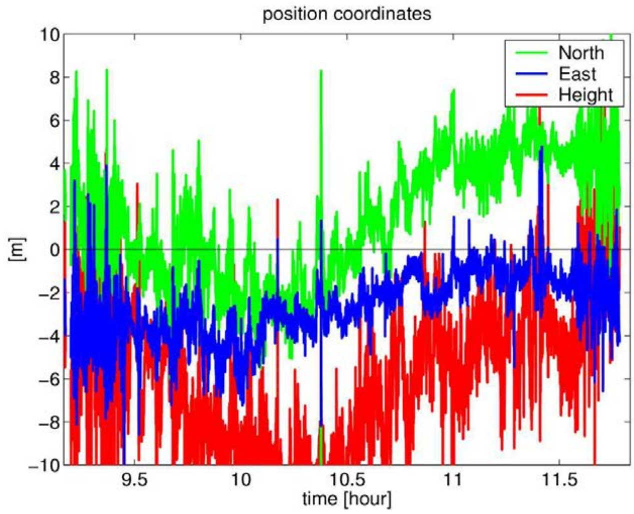

Fig.2: Standalone GPS positioning errors.

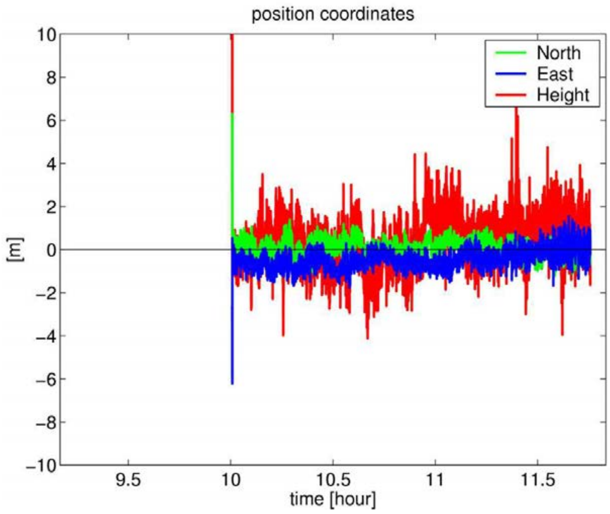

Fig.3: Wide Area Differential GPS position errors with EGNOS.

In February 2000, the EGNOS System Test Bed (ESTB) became operational, and results of this prototype EGNOS are shown below. These results, *single frequency*, pertain to instantaneous positioning, once the current message with correction data and integrity information has been acquired. EGNOS is expected to become operational in 2004.

In the kinematic experiment with the boat, a high-end NovAtel OEM3 receiver with Leica AT502 survey antenna was used. Table 1 lists the position accuracy figures and figure 3 shows the position error in all three components as a function of time (the time series start late by some 50 minutes, due to unavailability of the ESTB signal).

2.3 Global Differential GPS

Global Differential GPS (GDGPS) offers yet a higher class of accuracy, seamless all over the world. The results shown below are obtained with Internet-based Global DGPS (IGDG), which relies on a subset of NASA's Global GPS Network (GGN) with currently some 40 real-time stations. The data of these stations result in rapid service (real-time) GPS satellite orbits and clocks. Differences with the current GPS broadcast ephemeris are disseminated over the Internet in real-time (and commercially via geostationary satellites) and allow users, anywhere on Earth (i.e. truly global), to exploit the highly accurate satellite ephemerides in real-time.

The user needs to be equipped with a *dual-frequency* receiver (using the GPS L1 and L2 signals) delivering pseudorange code and carrier phase measurements. In addition a sophisticated modeling of these measurements is required. At present, dual frequency receivers are expensive, primarily because the current GPS L2 signal is not directly accessible for civil users, and the size of the high-end market is relatively small. The situation might change with the modernization of GPS (with a new civil signal on the L2-frequency and the first satellite to be launched in 2004) and the advent of Galileo. Dual-frequency receivers are likely to become much more affordable.

In the kinematic experiment with the boat an Ashtech ZXII-3 dual-frequency receiver was used, together with a choke-ring antenna. Table 1 lists the position accuracy figures and figure 4 shows the position error in all three components as a function of time (the initialization period, first 40 minutes, is left out of consideration for the accuracy figures). With Global DGPS decimeter accuracy can be achieved, though it should be noted that with a moving receiver, as in this kinematic experiment, currently a long initialization (convergence) time is needed (20-30 minutes) with continuous lock to the satellites' signals, to eventually reach this accuracy. Experimental results and further references on Global DGPS can be found in (Kechine et al. 2003).

3 Applications and examples

The 5-10 meter accuracy of GPS has pushed the development of the most important and well-known LBS: standalone in-car navigation systems. The (sub-) meter accuracy offers field inventory of all kinds of objects with hand-held Personal Digital Assistants (PDA) equipped with a GPS-module. The highest accuracy on centimeter-level is needed for Augmented Reality systems, in which information (as text and images) about the environment is projected directly within the view-field of the user. Although GPS can reach that level of accuracy other techniques could be applied besides GPS alone. An overview of tracking possibilities is given in (Zlatanova and Verbree 2003).

The current US GPS has been developed in a military context. The European Galileo, to be deployed by 2008, is set up primarily for civilian users. When integrated with telecommunication lots of new developments and services with Galileo in the area of LBS are foreseen. The LBS market is currently segmented into four categories:

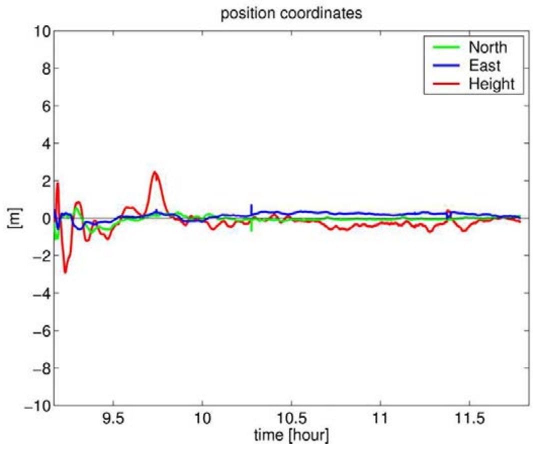

Fig.4: Global Differential GPS position errors.

- Information and navigation services, which provide data directly to end-users, in particular destination location and criteria for journey optimization.
- Emergency assistance, which provide the location of mobile users in case of distress and need for assistance.
- Tracking services, which provide location data.
- Network related services, where knowledge of user position improves communication services.

4 GNSS position availability

Compared to other positioning sensors for LBS, for instance using radio-signals for mobile communication of Wireless Local Area Networks (WLAN), a GNSS has the advantage of offering worldwide coverage. On the other hand, its weakest property is the requirement of, in principle, direct lines of sight to the transmitting satellites, which can be hard to realize particularly in urban environment, where typically most of the LBS applications will be used.

One cannot always take measurements to determine whether or not a GNSS is available within urban areas. One has to realize that visibility of the satellites is not only determined by the location of the observer and obstructions around him, but also by the moment of observation as the satellites are in orbit. Besides, the actual observation of the availability of GPS during a day at or nearby a busy road-crossing is impossible at all because of the traffic.

Simulation is the answer to these limitations. But simulation requests a proper representation of the reality, both of the space-segment as for the Earth-surface. The actual orbits of the GPS are known by the almanac, but in comparing Galileo and GPS the nominal constellation of GPS is put side by side with the (proposed) orbits of Galileo. We have calculated the elevation and azimuth angles for the 24 GPS and the 27 Galileo satellites for each minute during a full daytime for the test-area in Delft, at 52 degrees Northern latitude in the Netherlands. At a fixed location on Earth, the geometry of both GPS and Galileo basically repeat after 24 hours.

The old city of Delft has very narrow streets with built-up areas of around 8-10 meters, with famous Dutch roof shapes. A partial area of the city is modeled in three dimensions by airborne laser-altimetry. A typical example of this area is shown in figure 5.

4.1 Creation of a three-dimensional city model by airborne laser altimetry

To make a realistic estimation of the GPS/Galileo availability an accurate three-dimensional model of the urban environment is required. Since a few years high resolution airborne laser scanners have become available (Baltsavias, 1999). The dense point clouds that can be produced by these scanners allow a semi-automatic extraction of building models. For 3D city modeling, laser scanning has become an attractive alternative to mapping in stereo photographs (Brenner and Haala 1998, Vosselman and Dijkman 2001).
To obtain the 3D model of a part of the city of Delft, data acquired with the TopoSys I scanner was combined with the cadastral data with all parcel boundaries. The parcels were labeled by hand in three different categories: building, street and canal. For modeling the buildings each parcel was treated individually. The strategy followed was to split each parcel into segments such that the point cloud within each segment can be represented by a simple roof shape, like a flat roof, gable roof, hip roof or gambrel roof. The segmentation was done by hand after an interpretation of the laser scanner data that is presented to the operator in different representations. Figure 6 shows the grey value encoded heights of the point cloud together with a perspective view on the point cloud that can be rotated interactively.

Fig.5: The 'Oude Delft' with the 'Old Church'.

Figure 7 shows the segmented parcel and the building model that is reconstructed by fitting gable roof models to the point clouds in the different parcel segments. In this case the ridge orientation of the middle roof has a small error. This was caused by a small misalignment between two overlapping strips of laser data. In general, this procedure, however, allows a rapid 3D modeling of the buildings. The city model used in this project and shown in Figure 8 was reconstructed in about four hours.

The street surface of the city model was reconstructed automatically by filtering the point clouds that were located within the street parcels. Morphological filtering was applied to distinct between ground points and points on vegetation, cars, fences, and other objects. The water level in the canals was also reconstructed from the laser data by selecting the height corresponding to the first peak in the height histogram of the laser data (Vosselman 2003).

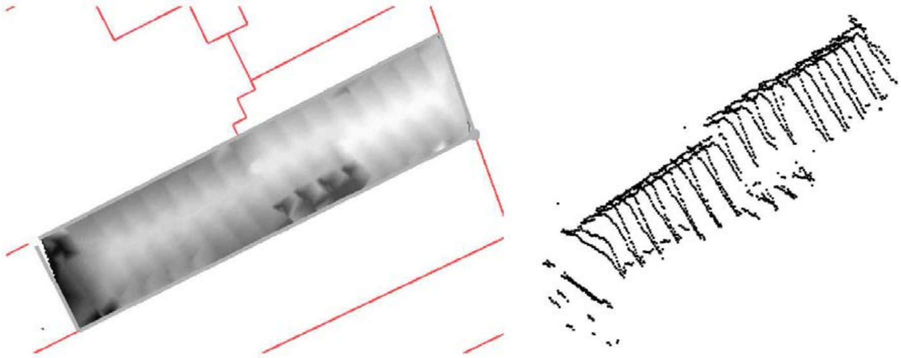

Fig.6: Two representations of the laser data within a parcel used to decide on the optimal segmentation into segments.

4.2 Representation of the ground surface

The 3D-city model of the old town of Delft is built up by a polygonal representation of the canals, the streets and the roofs. The quaysides and the walls - the connections between the streets and the canals at one hand and the connection between streets and the roof tops at the other - are thought to be vertical and modeled as vertical polygons. The visibility calculation however is based on a triangulated irregular network (TIN) that does not allow vertical polygon constrains. The solution to that problem is found in a minimal negative buffering of both roofs and canals polygons by 10 centimeters. These datasets are the input for the surface model of this part of Delft represented by a TIN. A height-rendered image of this TIN is shown in figure 8.

4.3 Calculation of visibility and availability

Visibility Calculation – the Algorithm
The actual visibility calculation is performed within the GIS-package ArcView 3.2a with the extension 3D Analyst. The high-level scripting language Avenue allows fast prototyping of the algorithm with a proper visual feedback of the results within both 2D and 3D scenes.

The simulation of the availability of GNSS consists of two algorithms. The first one calculates the total of targets (satellite positions at a certain time) seen from the observation point by:

```
Count = 0
for each aTarget 'possible observable satellite
  if (aTIN.LineOfSightsAsShapes (anObserver, aTarget,
      ListOfShapes) = True) then
    Count = Count + 1
  end
end
```

Satellite signal propagation is assumed to take place along geometric straight lines. The request `aTIN.LineOfSightsAsShapes` returns not only whether or not `aTarget` is visible from `anObserver` across `aTIN` Surface, but also returns aListOfShapes containing `theObstacelePointZ` and the visible or invisible parts of the profile line. See figure 9 for the visual feedback of this calculation, with red the GPS visibility and within purple the Galileo visibility.

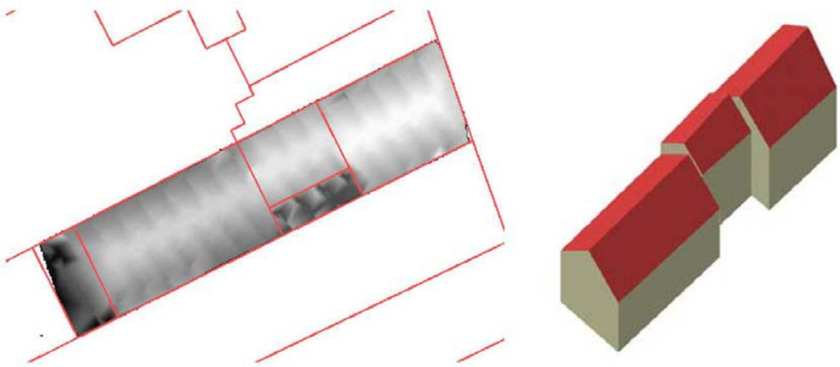

Fig.7: Segmented parcel and the reconstructed roof models.

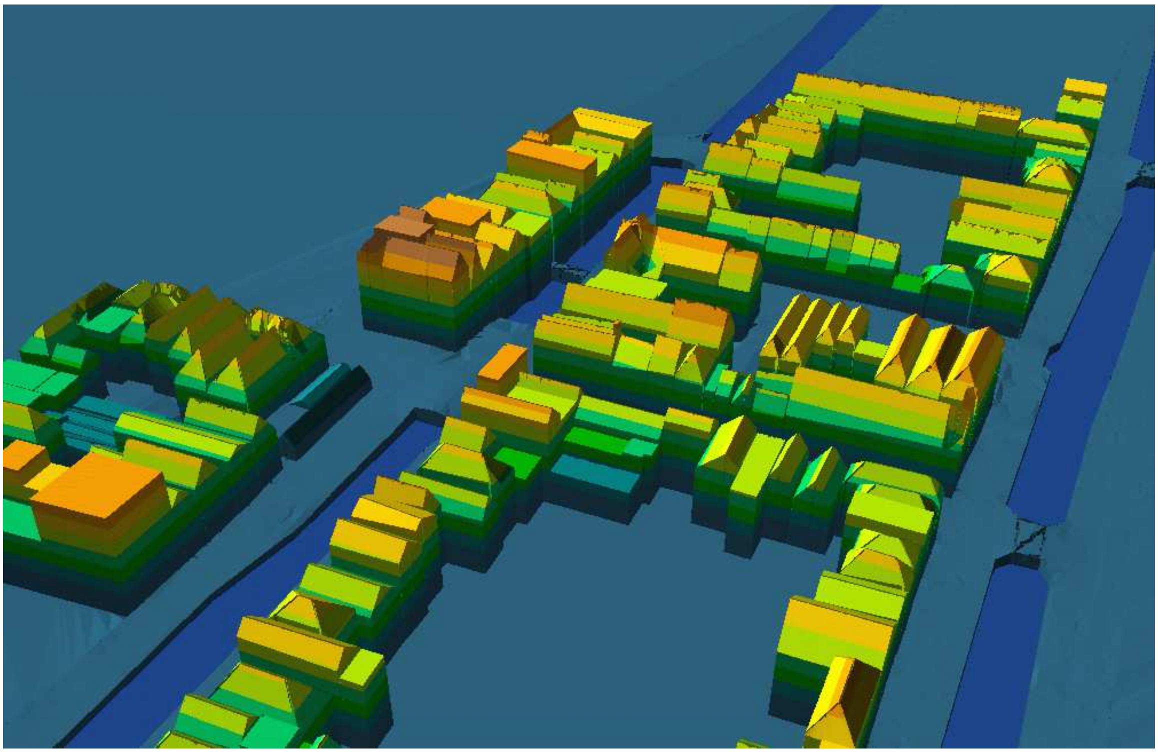

Fig.8: Triangulated Irregular Network, rendered by height.

Availability algorithm

The second algorithm calculates the availability of 'enough' satellites during a day time. We have chosen about 50 test observer points, with a height of 1.80 m above street-level. For each of these observer points the total number of visible satellites during a day time is calculated. During a day time means 60*24 = 1440 different constellations for both GPS and Galileo. Each Target (24 GPS satellites and 27 Galileo satellites) within these constellations is checked by the request:

```
aTIN.ObscuresTarget (anObserver, aTarget).
```

For GPS and Galileo alone observing four satellites simultaneously is the minimum for a position fix, without any preliminary knowledge as a known height. In combination of GPS and Galileo this requirement for position availability holds true, but this demand can be extended with at least three GPS and two Galileo or two GPS and three Galileo satellites. Availability is analyzed here regardless the actual geometry of the visible satellites, which can have a large impact on the eventual position accuracy.

The percentage of 'valid' cases gives an indication of the availability of GPS, Galileo and the combination of both within urban areas. The percentage of availability is indicated by the legend as given in figure 10. The results of the test are shown within figures 11 (GPS), figure 12 (Galileo), and figure 13 (Combination).

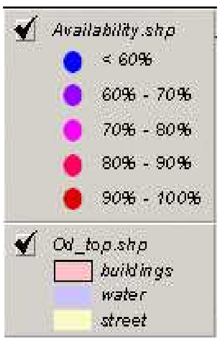

Fig.10: Legend visibility (Blue – Red: <60% - 100% availability).

4.4 Simulation of GNSS availability - Conclusions

Out of these figures it can be concluded that the coverage of GPS alone is not sufficient within urban areas. But for navigation purposes it has to be stated that the visibility on street crossings is far better than within the street lanes. And decisions where to go are made at crossings. Besides, car navigations systems use map-matching and auxiliary sensors to keep the car on track. A second consideration should be made upon the required visibility of four satellites. If the height is known and steady (as in the streets) a position fix can be calculated out of the measurements to three visible satellites. This will improve the availability map considerably.

The calculated availability for Galileo alone is better than for GPS. The amount of proposed satellites (27 for Galileo compared to 24 for GPS) is due to this result. Again, the results will improve when relaxing the demand of four visible satellites to three.

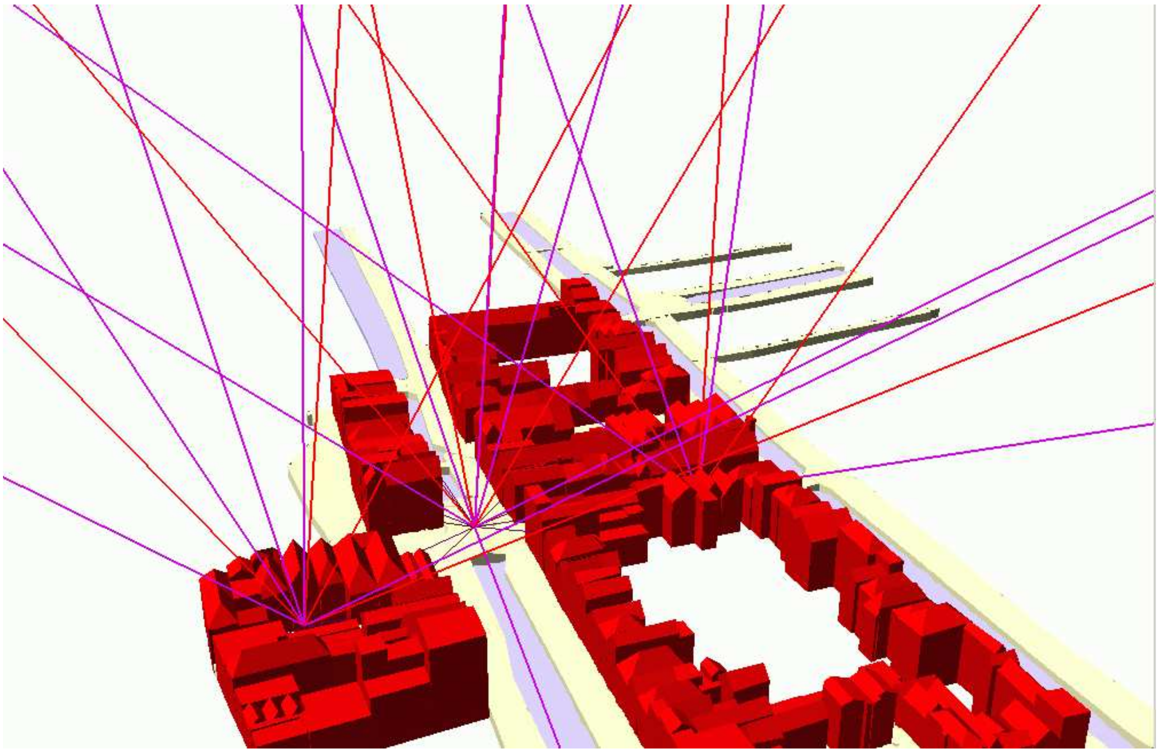

Fig. 9: Some examples of visibility of GPS and Galileo.

Fig. 11: Availability GPS during a day time.

Fig.12: Availability Galileo during a day time.

Fig.13: Availability of GPS and Galileo combined during a day time.

The combination of GPS and Galileo is very promising. Not surprisingly with 51 satellites to choose from. Not all are above the horizon, but it is clearly shown that - besides very narrow streets - the availability of the combination is nearly 100%. This result is however a little optimistic, because we have not taken into account the obstruction by trees and obstructions other than buildings. As a compromise it is to be noted that both for Galileo and GPS the plain nominal satellite constellation was used. For GPS there are usually a few redundant operational satellites, and also Galileo is planned to have active spare ones.

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User tracking as an alternative positioning technique for LBS

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Abstract

Different approaches are used for positioning of mobile users and all of them have advantages and disadvantages. The Global Positioning System (GPS) offers the easiest and most accurate 3D positioning of the user but it is not operational indoors. The positioning within mobile networks (using only the information related to the base network transmitter) could be made available everywhere but it is rather inaccurate. Still, there are many situations where the position of the mobile client cannot be detected with the needed accuracy and within an acceptable waiting time.

This paper investigates on user tracking (more specifically optical tracking) as an alternative approach for establishing locations. The tracking system utilised within the outdoor AR reality system (i.e. UbiCom project) is discussed and new ideas for users tracking for LBS are presented. The ideas are motivated by and linked to the OpenGIS Consortium (OGC) specifications for Location Based Services and related OGC specifications for Web Services.

1 Introduction

Many systems already exist that offer Location Based Services (LBS) with a variety of services (from only visualisation and navigation to update of information) for different applications. All of them however rely on GPS positioning. Currently OGC is developing OpenGIS Location Services (OpenLS) specifications (in stage of collecting comments).

OpenLS specifications (OpenGIS Specifications, 2003) aim at defining the mechanism a mobile user is served by a GeoMobility Server. To date OpenLS has six core services, i.e. Gateway (access to servers to get position), Directory (access to information related to restaurants, cinemas, and other Points of Interest), Geocode (conversion from address to co-ordinates), Reverse Geocode, Route (commutation of route) and Presentation (in case of maps the service should provide images) (Fig. 1). The services are intended for all classes of mobile devices. The request should contain the type of the user device (according to a list with well-known devices) and a number of parameters specifying the range and type of requested information.

As it can be realised, the possibilities for introducing a position are *automatically* (using mobile networks via the Gateway Service) and *manually*, by providing address/co-ordinates. A sensible question is whether such a mechanism is sufficient. Unfortunately all approaches have drawbacks.

Mobile networks (GSM, GPRS, UTMS) are available everywhere but the positioning accuracy is rather low (100m and more). It may even occur that a mobile phone (e.g. on last floors of a high building) is connected to a transmitter in a cell different from the cell the mobile unit is located (thus the accuracy may go down to kilometres). Some solutions to increase the accuracy of mobile networks already exist (e.g. *Cell Global Identity* and *Time Advance Positioning Method (CGI-TA)*). The mobile client is located within a network cell with the help of supplementary information (e.g. postal code information, street, town names). The accuracy is further improved by using the time taken by the signal to reach the mobile device. Still, due to lack of directional information, the

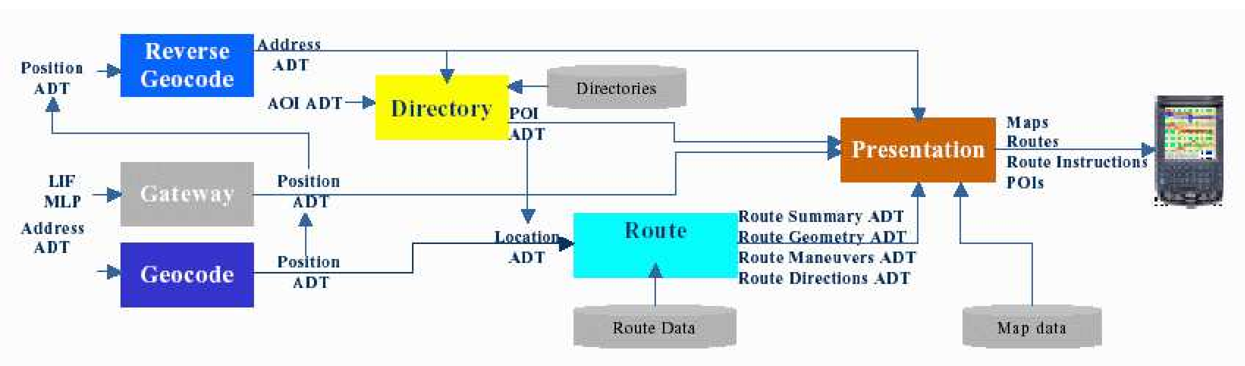

Fig. 1: Services and data types supported by GeoMobility server (OpenLS)

user could be located anywhere in a circular band (or a section of a circular band) around the base station. Thus, the uncertainty remains.

Standard *GPS positioning* provides the highest accuracy (1-10m). In addition, GPS receivers are getting rapidly portable (GPS chips are implemented in handheld devices), cheaper and convenient for general use. However three general problems can be distinguished:

- Disturbed satellite availability due urban canyons in cities or in forest areas. It is expected that it will be significantly improved after the European System for global positioning Galileo becomes operational. More information and several interesting examples can be found in (Verbree et al, 2004).
- Non-operability indoors.
- User authorisation is required for sending automatically the co-ordinates to the GeoMobility Server.

Hybrid solutions attempt to overcome individual problems of GPS and mobile networks by providing satellite data (e.g. the almanac) and thus speeding up the initialisation.

The *address specification* is theoretically very attractive (suppose clear indications of street names and street numbers are available), but practically it might be very inaccurate. Two major factors play a role:

- The accuracy (scale) of the base map used for implementation of the Geocode service.
- The approximation used to link street numbers and corresponding co-ordinates. The geo-coding is usually linked to the street. Very often (especially in central areas) one street number corresponds to a complex of buildings (with different shapes). The user might be inside the complex, but he/she will be located as being on the street.

Apparently, global positioning approaches are still not at a level to locate the user always, everywhere with an acceptable accuracy. In this paper we concentrate on a relative positioning of the user. We believe user tracking can be seen as a supplementary to global positioning techniques, which will provide data about the movement of the user when global approaches fail. Motivation we find in fast developments mobile technology toward minimisation, standardisation, improved speed and resolution.

2 Relative positioning

Relative positioning can be defined as process of evaluating the location and orientation (direction of movement) by integrating information provided by diverse sensors. The integration starts in a certain moment at an initial position and is continuously updated, i.e. the movement of the user is continuously tracked. An advantage of such a relative localisation is that tracking can be done relative to some object the application is interested in, for instance the location where GPS positioning fails.

Relative tracking has been initiated indoors with the goal to provide high accuracy tracking of human body (e.g. head, hand, full-body) basically for Augmented Reality (AR) systems. A plenty of research (Hit Lab, 1997) employing a variety of sensing technologies (*mechanical*, *magnetic*, *acoustic*, *optical, radio*) deals with motion tracking and registration as each technology has strengths and weaknesses. Existing systems can be grouped into two categories: *active-target*, and *passive-target*. Active-target systems incorporate signal emitters, sensors, and/or landmarks placed in prepared and calibrated environments. Passive-target systems are completely self-contained, registering naturally occurring signals or physical phenomena. Examples include compasses sensing the Earth's magnetic field, inertial sensors measuring linear acceleration and angular motion, and vision systems sensing natural scene features. Most of the outdoor tracking is based on a sort of passive-target systems utilising vision (Azuma, 1997). Vision methods can estimate camera position (thus user position) directly from the same imagery observed by the user. But vision systems suffer from a lack of robustness and high computational expense.

Unfortunately, all tracking sensors used in passive-target systems have limitations. For example, poor lighting disturbs vision systems, close distance to ferrous material distorts magnetic measurements, inertial sensors have noise and calibration error, resulting in a position and orientation drift. Hybrid systems attempt to compensate for the shortcomings of a single technology by using multiple sensor types. Among all other approaches, the most common is passive-target magnetic combined with a vision system because:

- Inertial gyroscope data can increase the computing efficiency of a vision system by providing a relative frame-to-frame estimate of camera orientation.
- A vision system can correct for the accumulated drift of an inertial system.

2.1 UbiCom tracking system

The general idea of the UbiCom project was developing of AR system helping urban planning and maintenance by visualising newly designed objects (buildings, statues, etc) and/or providing information about objects (pipe lines, electrical cables, cadastral boundaries), which are not visible in real world. The tracking system used for the AR project UbiCom (UbiCom, 2003) is a typical example of a hybrid magnetic-inertial-vision system. One of the main goals for the UbiCom position tracking system was a

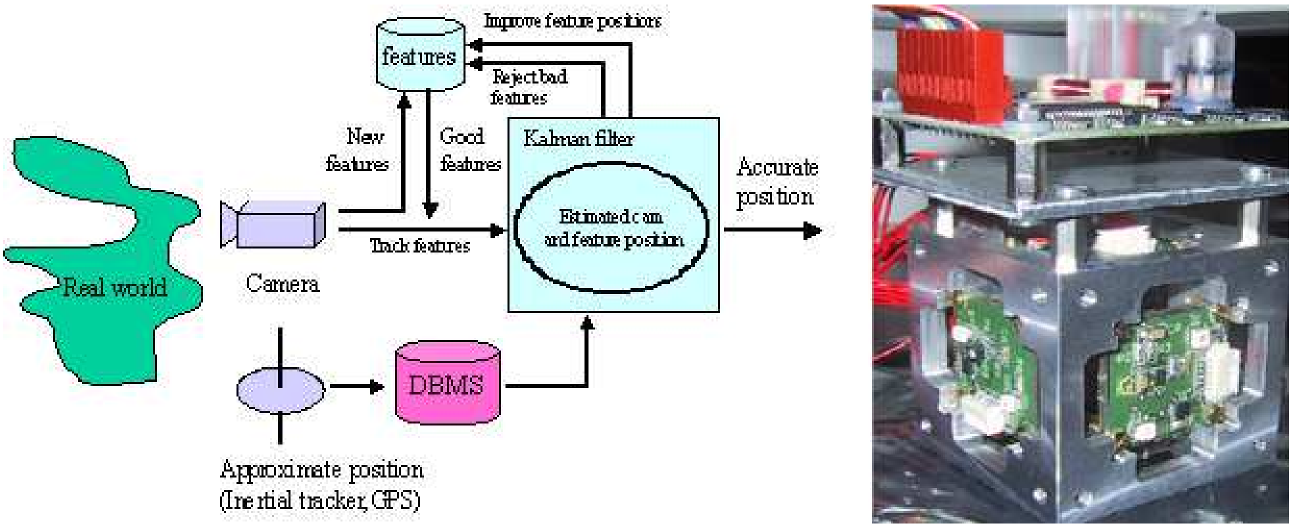

Fig. 2: Set-up of the UbiCom tracking system and the inertial cube (in-house development)

centimetre range accuracy and 2ms latency. The initial investigations on inertial tracking and GPS positioning have shown rather large drift violating the required accuracy. The main job of the additional vision system was to resolve this drift problem.

Fig. 2 shows a very general schema of our AR tracking system. It consists of a GPS receiver (to determine initial location), an inertial cube (to determine orientation and acceleration) and a camera (for the vision system) (Persa and Jonker 1999). This equipment is a part of the mobile unit. On a backbone, a 3D model of the test area was available and organised in DBMS. We concentrated on DBMS organisation to simulate maximally real-world situations, where geo-information is stored in GIS/DBMS software. The system operates as follows:

- An initial position and orientation are provided by the GPS receiver and the inertial cube
- The data (x,y,z, direction of view, Field of View) is sent to the database containing a 3D model of the area.
- 3D subset of the model (within the Field of View) is extracted and send to the processing unit (on a backbone).
- Simultaneously images from the video camera are also provided to the processing unit.
- Matching database data with video data is performed, which results in computing шге accurate position of the userл
- The measurements of the inertial system are used to compute positions for a certain period of time (determined on the basis of drift evaluation).
- On the basis of a current position and a direction of movement, a new set of 3D data is extracted and matched with features on images from the video camera.

The core of our tracking system is matching features extracted from the video camera with features extracted from the 3D model. In our case we have used line matching, i.e. 2D match of lines (edges) detected on the image and lines stored in the database. The lines in the database are organised in a model, specially designed for the purpose, consisting of outlines of real-world objects and loose lines on facades of buildings. To be able to distinguish between large amount of loose lines, they are grouped according to a criterion 'belonging to a particular façade'. Prior retrieving lines, invisible facades are excluded from the set, which means the corresponding lines are also not considered. Thus the number of lines to be selected is significantly reduced and corresponds in certain degree to the lines that might appear in the video images.

The approach looks promising, but we have encountered a lot of problems, basically due to the high requirements for AR systems. Among all, the matching procedure is most interesting for the scope of this paper. The line matching procedure contributed poorly to the positioning, because features detected on the video images were rather different from the lines stored in the database:

- The images used for both data sets were different in terms of resolution and time of the day (year). The images used to extract 3D lines and populate the database were taken once, at the beginning of the project.
- The line extraction algorithms were different. The 3D lines stored in the database were extracted from a sequence of high-resolution images applying several filters to reduce amount of features not part of facades (threes, cars, shadows). The edge detection algorithm was based on line-growing algorithm (Zlatanova and Heuvel, 2002). The edge detection algorithm used on the video images was based on Hough transform of the image, because the performance of the line-growing algorithm was unsatisfactory.

Fig. 3: HP PhotoSmart camera 1.3Mb and Xsense motion inertial tracker

3 Tracking systems for LBS

The requirements for LBS are very similar but (in most of the cases) not as strict as for an AR system. Similarly to an outdoor AR system, a LBS tracking system will be based on passive-target approaches (since in general case prepared environments do not exist) and LBS will need access to geo-data. However, the LBS tracking system should not necessarily provide an accuracy of few centimetres and the response time can be several seconds (instead of ms).

The system architecture aimed at the UbiCom project can be applied for LBS in three variants (depending on the hardware) as a hybrid system (using inertial tracker and accelerator), as a pure vision system or using only a tracker.

3.1 Hybrid system

The components needed for a hybrid tracking system will be a telephone cell, camera, inertial tracker and GPS receiver. Nowadays different combinations of mobile devices can be used, e.g. a telephone with integrated camera, PDA with a camera, PDA with GPS, etc. Numerous add-on devices are also available. For example, HP PhotoSmart camera has resolution 1.3MP, Xsense (inertial trackers) has developed a 3D motion input device for PocketPC (P3C) (Fig. 3).

The proposed user tracking can be summarised as follows:

- ‘Lost satellite reception’ is used as a trigger to initiate tracking. The direction of the user and the speed are being registered and the position is computed for a certain period of time.

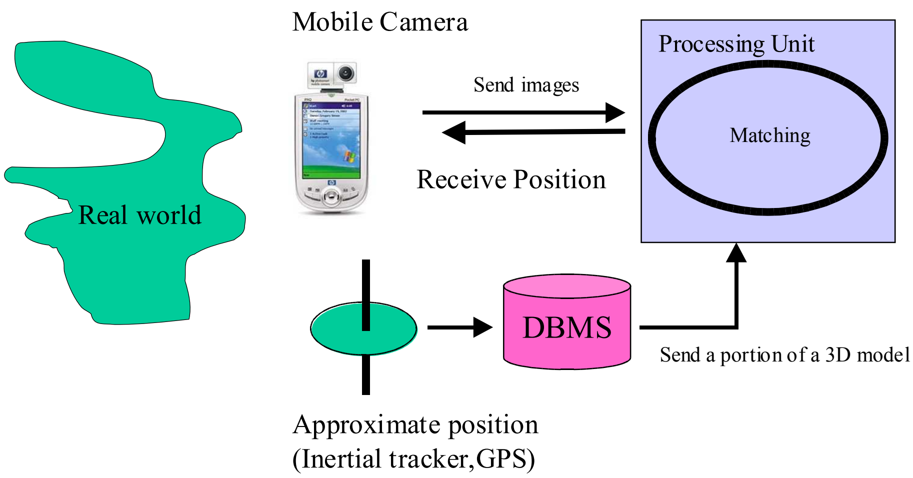

Fig. 4: LBS hybrid tracking system: inertial tracker + vision system

- The user is connected to a Gateway and the last available co-ordinates (and/or the direction) are sent to the database to extract a portion of the 3D model.
- The user is prompted to take an image from the direction of movement.
- The image is sent to the processing unit to perform matching and compute a refinement of the current position.
- The position is send back to the mobile unit.
- Depending on the drift of the inertial system, the above two steps are repeated regularly until necessary.

In this set-up the most important aspect is matching reality with a predefined model. We expect better performance in this set-up compare to the one in the AR system, because the two major obstacles mentioned above can be avoided. The image resolution sent by the user can be better than the resolution of video camera. Furthermore, if the match fails the user can be prompted to take a new image. If line matching is applied, one line extraction algorithm can be applied for both images coming from the mobile user, and images used to create the 3D model. In case of 3D textured models, it is possible to compare images, e.g. a colour image obtained from the camera 3D perspective image from the model (created with WTS, see Section 4). This approach is expected to accelerate the matching procedure although different lighting and weather condition may introduce uncertainties (see Section 3.2).

A special thought about that approach could be taking images of well-known features like brand names and other commercial expressions. If the user specifies enough information on what he or she is looking at, the processing unit should be able to limit the possible locations of the user. A picture of an ATM indicates the user is very close to that feature. This idea could also be applied when image matching is too complicated to establish. One can think of an application at the handheld that tries to identify the location of the user by requesting clear identifications of what the user looks at in the real world.

3.2 Vision System

A second approach can be realised without using an inertial system. The inertial system can be substituted with tracking features on the images obtained from the mobile camera. The feature tracking can introduce certain drift as well, and most probably after a given period of time a request for a 3D model still will be necessary.

- On ‘lost satellite reception’, tracking is initiated by sending the last available co-ordinates to the database to extract a portion of the 3D model.
- The user is prompted to take an image. The image is sent to the processing unit to perform matching. In this case, besides the position of the user, appropriate features from the images (which are going to be used for tracking) have to be coordinated.
- On regular basis, a sequence of images is taken, features are tracked and the position is computed.
- The above two steps are repeated until necessary.

The disadvantage of this approach is that the user has to be asked to take images more often than in the previous case. Too many images will increase power consumption and may reduce the real operable time of the mobile unit.

The major issue in this approach is the type of features that can be tracked. Supposed a fast algorithm is selected, feature tracking can be performed on the mobile unit. Several different features can be used (Pasman et al, 2001 for more details) namely *templates*, *point*, *lines*, *corners*, *colour* and combinations of them. *Template tracking* is tracking a position based on a piece of real-world scenery. Templates are small image patches that can be followed over a range of camera positions. Reliable templates can be extracted automatically and their position can also be estimated automatically. Template tracking has shown accuracy better than 1 cm if nearby (1 m) features are visible (Davidson 1999). Such systems can work even when less than three features are in view. *Corners* (e.g. crossings of lines, or gradient and curvature measurements) are considered very appropriate features for fast detection and processing (You et al 1999). *Colour* might be a powerful means to enhance tracking robustness. Colour tracking is still not very well explored, perhaps due to the fact that colours are highly invariant when lighting conditions change.

3.3 Tracking without vision system

Having in mind fast technology developments, developers might be able to remove completely the drift of inertial systems and accelerometers in a very short time. Vendors already report devices without drift (e.g. inertial system of Xsense). More extensive market study may reveal existence of devices that can be easily combined in a working driftless solution. This practically will allow tracking without need for a drift correction and therefore matching with a 3D model will be either redundant or very occasional.

4 Realisation of user tracking for LBS

Last but not least is how tracking process will be integrated with the concepts of OGC and some other initiatives for interoperability. In the view of harmonisation and documenting of available datasets and providing common access to spatial data (e.g. INSPIRE, 2003), LBS also have to make use of existing data (as they are organised in different software and located on different servers). Technically, a user tracking as it is described above can be realised with the help of OGC Web services. Fig. 5 shows a *Tracking server* that consists of Tracking portal, Data processing unit and Data discovery unit.

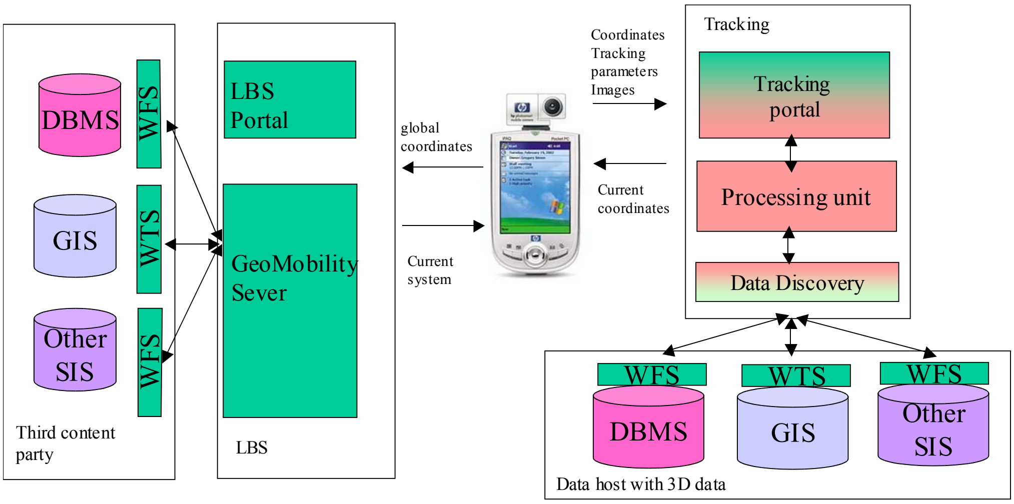

Fig. 5: User tracking with respect to OpenGL and OGC Web Services

The Tracking portal has to ensure the communication between a mobile device and the Data processing unit. A Data discovery service has to be able to locate appropriate data and fetch portions of a 3D model. Currently, Web Feature Service (WFS) and Web Terrain Service (WTS) are the two OGC web services (OpenGIS Specifications, 2003) that can be utilised to get the data over the Web. Implementations of these services are already on the market (e.g. IONIC, 2003).

WFS is a 'geometry service', i.e. it returns geometries described in GML. The Web Feature Server supports GetCapabilities (what kind of services are available), DescripeFeatureType (data schema), GetFeature (selection of geometries) Transaction (edit, delete, add feature) and LockFeature (locking feature when changing) operations. This service can be used to request objects in the area of interest in case of matching geometries (lines, points, corners). GML does not have limitations on dimension, thus 3D data can be exported.

WTS is an 'image service', i.e. WTS specification (in status 'Request for comment') defines a standard interface for requesting three-dimensional scenes. This service has to be used in case of matching images (template, colour). The WT Server is expected to support two operations GetCapabilities and GetView. The view or a '3D scene' is defined as a 2D projection of three-dimensional features into a viewing plane. To be able to create this view, the server has to receive a list of parameters such as Point of Interest (x,y,z of user focus), Distance between the user and the POI, angle of View, etc.

Once the co-ordinates are obtained from the tracking module, they are forwarded to the mobile device for further use with the GeoMobility server. In this respect, the services of the GeoMobility server (as they are designed at the moment) do not require modifications. The GeoMobility server will obtain the global co-ordinates from the mobile unit.

5 Conclusions

In this paper we have presented our concept on tracking mobile users as an alternative positioning technique for LBS. We presented three passive-target approaches with and without a vision system. We consider relative tracking a very interesting and promising approach for locating mobile users in case of:

- Dense urban areas, where GPS positioning fails.
- 3D indoor navigation.
- Close spaces, such as tunnels, undergrounds, etc.

A very important requirement for tracking using a vision system is the existence of a 3D model. However, the model can bear much more simplifications compared to the model required for AR systems. For outdoor areas, the level of resolution used to create 3D city models is expected to be sufficient. This theoretically means, that there is no need to create a specialised 3D model. 3D indoor models can be obtained from construction companies. Topological structuring is not of particular interest since small discrepancies are not of importance, which means CAD models have to provide sufficient detail. Though, it should not be forgotten that 3D topology is desirable for 3D routing (Zlatanova and Verbree, 2003).

Tracking of the user will not require changes of the OpenLS specifications, i.e. tracking will be organised as a separate module complementary to the GeoMobility Server. Furthermore, the data required for user tracking can be obtained from different data hosts using OpenGIS Web services that will ensure flexibility and interoperability.

The concepts presented in this paper are still to be investigated. As mentioned before, could be that a user tracking system needs only an appropriate assembling of components. To be able to develop and implement an optical tracking system still many issues have to be addressed:

- Mobile GUI for requesting and sending images.
- Testing and selecting appropriate matching procedures.
- Investigating suitability of 3D CAD models of interiors for feature matching.
- 3D visualisation on mobile devices using OpenGIS Web Standards.

The possibility to track a mobile user indoors and outdoors will definitely increase the functionality and operability of LBS and can be a starting point for 3D LBS. The most challenging topics in 3D LBS are mechanisms for 3D geocoding and 3D routing (and the corresponding browser for 3D visualisation and navigation on the handheld).

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Localisation with sketch based input

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Abstract

This article is dealing with an alternative method of localization. It proposes to use sketch based input as a description of the users location or a remote place. Sketches are assumed to be map like drawings in two dimensions that can be assembled on a computer screen for direct interpretation by a processing tool. For the localization process a common representation of the sketch and the reference data must be derived from some basic properties of both data sets. Sketches are an imprecise representation of the thoughts a person has about a situation and emphasizes the relations between objects. This relations are of a topological nature and do not represent a precise geometry. The properties are leading to a data structure for the search process that is organized as a semantic network, modelling the objects and relations as nodes of a graph. This graph is the foundation on which a search algorithm can be built. It aims at finding a sketched situation in a reference data set by scanning through the reference and finding corresponding nodes of the semantic networks. Therefore a constraint tree search approach is used. It is growing a state tree while exploring potential assignments of nodes. The search space is restricted by constraints that are applied to potential assignments of objects in the sketch and in the reference. Some examples are shown to illustrate this process.

1 Introduction

For quite some time our society enjoys the improvements of technologie in the sector of telecommunication. In the year 2002 approximately 70% of all citizens of the Federal Republic of Germany were owners of a mobile phone (Statistisches Bundesamt 2003). While only a short time ago the mobile phones were only useful for the exchange of speech or short messages, today an increasing number is extended to universal devices, the difference between computer and mobile phone is disappearing more and more. Industrie and research has realized that the position of a user is of big interest for several services. This services are developed under the term „location based services“ (LBS).

Common methods for position determination of mobile phones rely on an existing net of cells with antennas controlled by a net provider. The position of a user in this setup is a relatively uncertain determined point which can be derived from the cell that is actively communicating with this phone. For many applications this procedure is sufficient but by far not for all. For this reason an increasing number of GPS receivers are integrated into the used devices to allow a much more precise position determination and real navigation solutions. For example in the USA the manufacturers are bound by law to allow a reliable location of mobile phones in cases of emergency. (FCC, 2003; 911 Act)

Especially in the sector of pedestrian navigation this positioning information in combination with data of the environment is interesting. This additional data supports the user in realising where he is and which landmarks he can use for orientation if he wants to follow a planed route (Corona & Winter, 2001) (Elias, 2003).

The use of GPS has some drawbacks because it is not relyably accurately in densly build areas. This might change with the introduction of GALILEO and the increasing number of available satellites. But what happens if someone wants to find the current place given by a description or if he is not present at the given place? One possible solution of this problem is to let the user draw a sketch of the place in mind. This sketch is automatically interpreted by the computer and the system tries to find out where the sketched situation is located. This method would also be useful for easy routing or for specifying query areas in a spatial search engine.

Actually an sketch input tool for a spatial search engine in the project SPIRIT is developed. This tool will provide a web interface for the easy construction of sketches on a computer. It will be possible to produce sketches of realistic situations and use them as input to the search engine.

The sketching tool will be used in the SPIRIT project as a contribution to the multi modal user interface of a spatial search engine. The search engine will allow to use spatial query terms and select only those web site which can be located in an area covered by these terms. Several different interfaces, including the sketching interface, are developed to enter the spatial query terms and use them for a query (Jones, 2002). How this idea can be achieved is outlined in the next sections.

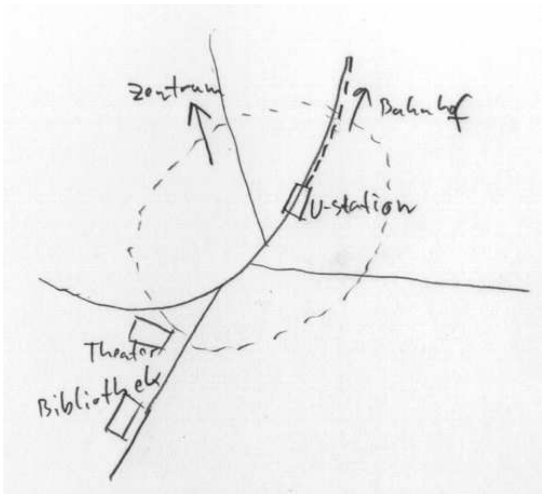

Fig. 1: Sketch of a place in Hannover (Aegidientorplatz)

2 Sketches

At first a definition of the term “sketch“ is helpful because the general definition of this term is very comprising. You easily can think of sketches which don't help in finding a place like naturalistic drawings of a sculpture or a drawing which was intended to explain the usage of a machine:

“traditionally a rough drawing or painting in which an artist notes down his preliminary ideas for a work that will eventually be realized with greater precision and detail. The term also applies to brief creative pieces that per se may have artistic merit.“
(www.britannica.com, 2003: “sketch”)

More suitable is the restriction to the term of a „map sketch“:

“only approximately true scaled handdrawing without any exactly measurements.“
(translation from www.wissen.de, 2003: “Kartenskizze“)

For the interpretation of a sketch, it is now interesting how a sketch is assembled from basic elements. The drawing surface limits the sketch to two dimensions. Lines are drawn on this surface and combined to build a picture. Subject of the drawing is the spatial distribution of objects and their relations. A sample sketch is shown in figure 1. There are several possible ways for expressing the occurrence of an object. It ranges from realistical drawings to abstract pictograms. Figure 2 shows a house drawn in three degrees of complexity. On the left a naturalistic symbol is used while in the middle only the shape is preserved. The right symbol will not be recognized as a house without further explanation but can be drawn very fast. It can be used if somewhere in the sketch a textual anotation marks this symbol as a house. Investigations have shown that abstract pictograms are prefered while realistical drawings are rarely used (Blaser, 2000). Every object can be assigned to a class using its appearence or by annotating it with text. All objects are arranged on the drawing surface in a way that their neighbourhood gives hints on the neighbourhood relations in nature. But exceptions, where the relative position in nature can only be reconstructed by interpreting textual annotations, are not uncommon.

The easiest method to create a sketch is to draw it onto a piece of paper. But for the introducted applications it makes more sense to have the possibility of a direct input of a sketch into the computer. PDA's and TablePC's which support comfortable and fast drawing on their screen with a pen and provide a quite realistic feeling of the drawing action are available today.

The electronic drawing surface extends the creative possiblities of a potential user. For example some kind of keyboard input is available for text creation, drawing steps can be undone and frequently used object types can be offered as drag and drop icons of symbols which can easily be moved to the drawing surface. The limiting borders of paper sheets aren't of any importance when using such a device.

3 Problem description

Suppose the user has an idea of a spatial situation in his mind and now wants to know where the situation is located. For example he/she knows a good restaurant in Rome, but remembers only that it was located down to the river and at a large place.To find something in general needs something to exist where it can be found. Here, this can be a reference data set that contains all relevant information for comparison with a sketch. The sketch is then a partial set of the reference if one or more solutions of the query exists (Fig.3). As a reference data set the geometric and semantic contents of a GIS can be used. But because sketches are only a rough approximation of reality, to find a solution for a query is not an easy task. First of all a common representation of the sketch and the reference must be identified that makes them comparable and to provide enough information to have a good representation of the data for the query.

The sketch data and reference data are of very different nature and some processing must be performed to have a comparable representation of both data sets. A sketch must be scanned for contained objects using patterns which describe how an object of a certain type is usually drawn. The patterns of object models can be constructed manually (Weindorf, 2001), or may be by Machine Learning (Mitchell, 1997) from sample sketches. Additional information on the contained objects can be derived from the textual annotations in the sketch.

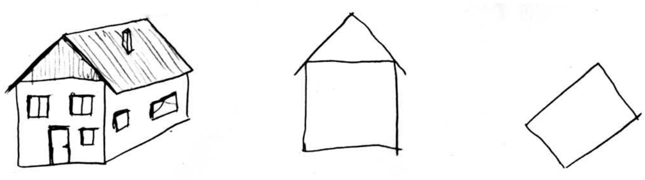

Fig. 2: Levels of symbol complexity

Following to this a process must derive topological and geometrical relations between objects from both datasets. Those relations then build a comparable basis on which a search algorithm can work. This articles focuses on the construction of a proper data structure and an algorithm being able to find a sketched situation in this data structure.

4 Data properties and general approach

At first an investigation on the properties of the sketch data and the reference data is needed. Like indicated earlier in this article a sketch is not a geometrical exact description of a situation but a manifestation of the thoughts of someone who has drawn the sketch. Humans think in terms which are relatetd with each other with associations (Spitzer, 2000).
A situation tends to be drawn in a simplified manner. A group of houses e.g. kann be shown by a single symbol, this way area like phenomenons are shrinking to point symbols. But this does not apply to every situation, for example when someone wants to express that something is inside or outside an area.

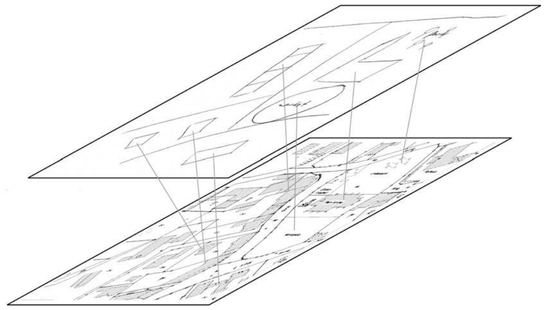

Fig. 3: Sketched situation as part of a reference data set

For objects with line shapes it is not necessary to copy its natural shape. Much more important are the points where intersections and turn-offs are located. An important information is whether two objects are separated by a line object in between, affecting their neighbourhood relation (Fig.4). Only prominent sharp bends of the road could be from interest in order to identify a road or a section of the road.

Usually a sketch only contains the characteristical objects and relations of a situation. Everything else is left out to win space on the drawing surface and to emphasize important objects. If a sketch describes a route only the important roads and most visible objects which can be used for orientation are drawn. Non visible objects or not important enough objects are left out, even if they cover a noticable area in nature. From the cartographical point of view for the reconstruction of a sketch a process is needed which inverses the operations of generalisation.

At the beginning of the interpretation process only an unordered collection of lines, texts and symbols with given coordinates in respect to the drawing surface is given. First aim of the interpretation is to identify objects and to extract topological and geometrical relations between them (Fig.5). An extensible list of examples for the relations contains neighbourhood, distance, direction, clustering, parallelity, orthogonality, line intersections and containment (Egenhofer, 1993). How the objects can be extracted and how the topological and geometrical relations are calculated is not in the scope of this paper.

A sketch usually does not exceed a certain degree of complexity because it must be kept understandable to a potential sketch reader. The number of objects and relations is also limited, leading to a small data set. The reference data by contrast is very different in nature. It can get very large, because it must provide all details of the area where the search service is be provided. It is a geometrically exact description of the area, where the coordinates are given in a national or international reference frame. A typical source of such data is a GIS, which contains readily interpreted objects and their attributes. This fact simplifies the conversion into a commom representation because no automatical object detection is needed. However, it is necessary to extract the same topological and geometrical relations between the objects to get a comparable basis.

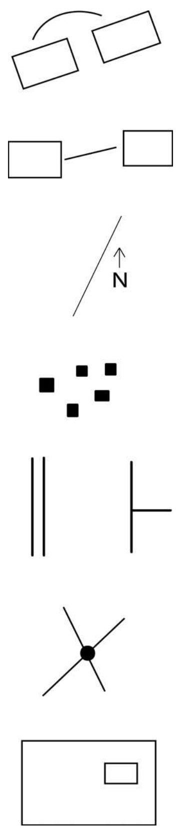

Fig.4: Topological relations

5 Data structure

The properties of the data are the basis to derive a suitable data structure which allows to perform fast queries. This section wants to outline the principles of the data organisation providing only a skeleton that must be extended and adjusted for a real implementation.

The basic elements in such a structure must be relations between objects. Every object has to carry a unique name. Objects in the sketch and in the reference must be named semantically equivalent, making a check for coincidence possible. Additionally, every object is assigned to a class which defines common properties in a set of objects. A case only allowed to appear in sketches is the existence of anonymous objects which don't carry a name but are assigned to a class. Anonymous objects can lead to multiple equivalent solutions in a query, because many objects in the reference can match these objects in the sketch, but they allow the definition of sketched patterns where only some general conditions about the wanted area are defined. The same is true for relations between objects. In the sketch relations are always anonymous while in the reference they must have a unique name. The next section uses the term "concept" when referring both to objects and relations.

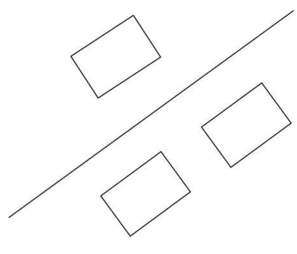

Fig.5: Separation of buildings

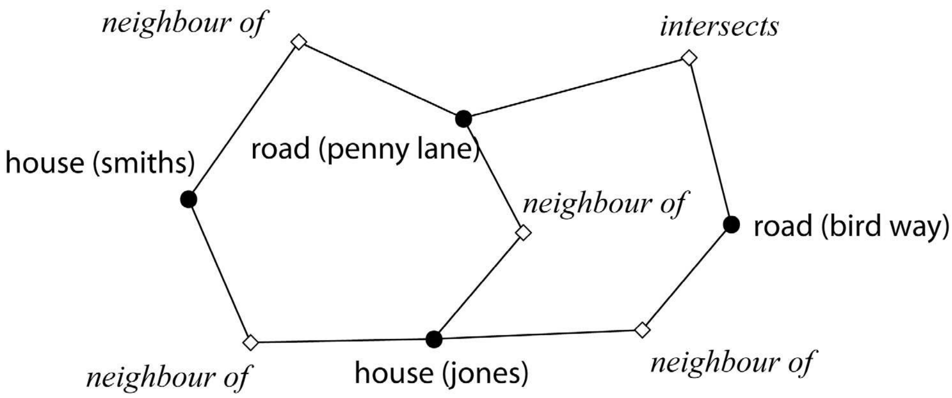

Fig.6: Semantical network of objects and relations. The relations are shown in italic, the objects all have unique names

Concepts must be connected to each other with links to form a statement. To indicate that a house is a neighbour of a road, the concept of the object „house“ must be linked to the relational concept „is neighbour of“ which itself is linked to the concept „road“ as shown in figure 6. The concept „is neighbour of“ shows how the concepts „house“ and „road“ are related. The house and the road would additionally carry unique names, e.g. “Smiths”, allowing to reference them. A larger number of relations modeled this way referring to the same set of objects is called a semantic network. Usually only the concepts of objects are nodes in a network of this sort and the relations are assigned to the links. Here the relational concepts are also nodes and the links don't carry any properties. This allows to model relations between more than two concepts but more important is that it simplifies a searching algorithm based on this data structure. Note that this requires an alternating use of relational and object concepts.

6 Algorithm

Now it is possible to search sketched situations which are stored as semantic networks of objects and relations in a large reference data set which is also stored as a semantic network of objects and relations. The problem of matching two spatial situations can be solved with a search process (e.g. Winston, 1984). A well known algorithm for pattern matching tasks, the constraint tree search (CTS) is used and adapted for this special case. This method is searching a state space for valid solutions. Depending on one state new states are created and checked if they are valid. Only valid states are followed, building a state tree with a growing number of branches. This tree is completely searched until one or all valid solutions are found. The runtime of the algorithm strongly depends on the number of possible and valid states which result at each branch of the state tree and is always exponential. If this is limiting the practical usage depends on the general conditions of the problem and the data model (Grimson et al., 1993)

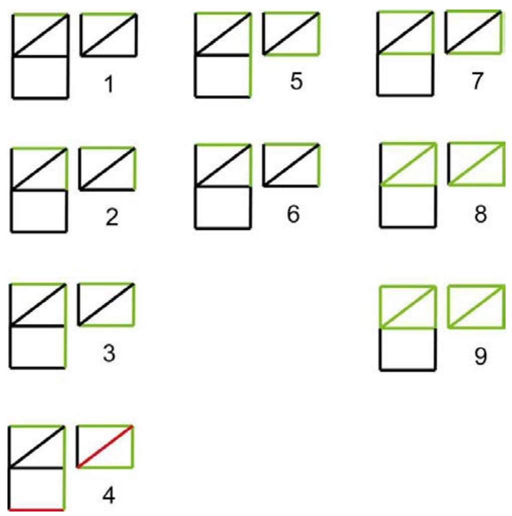

Fig.7: Iterating through the state space. The left network in every step is the reference data set. The right network is always the sketch network.

The states of this special process in our case are formed by a list of concept pairs. The basic assumption is that each concept of the sketch data can be assigned to a concept of the reference data to build a valid solution. Two concepts can be assigned one another if their names are identical or if their classes are matching. The last option is only valid if in the sketch data no name for the object was given. At the beginning of the query process two assignable concepts from both data sets must be found to form a valid state. This needs only to be done for one concept of the sketch but has to be done for all concepts of the reference in worst case. For this step the run time is depending linearly on the number of concepts in the reference. But it is possible to limit the search space if additional information is used, e.g. the class of a concept, or if seldom or unique nodes are used as start nodes. This can exclude a lot of concepts to be proved in advance.

The algorithm is controlled by a depth search in the graph of the sketch data. All links are followed in one direction from its start node to its end node recursively. Depending on the following tests the depth search can be continued or taken back one step. In every step one link is inspected. For its start node it is always true that an assigned node in the reference exists. This explaines why a first pair of nodes is needed before starting the query algorithm. This property of the start nodes is true for every step of the query.

When the end node in the sketch is not assigned already, all links which originate from the start node of the reference are iterated. Links marked as already used can be ignored. A check is needed for the end node in both the sketch and the reference to prove if an assignment is allowed. If this is the case both links and nodes must be marked as used and an assignment between the end nodes must be established. Then the depth search can be continued by a recursive call with the next step. When returning from the recursion, all this assignments between nodes must be removed and the marks for used links and nodes must be cleared to restore the old state. Returning from the recursion means that the query was truncated by an invalid state or a solution was found and stored. A solution is complete if all links of the sketch are marked as used.

One possible case is that the end node in the sketch is already assigned to an end node in the reference. Then it must be checked if the start node in the reference has a link to this end node. If this happens the depth search can be continued recursively after marking the link as used. After returning from the recursion it must be taken care to restore the old state by removing marks. If no matching link is found in the reference data set, a valid solution does not exist on this track and the actual recursion step is quit. Figure 7 shows how a query works. Steps 1 to 4 are exploring the search space but in step 4 no legal assignment of links is possible. Steps 5 and 6 do backtracking until an unexplored state can be reached. The final solutions is found after exploring alternative paths in step 9. Note that this is not a unique solutions and further exploring of the state space would find more valid assignments.

```
Find first pair of nodes and make assignments
Search()
{
    Depth search in sketch graph: one step forward
    If all links of the sketch are visited
    {
        Store all assigned nodes as solution
        Exit function
    }
    If end node in sketch is used
    {
        Find link from start node in sketch to end node in
             reference using link list of start node
        If link is already used
        {
            Search()
        }
        Else
        {
            Mark link as used
            Search()
            Mark link as unused
        }
    }
    Else
    {
        For all links originating in the start node in
             reference
        {
            If link unused
            {
                If end nodes in sketch and reference are
                     assignable
                {
                    Assign end nodes
                    Mark both end nodes as used
                    Mark link as used
                    Search()
                    Mark link as unused
                    Mark both end nodes as unused
                    Remove assignment of end nodes
                }
            }
        }
    }
    Depth search in sketch graph: one step back
}
```

Fig. 8: Pseudocode for the query algorithm

The algorithm can be written in pseudocode as shown in figure 8.

The runtime of the algorithm strongly depends on the structure of the graphs building the semantical networks. In general it can be assumed that the sketch graph is small which limits the number of potential links to follow and limits the needed query time. Important is further if it the graphs are dense or thin. Thin graphs provide less possible tracks to follow in each node what speeds up the query. Are the links connecting only local concepts, the algorithm searches only in a small amount of nodes of the reference. Nodes far away can then be assumed to be unimportant for the query and are not visited during the searching process. All this must be taken care of when implementing a data model for the semantic networks.

7 Results and further work

The shown algorithm has been implemented in a program. Some small tests with simulated road data showed already a reliable detection of patterns in a reference data set. Only connections between turn-offs and intersections were modeled. Only the classes intersection, connection, same sided turn-off and opposite sided turn-off were used. The tested area and patterns were small so that no final conclusion regarding the practical run time and reliability can be drawn (Fig.9). But an analysis of the visited paths supports the assumption that many of the combinations are dropped as invalid and the search tree is strongly pruned.

The next step will be devoted to the automatic extraction/conversion of GIS data into the semantic network. This will allow to make more tests on the performance and behaviour of the approach, especially concerning the concepts needed. Then, investigations have to be conducted taking the uncertainty of the given concepts into account: Whereas the information in the reference data set can be considered as of high quality, the result of the

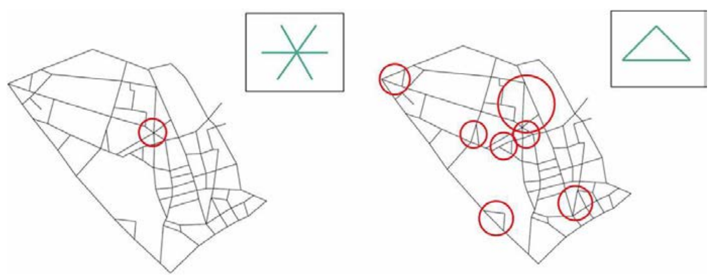

Fig. 9: Sample data. The left pattern is unique but the right pattern occurs multiple times

sketch interpretation has some uncertainty. This will include ambiguous concepts (object is one building or small village) and also missed concepts (e.g. user did not draw small path as he/she considered it was unimportant). Then, the concept of Wildcards will be used (Vosselman, 1992). Future work will also have to investigate the use of pre-defined icons for sketch productions.

8 Acknowledgements

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A Standard API für Positioning in Telecommunication Networks

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Abstract

In 2002 the Location Interoperability Forum (LIF) has standardized a new version of the location platforms' application programming interface (API), the Mobile Location Protocol (MLP) 3.0. Meanwhile the LIF's successor organization, the Open Mobile Alliance (OMA), adapts and completes this standard in details. In the near future MLP 3.1 is expected.

MLP 3.0/3.1 encapsulates the concretely used positioning technique. This means, location applications can access the API without being aware of the underlying location platform's positioning technique. Nevertheless the API is strongly influenced from mobile telecommunication network environments. To what extent telecommunication independent positioning techniques can be met with this API must still be proved in practical use.

SIEMENS has implemented a location platform supporting MLP 3.0/3.1 as far as the needed prerequisites are provided by the mobile telecommunication networks. It is planned to reach the full functionality step by step. This location platform is based on the reference architecture as specified in the 3GPP standard TS 23.271. Currently integration of a satellite based positioning technique which is quite telecommunication network independent, is in a conceptual stage.

MLP 3.0/3.1 is an XML based protocol which uses HTTP or HTTPS as transport layer. It allows synchronous und asynchronous location requests and processing of location reports induced by mobile telecommunication networks. In addition push services are foreseen. They will allow an application to request to be triggered in case certain predefined events occur in the telecommunication network, for example, if a mobile subscriber enters or leaves a specific geographical region.

The present contribution gives a description of the services provided by MLP 3.0/3.1 for developers of location applications. It includes practical usage hints and discusses the realization state of the functions behind the API.

1 Introduction

In the last years 3GPP (3rd Generation Partnership Program) has published a comprehensive set of standards for location services. Core of the standard set is the technical specification TS 23.271 which describes the interworking of all components necessary for positioning of devices in mobile telecommunication networks.

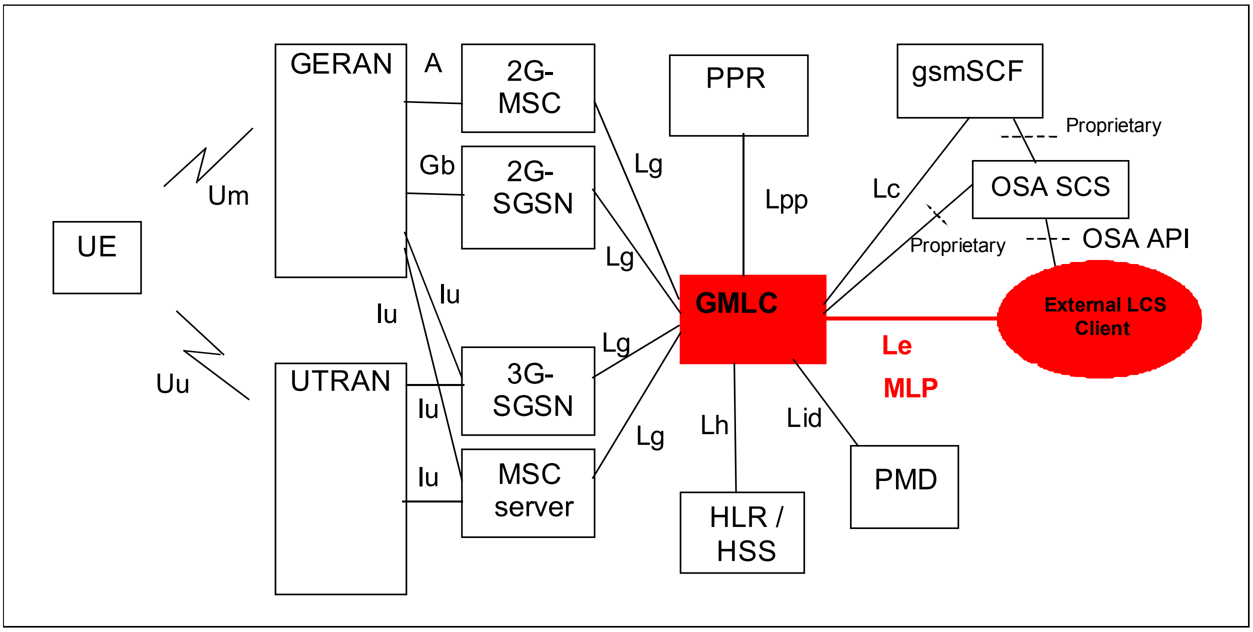

Fig. 1: Components for Positioning according to 3GPP TS 23.271

Fig. 1 shows all concerned components. The GMLC has a central position. It is the interface

- to the positioning applications via reference points Le and Lc;
- to the call processing part of mobile networks (Core Network) via reference points Lh and Lg;
- to the Privacy Profile Register (PPR) which controls the authorizations to locate mobile devices, via reference point Lpp;
- to the Pseusonym Mediation Device (PMD) which administers anonymized subscriber identifications, via reference point Lid.

The location platform developed by SIEMENS supports the interface to positioning applications (referred to as External LCS Clients in Fig. 1), to PMD and Core Network. The PPR is integrated into the location platform. The elements and interfaces indicated by bold text and fillings in Fig. 1 show the topic of the present contribution.

The MLP interface is 3GPP's favored implementation of reference point Le. Besides the MLP interface standards for access according to OSA/Parlay (referred to as OSA API in Fig. 1) and according to the web service based ParlayX exist.

The actual positioning, including communication with the searched mobile device, is done in the Radio Access Network part of mobile networks (GERAN für GSM and GPRS networks, UTRAN for UMTS networks). According to the 3GPP standard the GMLC has no direct connection to the Radio Access Network and the searched mobile device. The location platform of SIEMENS provides proprietary interfaces to these components. These proprietary interfaces are needed for integration of satellite based positioning techniques. The MLP interface, the focus of the present contribution, is not affected by this enhancement.

2 MLP Services

MLP 3.0/3.1 includes 5 services:

Standard Location Immediate Service: This service shall be used for positioning of mobile devices on behalf of commercial applications of 3rd party providers. Hence it is discussed predominantly in the present contribution. Further potential users are internal applications of mobile network operators and interception applications of law enforcement agencies. A characteristic of the Standard Location Immediate Service is an authorization control whether positioning of the wanted mobile device is allowed. At least in Europe mobile subscribers must explicitly accept being located by commercial applications.

Emergency Location Immediate Service: This service is used for emergency call applications in USA. In USA mobile network operators must be able by law to locate very accurately subscribers who have issued an emergency call. Comparable EU regulations are currently discussed, but not expected in the near future. From the application interface's view this service behaves as the Standard Location Immediate Service, only with a higher priority in internal handling. Because the Emergency Location Immediate Service is explicitly not thought for commercial applications it is not further discussed in the present contribution.

Standard Location Report Service: This services assumes that a mobile subscriber has located himself/herself and wants to deliver the determined position actively to a commercial application. For this service so far the needed prerequisites in the Core Networks are lacking. Thus it is not supported by the location platform of SIEMENS and not further discussed.

Emergency Location Report Service: Also this service is only provided for emergency call applications and thus not discussed in more detail. Via this service the Core Network delivers as fast as possible a rough position of the subscriber who has issued an emergency call, to an emergency call application. A subsequent more detailed positioning is done by the Emergency Location Immediate Service.

Triggered Location Reporting Service: This service enables applications to specify events on whose occurrence the location platform is informed. Then the location platform processes the event. Corresponding to the event type 2 sub-services exist:

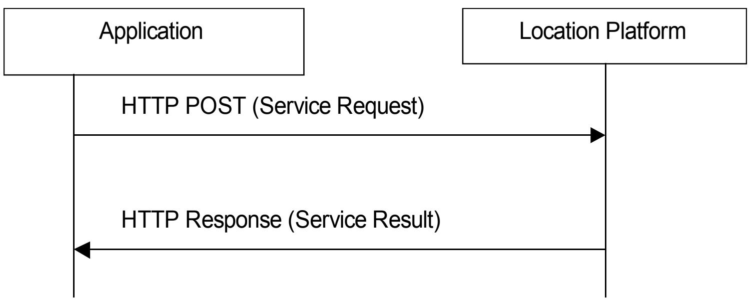

Fig. 2: Service Access by an Application

- Periodic Location Service: The event is a timer that has run out. After every period the location platform starts the Standard Location Immediate Service.
- Deferred Location Service: The location platform (on behalf of an application) has requested from the Core Network to be informed about certain events. Examples are if a mobile device becomes reachable, or if a mobile subscriber has entered or left a specified region. So far the needed prerequisites in the core networks are lacking. Thus this sub-service is not supported by the location platform of SIEMENS and not further discussed. Development of restricted prototype functions is planned.

All MLP services are working independently of the positioning technique concretely used in the Radio Access Network. The only difference is the granularity of the determined position.

2.1 Transport Layer

The location platform uses HTTP (resp. HTTPS, if configured accordingly) as transport protocol for all MLP services. The location platform provides an URL address consisting of IP address and port number, e.g.: http://127.0.0.1:9211. All applications access the location platform via one and the same address.

Fig. 2 shows the message sequence for MLP services accessed by an application (Standard Location Immediate Service und Emergency Location Immediate Service). The service answer in the HTTP Response may be (dependent on the service and the application's request) a plain acknowledgement or it may already contain the determined position. In the former case an asynchronous HTTP message follows later, as shown in Fig. 3. MLP services issued by the location platform (Standard Location Reporting Service und Emergency Location Reporting Service) are also described by Fig. 3.

2.2 Standard Location Immediate Service

The location platform supports a synchronous and an asynchronous service mode. The application selects the mode during the service request. In the synchronous mode the Standard Location Immediate Answer contains the result. In the asynchronous mode the Standard Location Immediate Answer is just an acknowledgement; the actual result follows in an asynchronous Standard Location Immediate Report.

2.2.1 Parameter Description

The following semi formal descriptions use the following symbols:

+	Once or multiple,
*	Not, once or multiple,
?	Optional,
|	Or,
,	Fixed sequence.

The syntax is based on that of the MLP standard. Restrictions of the location platform of SIEMENS are mentioned in the verbal description part.

Header
The header data enable the location platform to identify the accessing application and to verify whether the application is authorized. The location platform controls whether the application is authorized to access the wanted MLP service and to position the wanted subscriber.

Structure: hdr ((client | sessionid | (client, sessionid)), subclient*, requestor?)

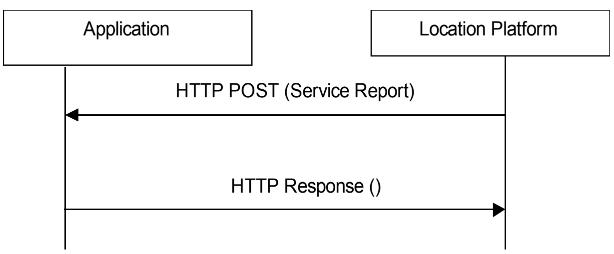

Fig. 3: Asynchronous Answers or Access by the Location Platform

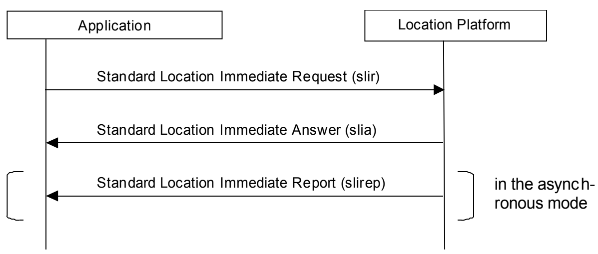

Fig. 4: Message sequence of the Standard Location Immediate Service

Parameter	Description
client	**(id, pwd?, serviceid?, requestmode?)**
	id: Identification of the accessing application.
	pwd: Password of the accessing application; mandatory (contrary to the standard).
	serviceid: Identification of a sub-function of the accessing application.
	requestmode: Type of location request. **type**: (ACTIVE | PASSIVE) ACTIVE: Positioning of a 3rd party. PASSIVE: Self-positioning of the mobile subscriber.
sessionid	Identification of an existing session between location platform and application; currently ignored.
subclient	**(id, pwd?, serviceid?)** Identification of application service providers (ASPs), brokers and portals in the chain between application and end user of the application.
requestor?	(id, serviceid?) Identification of the end user of the application; currently ignored.

Tab.1: Header-Parameter

Standard Location Immediate Request
Structure: slir ((msids | (msid, codeword?, gsm_net_param)+), eqop?, geo_info?, loc_type?, prio?, pushaddr?) res_type

Parameter	Description
msids	**(((msid, codeword?, session?) | (msid_range, codeword*))+)**
	session: **type** (APN | DIAL) APN: GPRS session. DIAL: GSM/UMTS session.
	msid_range: **(start_msid, stop_msid)** **start_msid**: **(msid)** **stop_msid**: **(msid)**
msid	Identification of the searched mobile device. **type** (MSISDN | IMSI | IMEI | MIN | MDN | EME_MSID | ASID | OPE_ID | IPV4 | IPV6 | SESSID)) The location platform supports MSISDN, IMSI, IPV4, IPV6 und SESSID. The PMD (reference point Lid) converts the last 3 types into an MSISDN or IMSI. **enc** (ASC | CRP). The location platform only supports **ASC**II-Coding.
codeword	Password for positioning a mobile device, defined per mobile subscriber; currently ignored.
gsm_net_param	**(cgi?, neid?, nmr?, ta?, lmsi?, imsi?)** Various positioning related information from the core network.
	cgi (mcc, mnc, lac, cellid): Identification of a radio cell. **mcc**: Mobile Country Code. **mnc**: Mobile Network Code. **lac**: Location Area Code. **cellid**: Cell number.
	neid (vmscid | vlrid | (vmscid, vlrid) Core network element currently serving the searched mobile device. **vmscid**: Visited Mobile Switching Center. **vlrid**: Visited Location Register.
	nmr: Network measurement results of the searched mobile device; currently ignored.
	ta: Advanced timing information of radio signals; currently ignored.
	lmsi: Local identity of the searched subscriber in the VLR; currently ignored.
	imsi: International Mobile Subscriber Identity
eqop	**(resp_req?, resp_timer?, (ll_acc | hor_acc)?, alt_acc?, max_loc_age?)** Requested quality of the positioning result.
	resp_req: Accepted answer behavior. **type** (NO_DELAY | LOW_DELAY | DELAY_TOL)
	resp_timer: Accepted response time.
	ll_acc: Requested accuracy of latitude and longitude in seconds; currently ignored.
	hor_acc: Requested horizontal accuracy.
	alt_acc: Requested vertical accuracy.
	max_loc_age: Accepted age of determined position.

Parameter	Description
geo_info	**(CoordinateReferenceSystem)** Requested format of determined position.
	CoordinateReferenceSystem (Identifier) **Identifier (code, codeSpace, edition)** The location platform only supports EPSG 6.1 according to codeSpace www.epsg.org.
loc_type	**loc_type**: Type of position. **type** (CURRENT | LAST | CURRENT_OR_LAST | INITIAL) INITIAL is only relevant for Emergency Location Immediate Requests; for Standard Location Immediate Requests it is handled as CURRENT.
prio	Request priority. **type** (NORMAL | HIGH)
pushaddr	**(url, id?, pwd?)** Address for the asynchronous Standard Location Immediate Report.
res_type	Requested service mode. **res_type** (SYNC, ASYNC)

Tab. 2: Standard Location Immediate Request Parameter

Standard Location Immediate Answer
The Standard Location Immediate Answer is the synchronous answer to the Standard Location Immediate Request. It contains (according to the attribute res_type in the request) either the determined position or an identifier for correlation of the following asynchronous position.

Structure: slia ((pos+ | req_id | (result, add_info?)), sag_imsi*)

Parameter	Description
pos+	**(msid, (pd | poserr), gsm_net_param)**
	msid: See Tab. 2.
	pd (time, shape, (alt, alt_acc?)?, speed?, direction?, lev_conf?) **time**: Time of positioning. **shape**: Coordinates of the determined position and an area of uncertainty in form of various geometric shapes. **shape (Point | LineString | Polygon | Box | CircularArea | CircularArcArea | Elliptical Area | GeometryCollection | MultiLineString | MultiPoint | MultiPolygon).** The location platform supports Point, Polygon, CircularArea, CircularArcArea, Elliptical Area. **alt**: Altitude of mobile device. **alt_acc**: Accuracy of altitude. speed: Currently not supported. direction: Currently not supported. **lev_conf**: Probability of the correctness of the delivered result in percent.
	poserr (result, add_info?, time)
	gsm_net_param: See Tab. 2.
req_id	Identifier for correlation of a following asynchronously received position.
result	Text und numeric interpretation.
add_info	Optional, additional information.

Tab.3: Standard Location Immediate Answer Parameter

Standard Location Immediate Report
The Standard Location Immediate Report contains the asynchronous answer with the determined position.

Structure: slirep (req_id, pos+, sag_imsi*)

Parameter	Description
req_id	See Tab.3.
pos+	See Tab.3.

Tab.4: Standard Location Immediate Report Parameter

2.3 Triggered Location Reporting Service

Die Location Platform of SIEMENS supports periodical location requests. For deferred location requests the prerequisites in the core networks are lacking.

Fig. 5 shows the general message sequence. The application requests periodical positioning of a mobile device. The location platform acknowledges the request synchronously. Periodically the location platform sends the requested location reports. The application can stop the periodical request at any time; the location platform acknowledges the stop synchronously.

3 State of the Art behind the MLP Interface

At the End of 2003 providers of core and radio access networks support the interfaces at reference points Lg and Lh and the functions behind only rudimentarily or in small, isolated regions. Changes of this situation cannot be expected in the near future. Reasons are the considerable investments needed for extensions of the networks which may not redeem with the calculated revenues of positioning applications.

Outside the mentioned isolated regions location platforms can only deliver positioning information in the granularity of radio cells. A radio cell describes the range of a radio receiver. The granularity of this positioning information is in urban areas (dependent on the cell size) between 50 and several 100 meters, in rural areas up to several kilometers.

Thus the location platform can only convert the cell id which is usually the only information it gets from the core networks, into coordinates and uncertainty area (= shape). The conversion result is transmitted to the requesting application. If the cell format (and thus implicitly the uncertainty area) is a circular arc with or without an inner radius the location platform takes the arc's center of gravity as coordinates of the searched mobile device. Otherwise, if the cell has the shape of a circle or an ellipse, the location platform takes directly the coordinates of the radio receiver.

The new satellite based solution which avoids the current restrictions in Core and Radio Access Network, brings a considerable improvement. The positioning technique enables a granularity between 10 and 100 meters. As a difference to the radio network based techniques this one delivers better results in rural areas. Also the satellite based positioning technique needs some extensions in the core and radio networks, but they are not that expensive. Only a predefined interface to the GPS system must be provided. Nevertheless this technique has a main disadvantage. It can only position mobile devices that include a GPS receiver and that can communicate directly with the location platform (e.g. via WAP).

4 Summary

The location platform of SIEMENS offers a web based public HTTP interface to commercial positioning applications. Via this interface applications can access standardized location services for immediate and periodical positioning. The interface encapsulates the actually positioning techniques supported by the location service provider. The reachable granularity is strongly dependent on the used positioning technique.

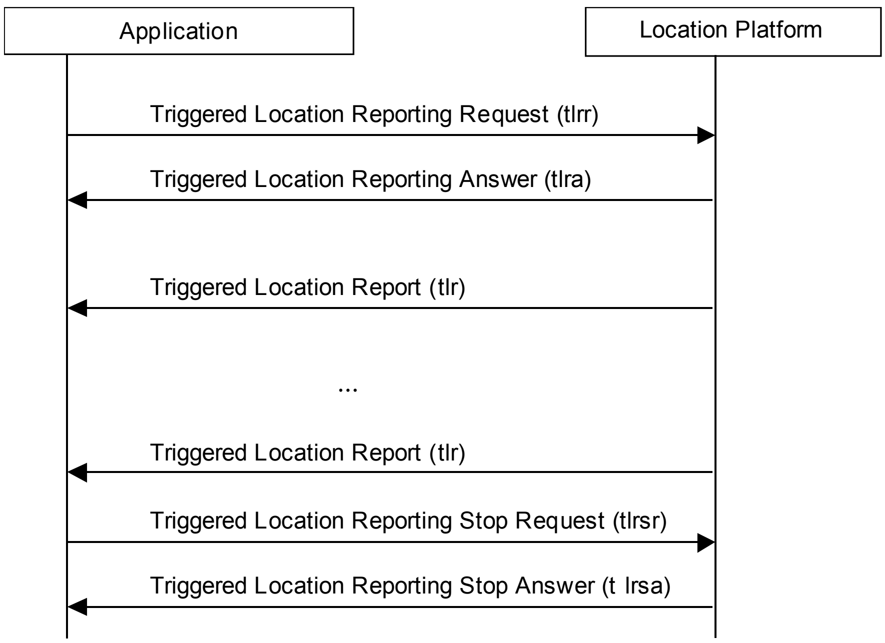

Fig. 5: Message Sequence of the Triggered Location Reporting Service

5 Abbreviations

2G	2nd Generation (GSM, GPRS)
3G	3rd Generation (GPRS, UMTS)
3GPP	3rd Generation Partnership Project
A	Reference point between Radio Access Network and Core Network (GSM)
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange
ASP	Application Service Provider
EPSG	European Petroleum Survey Group
Gb	Reference point between Radio Access Network and Core Network (GPRS)
GERAN	GSM Edge Radio Access Network
GMLC	Gateway Mobile Location Center, realized by the presented location platform
GPRS	General Packet Radio Service
GPS	Global Positioning System; satellite based positioning system
GSM	Global System for Mobile Communication
gsmSCF	Service Control Function for GSM; controls call processing in Intelligent Networks
hdr	Header
HLR	Home Location Register (GSM, GPRS)
HSS	Home Subscriber Server (UMTS)
HTTP	HyperText Transfer Protocol
HTTPS	HyperText Transfer Protocol Secure
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
ISDN	Integrated Services Digital Network
Iu	Reference point between Radio Access Network and Core Network (UMTS)
Lc	Reference point between Intelligent Networks and GMLC
LCS	Location Service
Le	Reference point between positioning applications (LCS Clients) and GMLC
Lg	Reference point between Core Network (MSC, SGSN) and GMLC
Lh	Reference point between Core Network (HLR / HSS) and GMLC
Lid	Reference point between PMD and GMLC
LIF	Location Interoperability Forum
Lpp	Reference point between PPR and GMLC
MLP	Mobile Location Protocol
MSC	Mobile Switching Center (GSM)
MSISDN	Mobile Subscriber ISDN
OMA	Open Mobile Alliance
OSA	Open Service Architecture
PMD	Pseudonym Mediation Device
PPR	Privacy Profile Register
SCS	Service Capability Set
SGSN	Serving GPRS Support Node (GPRS)
slia	Standard Location Immediate Answer
slir	Standard Location Immediate Request
slirep	Standard Location Immediate Report
tlr	Triggered Location Reporting Request
tlra	Triggered Location Reporting Answer
tlrr	Triggered Location Reporting Request
tlrsa	Triggered Location Reporting Stop Answer
tlrsr	Triggered Location Reporting Stop Report
TS	Technical Specification
UE	User Equipment
Um	Reference point between mobile device and Radio Access Network (GSM, GPRS)
UMTS	Universal Mobile Telecommunications System
URL	Unified Resource Location
UTRAN	Universal Terrestrial Access Network
Uu	Reference point between mobile device and Radio Access network (UMTS)
WAP	Wireless Application Protocol
XML	Extended Markup Language

6 References

3GPP TS 23.271, Release 6, Location Services (LCS) - Functional Specification, Stage 2.
3GPP TS 23.032, Universal Geographic Area Description for UMTS.
ITU-T Q.763 Calling Geodetic Location.
OMA, Mobile Location Protocol 3.0.

LBS & NAVIGATION

A View on Location-Based Services – 1000 Days After the Hype

Markus Uhlirz and Julius Kindler, Eisenstadt

Abstract

Location-Based Services (LBS) and Mobile Positioning were commonly marketed as future "killer applications" for 3G-type networks. Ambitious business plans and services relied on this prospect. A variety of obstacles, technical and non-technical, have so far prevented the large-scale success of LBS.
This paper takes a view on today´s reality of challenges faced when deploying LBS, discusses the resulting consequences and implications for commercial LBS service offerings today and gives an outlook on present and further trends for LBS applications.
A brief discussion of Mobile Positioning for TeleCartography applications concludes this paper.

1 Introduction

Ever since the enabling of mobile non-voice telecommunication services, the prospect of Location Based Services (LBS) has driven engineering phantasies, combining the advantages of a mobile communications device with real-time positioning information. Examples of such services were thought to be vehicle navigation or routing information. The combination of commercial interests and real-time location information allows a precise tailoring of the offer to the customer´s present situation.

1.1 Mobile Positioning and Location Based Service

The generic concept of mobile positioning is an ancient art, already practised by the sea-faring nations of Egyptians and Phoenicians many centuries B.C., using celestial fixpoints, observations and calculations based on the laws of geometry.

Electronic Mobile Positioning has become a commodity product within the recent decade, due to public availability of the satellite-based GPS system [1] and cheap handheld positioning devices as mass-cosumer products [2].

Location-Based Services can be provided today with a GPS receiver and portable data processing devices reading all necessary information from a static database integrated into the overall technical solution. Examples for such solutions are e.g. various implementations of guidance systems as commonly found in cars [3] or handheld solutions [4].

In this paper the terms „Mobile Positioning" and „Location Based Services" (LBS) shall furtheron be understood as being within the context of telecommunications networks, with or without additional usage of satellite systems.

2 LBS - The Last 1000 Days

One of the main drivers for developing telecom-based mobile positioning systems was the US American FCC requirement [5] to implement an emergency roadside service ("E-911") by September 2001. This E911 service shall allow positioning of a road accident with an accuracy of 500 feet (167m) in at least 95% of cases. This request has influenced many telecom and technology companies to investigate the feasibility of mobile positioning methods. Additionally, the potential of LBS for Health services, public safety, professional logistics and personal life-style was seen very promising. The revenue prospects of mobile advertising, better targetting of customers with promotion information based on their present locations has created great enthusiasm in the marketing world. A great variety of location-based services was identified and promoted accordingly. (see Fig.1)

2.1 The Views of 1999 and Today

Since the "happy days" of LBS in 1999 it appears that the users have not perceived the value of LBS as intended. Many of the anticipated LBS "killer applications" have not enjoyed the predicted market success. In consequence, the enthusiasm concerning LBS has considerably declined, both, with system suppliers and mobile operators. (see Fig.2)

"Friend-Finder" and "Child Tracker" have been initially launched by some operators and were taken off the net, following hefty discussions and legal cases concerning violation of privacy and the fears of potential ab-use of such operator services[1]. Other services such as Mobile Dating have turned out to be of little success, mainly because of competition by similar internet-based offers and lack of genuine value proposition. Location-based promotions, mostly using simple text SMS, have had little or negative effect to the targetted users and are often perceived as "mobile spamming"[2].

Services involving a direct reward or tangible benefit for the users, e.g. vouchers and directory enquiry services have received the user´s acceptance to some extent. However, the market success of these is also well below expectations of 1999.

2.2 Possible reasons

The network technology, terminals, applications, content, positioning methods, application interfaces, software and all other technical elements needed for putting together a successful LBS are available today. Still, the market success of LBS to date has not reached the anticipated levels. Why?

Some possible reasons for this development are:

- High CAPEX/ OPEX costs for LBS system
- Long and fragile value chain
- Regulatory and Legal Issues
- Unclear ownership of Location Data
- Market mechanisms („Push" vs „Pull" services)

3 Technology Aspects of LBS

This chapter describes the most common positioning methods used in today´s LBS systems in section 3.1 as a summarising overview. More details on positioning methods are found e.g. in [6]. The network aspects and transaction flow for LBS are introduced in section 3.2. Section 3.3 compares the costs and complexity of various methods and draws some conclusions from an operator´s perspective.

3.1 Positioning Methods and Accuracies

The GSM and UMTS systems were designed as telecom networks, in which accurate Mobile positioning has not been foreseen. Due to the principle of distributed intelligence in the GSM architecture, there is not a single network instance that holds all necessary information to allow a accurate positioning of a terminal. This fact causes major difficulties for implementation of LBS systems.
The positioning methods can be grouped into two main categories:

- Network-based methods
- Terminal-based methods

Each of these again can be divided into automatic positioning or manual positioning.

3.1.1 Location Area Code, Cell Identity

The only position information inherently available in GSM or UMTS systems is the Location Area Code (LAC)[3], in which a terminal was last registered by the network. This information is stored in the Home Location Register (HLR) of the terminal´s home network. Typically, a Location Area spans across many radio sites and covers an area of several hundred sq.km. This accuracy is suitable for call routing to a terminal roaming anywhere on Earth, but is inadequate for a precise positioning information.

The next granularity available is the Cell Identity (CID), an arbitrary identifier used for technical administration of the network. The CID can be unique within a network, but need not be. In case CID shall be used for positioning, the operator needs to ensure a unique numbering scheme that shall not be altered during the lifetime of LBS. The size of a radio cell typically varies between 20 sq.km in rural areas and 0.5 sq.km in dense urban areas, depending on the network layout. The CID is not readily available in the network, but can be read with some extra effort from the terminal and be transmitted as hidden SMS to the network, using small applications residing on the User´s SIM card. This is also referred to als SIM-Toolkit applications (STK).

In a step of further refinement, the accuracy of plain CID can additionally be enhanced by information on the the received signal strength (RX) at the terminal and Timing Advance used (TA). The Timing Advance information provides a rough indication on the distance of the terminal from the radio site, thus limiting the possible true position of the terminals to specific cell segments, in

[1] In late 2003, a Finnish operator has re-introduced their Child-tracker service, however under very strict and controlled conditions, allowing only the direct family members to query the location of their children.
[2] The typical „Welcome"- SMS received upon arrival at an airport in a foreign country are a simple form of such location-based spamming.
[3] For UMTS networks: Routing Area Identifier (RAI)

simplification assumed as concentric circles[4] centered on the radio site. The accuracy of a TA segment is approx 500 meter, therefore this information does not provide any meaningful improvement in urban areas, where cell coverage ranges are typically well below 1 km. (see Fig.3)

3.1.2 Triangulation (E-OTD)

The method of "Enhanced Observed Time Difference" (E-OTD) relies on the usage of well- synchronised radio sites, where the terminal reports its observed time difference between received radio signals to its serving cell. Knowing the timing properties of its neighbouring cells, a specialised Location Measurement Unit (LMU) in the serving cell can roughly calculate the terminal´s geographic position using a triangulation algorithm. The accuracy achieved with this method is in the order of 100m compared to the true position and heavily depends on the constellation and the geometry of the observed radio sites. (see Fig.4)

3.1.3 Assisted GPS

The method of "Assisted GPS" does not utilise any specialised radio network properties for positioning. As a terminal-based method it requires each terminal to have an additional in-built receiver for the public GPS positioning system. The calculated coordinates are then transmitted directly to the network.

This method achieves the best accuracy, in ideal cases yielding an uncertainty of few meters only. Disadvantages are the high costs of terminals and the fact, that GPS signals do not propagate well into buildings[5]. This effect is mitigated by transmission of assistance data from a reference receiver to the terminal. This data indicates to the terminal, which satellite signals are presently available, thereby increasing the terminal´s ability to acquire and decode the satellite signals even in unfriendly radio environments such as indoor.

Following graphs shows the most commonly used positioning methods and the positioning accuracy achieved, in dependance of the geographical environment. (see Fig5 and Fig.6)

3.2 Network Infrastructure

(see Fig.7)
Following figure shows the functional blocks involved in a typical LBS.
The Gateway Mobile Location Center (GMLC) is the gateway between the Mobile network and the requesting applications from external networks. The GMLC also handles the interface to the operator´s Billing Center. The GMLC receives requests from the application, checks the permission and subscription rights of the involved terminal with the operator´s HLR and passes the request to the network. On successful positioning of the terminal the GMLC will return the calculated position to the requesting application. In case of a terminal roaming in foreign countries these connections and queries may span across international networks.

The Serving Mobile Location Center (SMLC) is responsible for mapping the network-specific position information transmitted by the terminal into unambiguous coordinates values, e.g. Lat/Long or UTM coordinates. These coordinates are passed back to the requesting application by the GMLC. Depending on the positioning method applied, the SMLC may be either a separate piece of hardware or integrated into another network element, e.g. the Radio Network Controller (RNC) .

An incoming Positioning Request from an application is received by the GMLC. The GMLC checks the permissions,validity and subscriptions of the request and passes it to the appropriate Core Network. The network initiates the positioning procedure towards the terminal. The user is explicitly prompted to acknowledge the positioning event, which is then executed. The results are passed through the Core Network back to the SMLC, which calculates the coordinate values from the data recieved from the terminal. The coordinates are passed to the GMLC, which returns them to the requesting application. A positioning event typically takes several seconds from request to delivery, depending on the positioning method applied.

3.3 Complexity and Costs

(see Fig.8)
The graph above shows the Costs per User against achievable area resolution for various positioning methods. Horizontal axis is area in logarithmic scale. The vertical axis is unscaled costs, but can be assumed to be also logarithmic.

The method using only LA Code is very rudimentary and coarse in resolution. It requires very little adaptation in the network, essentially no new functionalities are needed. However, this method is not precise enough for most location-based services.

The method of Cell ID (including its enhancements) is presently the most commonly applied method, providing the best cost-to-benefit ratio for mobile operators. Most of today´s commercially offered LBS can be sufficiently handled by the CID method. This is the „main-stream" approach. Costs for CID method are mainly for the additional hardware needed (GMLC, SMLC) and the provisioning of SIM applications to the Users. Operational complexity and risk lies in the mapping of CID to coordinates, which

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[4] obviously this is overly simplistic. In reality, radio cells are almost never circles, but very irregularly shaped
[5] Most GPS receivers require direct Line-of-Sight to the clear sky for reliable positioning

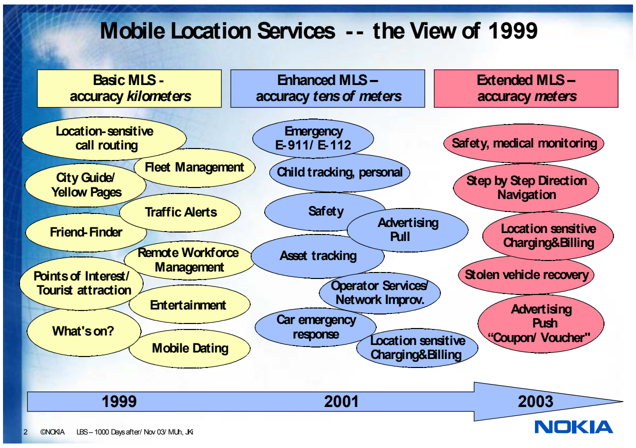

Fig.1: Mobile Location Services as seen in 1999 (Source: Nokia)

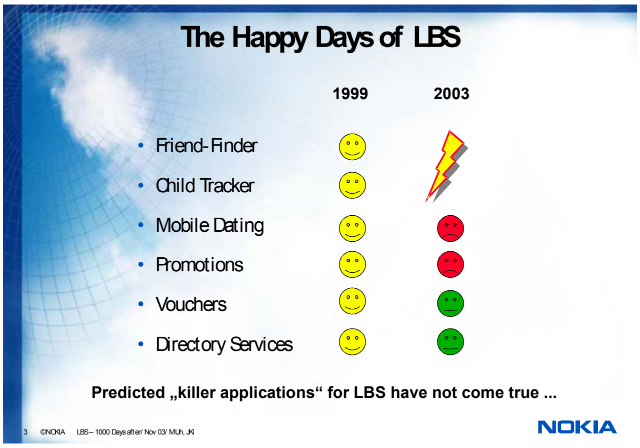

Fig.2 : LBS as seen 1999 and in 2003

typically is done in the SMLC. Any physical changes to the network, such as changes of antenna directions, antenna types, output power changes, insertion or deletion of new sites, will affect the networks cell layout and therefore the precision of the mapping process. This is the most vulnerable spot in the processing chain.

The E-OTD method provides a better resolution than CID, but also is considerably more expensive. The costs for this method are almost linear with the area to be covered, since the majority of radio sites within the LBS-enabled network area need to be equipped with an additional piece of hardware called Location Measuring Unit (LMU), which is both expensive in purchase and maintenance. Again, the same operational complexity and risk considerations apply, as for the CID method.

The A-GPS method imposes rather low costs on the network side, since no additional measurement and synchronisation units are required. Coordinates are delivered directly from the terminal to the GMLC. The main drawback of this method are the high costs for the User, since every user will need to purchasse a terminal with an additional A-GPS receiver. At the time of writing (Dec 2003) there are only two known high-end models of UMTS terminals[6] supporting this positioning method . No terminals are known for plain GSM-based networks.

Given the mentioned choices of positioning methods and the current market situation, mobile operators mostly opt for the CID-based method, despite its limited accuracy. Reasons for this shall be discussed in the following chapters.

4 Business Case Aspects of LBS

4.1 Value Chain for LBS

The value chain for LBS is long and fragile, the relations between the different participating parties are complex and partly with competing goals. This makes a smooth cooperation difficult and may be an explanation for the slow progress of LBS on the market.
The User is the ultimate requester and consumer of location-based services. Equipment for Positioning technologies are supplied to the mobile network operator by various external parties[7]. The mobile operators provide their own branded portals[8] offering access to various LBS services. The operator´s GMLC is the borderline between the mobile Network Domain and the Service Provider Domain. (see Fig.9)

The Mobile Location Service (MLS) Providers are companies, specialised on providing customised location-based software applications. They are provided with up-to-date and accurate geographical data by Data Aggregators, which in turn leverage their access to raw geographical information, such as detailed city maps, Point-of-Interest databases or electronic cartographic maps.

The Mobile Operator has a subscriber relation to the User, which is typically very fragile. Subscribers are the operator´s main source of revenues. They are costly to acquire and to maintain, easy to lose. The subscriber churn rate is one of the most closely watched buiness indicators for Operators. Therefore an operator will be very cautious not to lose their subscribers trust by breeching their privacy.

Towards the other side the Mobile Operator has a fragile relation towards the MLS provider. This relation is around fair Billing and revenue sharing of the provided services as well as the trust, that the MLS provider will not disclose any user´s personal information

[6] Motorola A920 and Nokia 7600 („Mango")
[7] e.g. TrueLocation, SnapTrack, Nokia, Cambridge Positioning and others
[8] e.g. Vodafone Live!, O2 Active, 3 Geo and others

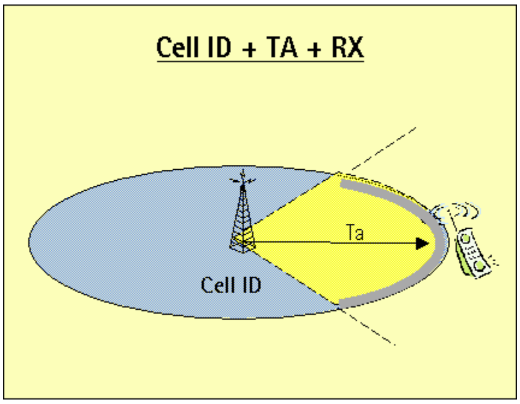

Fig.3: Positioning by Cell-ID

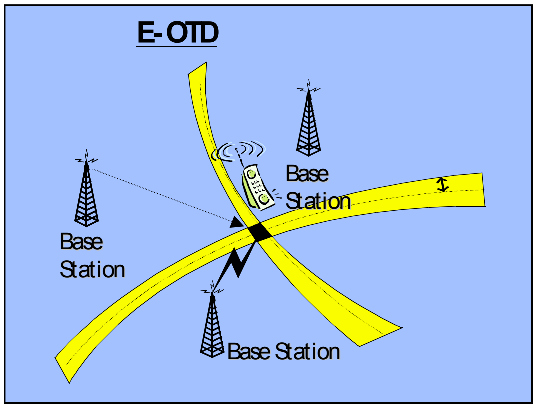

Fig.4: Positioning by Observed Time Difference

he may have access to in the provisioning of the services. On the other hand, MLS providers have an interest in gaining knowledge of subscriber profiling data and consumer´s usage patterns, which they can in turn market towards other parties, e.g. direct marketing firms, advertising companies etc.

This conflict of interests has led to many legal discussions, delays of service launch and even to discontinuation of LBS offerings in some cases. As a measure of risk containment, some operators have imposed a "Code of Conduct" towards their MLS providers. The complications associated with privacy issues, the neccessary investments for anonymising the LBS system, the overall too weak business case has caused several operators to reconsider their service offering and effectively to "pull the plug" on LBS.

4.2 Regulatory and Legal Aspects

Cultural difference in the valuation of personal privacy issues may explain the variation of progress speed for LBS in Asia, America and Europe. While Asian countries tend to be rather relaxed concerning user privacy, USA are more cautious and European countries take it very seriously. The European legislation has produced a number of laws and regulations ensuring user privacy.

In July 2002, the European Commission has issued a Directive on Privacy and Electronic Communications [7], specifically addressing the issue of LBS. In particular, Art 13 ("Unsolicited Communications") of the Directive states that Users must not be mailed with marketing and other unsolicited communications without their prior explicit consent.

Furthermore, Art 9 ("Location Data other than Traffic Data") regulates, that location data may only be collected from users after their explicit consent. Such data must not be stored any longer than required for the delivery of the requested service. Users must also be given by "simple means and free of charge" the possibility to temporarily refuse the further processing of their location-related data.

These regulations virtually rule out any plans around voucher distribution and location-based advertising, thereby depriving operators from a substantial stream of revenues. It also requires the location process to include an explicit acknowledgement of positioning events by the User, making the process more complicated in handling. Mobile operators may be required to install an anonymising middleware solution in their system, in order not to disclose the User´s personal data to any third party.

The given regulations and their financial impacts to the Business plan have caused the enthusiasm towards LBS to drop significantly with the mobile operators.

4.3 Ownership of Location Data & Privacy Issues

A number of legal cases have developed around the question of ownership of the User´s location data. Many third-party companies attempt to get hold of this knowledge as a re-sellable item. Mobile operators, however, knowing their fragile relation with their subscribers, do not want to take any risks with privacy issues and try to retain ownership of location data. The MLS suppliers claim, that the location information is extracted and made available by their applications and therefore claim the ownership rights. Some mobile operators have imposed a "Code of Conduct" with their MLS providers and intermediaries to ensure user´s privacy on basis of these agreements.

"Tricky Tracking"
Marketing companies have developed methods, which allow determining the exact location of users without any further involvement of operators or their LBS system: Posters with pictures of highly emotionally provocative pictures and questions are displayed in public advertisement space. Readers are asked to send an SMS reponse to a certain number. Such, the advertisers implicitly know exactly the time, the number and position of respondents, without infringing any privacy rights. These informations are then entirely owned by the advertisers and can be freely sold to other parties.

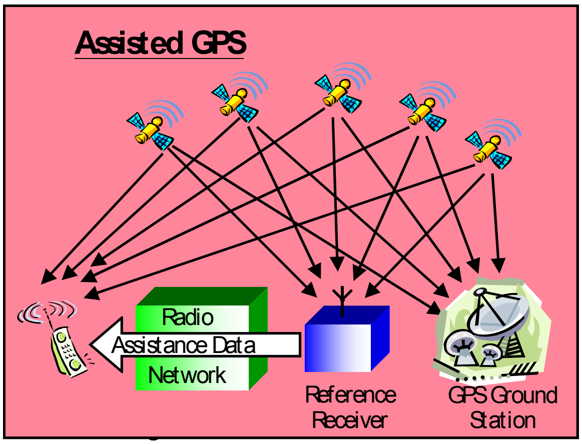

Fig.5: Positioning by Assisted GPS

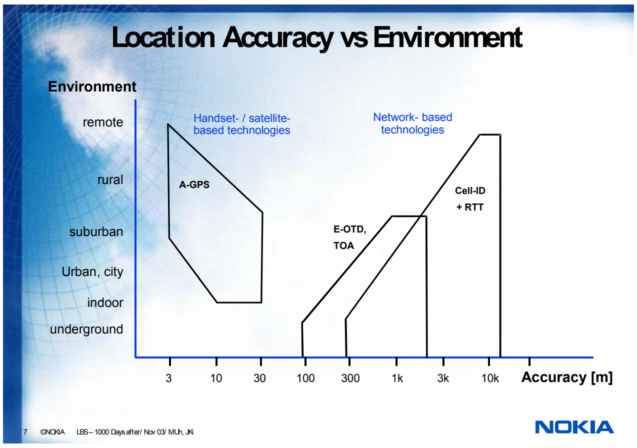

Fig.6: Positioning Methods and Accuracies

Concerning commercial LBS offerings, the operators find themselves in a dilemma:

- Privacy vs Ease of Use: more complicated handling of services
- Privacy vs Profit: high investments in privacy solutions needed
- Privacy vs 3rd Parties: disclosure of location data

These unresolved issues cause may explain, why LBS have taken a rather slow start during the last years.

5 Applications of LBS

5.1 Usability

A self-contained handheld GPS-receiver allows a continuous positioning of the user and permanent updating of the display and routing information. The user is always presented the latest position information, updates are typically each 1-2 seconds. This solution is e.g. commonly found in car navigataion systems and provides the state-of-the-art user experience.

A telecom-based LBS system requires, by the nature of the technology and complexity of the value chain involved, a considerably longer time to present a “first fix” to the User. This estimated position is a single snap-shot in time and needs to be repeated each time the position information needs to be updated.

Additionally, the imposed legal restrictions and regulations increase the number of transactions that need to be processed between network and User. This also includes the user´s manual and explicit confirmation for positioning. Automatised or robot solutions are very difficult to implement under these conditions.

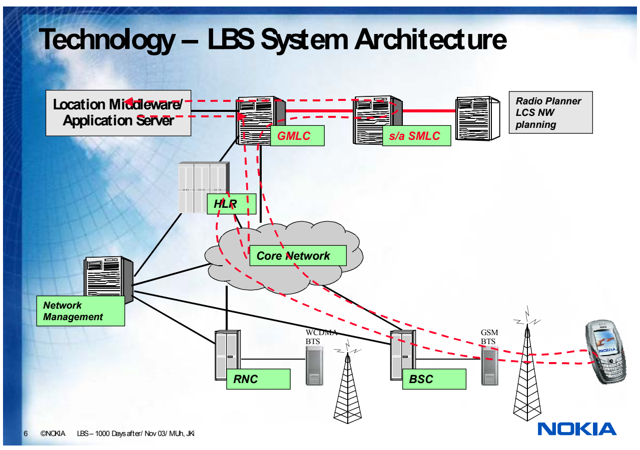

Fig.7: Functional Blocks of an LBS-enabled network infrastructure

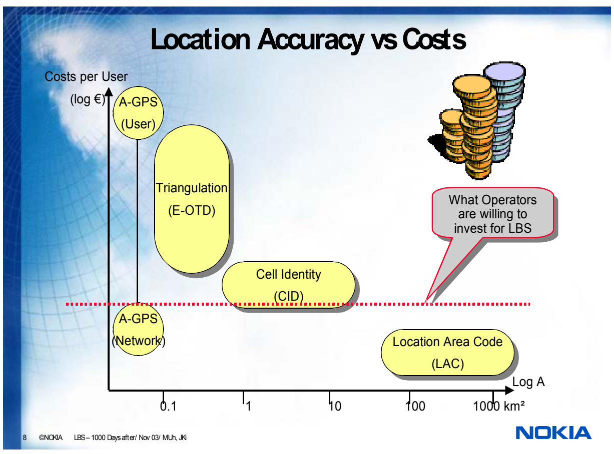

Fig.8: Positioning Methods and Costs

The usability of LBS services today suffers from complicated handling and rather long processing times, in which the User has to wait idle, until useful information is presented on his terminal screen.

5.2 Commercial Applications of LBS

The basic principle of an LBS is, that a Requester ("subject") communicates with an "object" ("target"). The term "location-based" can either refer to the variable position of the requester or the target. In most cases one of both can be static, only very rarely both ends are mobile.

Target-oriented applications: Examples of applications, in which the requester´s main interest is focussed on the location of the "target", while his own position is not relevant, are Friend Finder, Child Tracker, Asset Management, Dating, Advertising, Promotions, Vouchers, etc.

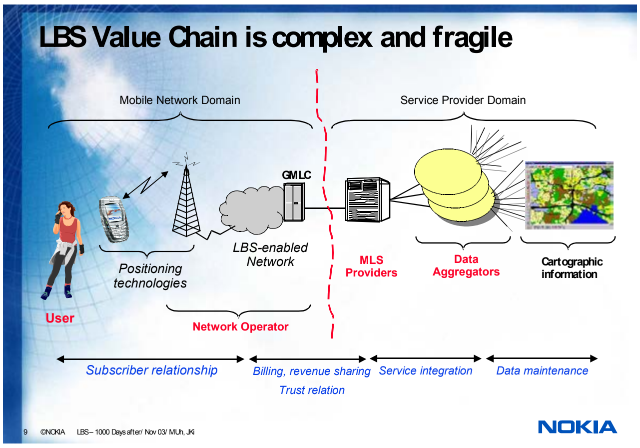

Fig.9: Value Chain for LBS

Subject-oriented applications Examples of applications, in which the requester´s position is assumed to be mobile while the target is static, are: Where-is-the-next, Navigation & Routing, road traffic conditions (speed cams, radar...), entertainment, culture, Point-of-Interest.

The target-oriented applications (also referred to as "Push" methods) are commonly seen as potentially intrusive to one´s personal life and are therefore kept on distance. Friend-Finder and Child-Tracker applications have mostly been either taken off the net or are handled very restrictively, where they still exist. Advertising, promotions & vouchers do not need very accurate positioning information nor need mapping details. They can be handled by simpler methods, e.g. SMS broadcastings in limited geographical areas. Asset Tracking and management are specialised applications for logistics and transport businesses. There is a comparably small market for these type of applications, specialised solutions exist, they do not necessarily need a full LBS infrastructure.

The subject-oriented applications ("Pull" services) are currently the mainstream interest, although the overall level of interest is rather low. Most common applications are queries of Directory services, such as "where-is-the-nearest-....", timetables for public transportation, road traffic and touristic information. For most of these cases, the exact user position is not needed. A rather coarse location information can be sufficient to supply the requested information.

Successful LBS applications fulfill a user´s existing need, they bring immediate value. Then the user is willing to use the service and to pay a small fee for it. Additionally, the service must be simple to use, provide trustworthy information and quick response times. The list of unsuccessful LBS service trials is long and reaches anywhere from Mobile Dating to promotional coupons or "shoot-´em-up"-style games. Main reasons for lack of sustainable success are: no real user need , no visible benefit, complicated to use, confusing visual presentation.

Up to date, the most popular LBS commercial services are simple directory services, providing "where-is-the-nearest-...." kind of information to the user. Following graph shows the Top-10 requests from a major operator in Japan. (see Fig.10)

5.3 Mobile Positioning for TeleCartography

Cartographic display on mobile devices is a powerful method of conveying dense information content for those literate to mapping. The challenges of rendering useful cartographic information on mobile devices are plenty and out of scope of this paper. We shall concentrate to the applicable methods of mobile positioning in the context of TeleCartography.

Location-based services often do not necessarily require cartographic information or map content outputs. In cases, in which an accurate position of the user is desirable, the industry consensus seems to be, to provide the user with an initial position estimation with an option of further manual refinement of accuracy. This procedure can be map-based or –more frequently -- text-based, using a selection list of e.g. street names or a free-text field for manual input. These methods are suitable for mostly urban areas and locations, in which external orientation in sufficient resolution is available and known (i.e. legible) to the user.

Cartographic information can give very precise information and quick orientation, provided that the user´s assumed position is correct. This is particularly true for routing applications. For routing tasks, the information displayed to the user needs to be refreshed sufficiently often to allow the user to monitor the progress of his travel. The continuous updating of the user´s position is a very time-consuming and costly task, if it is done repeatedly via a telecom network. Instead, it may be useful to determine the user´s initial position once, then to download once via the telecom network the entire cartographic information needed to accomplish the task. The repeated position update will be preferrably done by an "offline method", e.g. using an inbuilt GPS receiver in the terminal. In urban areas, where routing distances are typically short, the precision of the position estimate needs to be better than what mobile positioning methods can reliably offer. This again severely limits the usefulness of mobile networks for precise positioning tasks. For

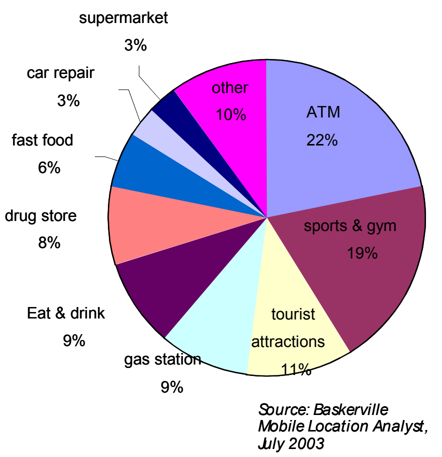

Fig.10: Breakdown of most commonly requested „ Where-is...“ services

extreme short-range routing, e.g. in shopping malls, even the GPS-assisted positioning methods will meet their limits, due to lack of satellite signal in indoor areas.

Additionally, neither GPS-systems nor network-based positioning will easily cope with the resolution of vertical position in multi-storey locations, e.g. office buildings or commercial centers. In such situations, alternative positioning methods can be thought of, e.g. use of RFID tags, which allow positioning of terminals with a precision of few meters in any short-range environment. These methods are also purely on application level, i.e. directly between tags, terminals and application databases, without the need and the risks of any involvement of the mobile network operators or intermediaries. The advantages of cartographic information can then be applied without the risks of mis-positioning due to the physical and practical limitations of mobile telecommunication networks.

In case of stationary targets, e.g. restaurants, hotels etc. the need for telecartography reduces to a simple routing task, which can be sufficiently well performed also with today´s tools. The flexibility and power of telecartography becomes more evident in case of routing towards a moving target, in which case both, the user´s and the target´s position needs to be updated regularly and the routing is recalculated accordingly. A use case for this would be e.g. catching a certain bus or metro at a specific station.

6 Conclusion

Location-Based Services have not yet reached the anticipated and predicted broad market acceptance. The technology needed in networks and handsets as well as interface and software standards are available and ready. Positioning methods in mobile networks have been developed with a reasonable resolution for most use cases. Currently, the main-stream positioning method uses cell-ID information with a resolution of a radio cell, which is typically well below 1 sq.km in urban areas. This is a compromise between cost-effectiveness and geographical resolution.

Mobile network architectures have not been designed to inherently provide accurate positioning of users, therefore only modest accuracies can be provided at reasonable costs. There is insufficient justification for the high infrastructure costs needed to provide a better spatial resolution. The industry consensus is to provide the user with an initial “best guess” position and rely on further manual refinement of position, where needed.

Mobile operators are facing a number of unresolved issues around User Privacy and commercial exploitation rights of the generated location information. The neutral cost/ benefit ratio for the users provides a very delicate balance between Usefulness and Privacy concerns around LBS. An overall weak business case of location-based services has caused many operators to call for a moratorium in further development and deployment of LBS services

The user demand and acceptance for telecartography applications is undoubted and supported by plenty of evidence and examples existing in the fixed internet world. The actual need for mobile positioning for location-based services remains to be seen within the next 1000 days.

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An Open Service Architecture for Mobile Cartographic Applications

Lassi Lehto and Tapani Sarjakoski, Masala

Abstract

The ongoing European integration process calls for a consistent, continent-wide geospatial data provision. A few European Commission-backed initiatives are already working to facilitate this process. In the case of the major national datasets, like topographic databases, the Pan-European geospatial data provision needs to be based on the principle of distributed databases, in which data is stored and maintained locally by the national authorities. In this paper a five-level open service architecture for spatial data delivery is proposed. The suitability of the architecture for various mobile applications is demonstrated in a discussion about how application systems can access the service on different levels. The approach is currently being tested in an European Union funded project: Geospatial Info-Mobility Service by Real-Time Data-Integration and Generalisation (GiMoDig). In the paper the test architecture implemented in the GiMoDig project is further elaborated.

1 Introduction

The recent European integration development creates a demand for continent-wide geospatial data services. Some European Commission-funded initiatives have been started to work on this issue. These initiatives include projects like GINIE, GETIS, EULIS, GiMoDig etc. Various data harmonisation processes of EuroGeographics, the co-operation body of the European National Mapping Agencies (NMA), also aim at the same target. As an example of the results of this work can be seen the development of the European-wide datasets, like EuroGlobalMap, EuroRegionalMap and SABE.

In the case of the major countrywide datasets, like the topographic reference databases, Pan-European spatial data services need to be based on distributed databases, which are maintained by local authorities. Standardised access interfaces and spatial data encoding mechanisms would be applied to achieve the desired cross-border accessibility. The same approach can naturally also be applied in a national setting. An example of this is provided by Bernard (2002). The problems related to the federation of distributed heterogeneous databases have been widely discussed in the research literature. In the context of Location Based Services (LBS) the issue has been treated for instance by Gruber and Winter (2002).

Use of mobile phones is about to reach saturation point in Europe. Location Based Services are currently seen as one possible new source for revenues. In many LBS applications geospatial datasets play a significant supporting role. Locations, whether they depict the user's own position, the closest service points, or geocoded address information, are best understood when shown on top of a map. The open service architecture described in this paper would provide a flexible platform for various different mobile applications. Depending on the capabilities of the mobile device in use, the client software could be designed to access the service on an appropriate level of the hierarchy.

2 Standardised Service Interfaces

Most of the existing Web and mobile map services are based on proprietary access interfaces and data formats. This situation is due to the protective actions taken by individual service providers or software vendors to defend the achieved position in the market place. Until recently extensive specifications for on-line processing of geospatial data did not exist. The situation has changed significantly, however. Now that first standardised interface specifications have been developed, the traditionally isolated spatial software vendors and service providers start seeing mutual benefits in supporting them.

Over the last years the emphasis in the work of the Open GIS Consortium (OGC, 2003) has essentially concentrated on developing access interfaces to network-resident geospatial data services. The first document published in this area was the specification about a network-based map service, called Web Map Service (WMS, 2002). A WMS-compliant map service provides map data to client applications in the form of an image. Recently OGC has published another service specification called Web Feature Service (WFS, 2002). A WFS-conformant service provides client applications with real spatial data, geospatial Features in OGC's terminology, not with pre-visualised map images like in the case of a WMS-service. According to the WFS specification the delivered spatial dataset is to be encoded in the Geography Markup Language (GML, 2003) format.

In the context of the OpenLS initiative a new map query interface definition, called Presentation Service, has been developed. This specification is specifically targeted for limited-capacity terminals. In addition to the Presentation Service, the following core

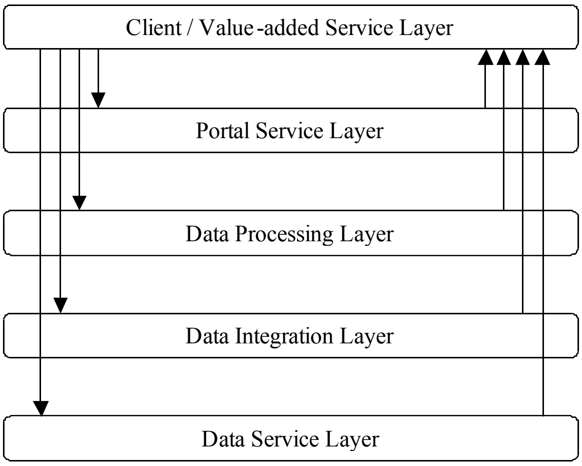

Fig.1: The Five-layer Open Service Stack

location services have been identified in the OpenLS process: Route Service, Geocoder / Reverse Geocoder Service, Directory Service and Gateway Service (OpenLS, 2003).

The most interesting OpenLS service category, from the geospatial data providers' point of view, is the Presentation Service. In addition to the obvious task of providing maps from the requested location, the Presentation Service is also expected to be able to visualise pieces of geospatial data coming in as a part of the presentation request. This information may contain, for instance, the position of the user obtained from the Gateway Service, a route geometry provided by a Route Service or a set of business locations received from a Directory Service. This data is regarded as an overlay to be displayed on top of the background map, supposedly provided by the Presentation Service itself.

3 Layered Service Architecture

Open system architecture of an on-line map service should be based on a layered service stack, in which a service would make queries to the service below it, do some processing on the data received as a response, and provide the results of this process as a service to the layer above (Lehto, 2003a). The level of detail in specifying the layers is a matter of discussion, but if the services were to be run on separate computers communicating through network, too fine-grained service definition would create a significant disadvantage in terms of overall system performance. Each clearly distinctive task in the service provision, potentially being in the responsibility of an individual organisation, should be put on a separate layer.

For the above-mentioned reasons a five-level system architecture is proposed (see Figure 1). In the first level the data providers (e.g. NMAs) would run a Data Service providing original spatial data in an XML-encoded form. Above the Data Services is the Data Integration layer. The main task of the Data Integration layer is to provide a single access point to the geospatial data sources of the participating data providers – serving data in a common data model and in a common coordinate reference system. The responsibilities of this layer thus include tasks like coordinate transformations and schema transformations. The Data Integration layer has a critical role in the various cross-border applications that are going to be developed in the increasingly integrated Europe.
The next layer in the service stack on top of the Data Integration layer is the Data Processing layer. On this layer various kinds of computations can be performed on the dataset received from the Data Integration layer below. These computations could include tasks like edge matching, generalisation, and various other forms of GI analysis.

The fourth layer in the system architecture could be called Portal Service layer. The main responsibilities of this layer can be listed as: provide basic metadata service to the client, process the service requests coming from the client forwarding the request in an appropriate form to the Data Processing layer, and transform the resulting set of geospatial data into a map image formatted appropriately for the capabilities of the client platform in use.

On the fifth layer are finally the client applications. An advantage of the layered architecture approach is that the service results can be adapted to a wide set of different client environments. For example the following three client platforms could be considered: the traditional Web browsing on a PC platform, Scalable Vector Graphics (SVG, 2001) based clients on PDA devices, Java Mobile Information Device Profile (Java MIDP, 2002) clients on mobile phones.

As the standardised, open interfaces are to be applied on different layers of the service architecture, the system provides a flexible framework in which clients do not necessarily query the topmost layer of the hierarchy but can rather communicate with the service that provides best support for the task in hand. More powerful clients might thus consult the Data Service interfaces directly, whereas some client applications might prefer to access a Data Processing Service, and the most restricted platforms might require the client application to rely on the Portal Service Layer providing raster map images. Instead of a client application the fifth service layer can be represented by a domain-specific service provider that can access the service hierarchy on an appropriate level and provide the resulting user-oriented service content to the real client applications.

4 The Role of Open Interfaces

For the case of openness, the communication from layer to layer has to be based on internationally accepted interface standards. At the moment the main interface specifications that could be considered in the architecture include WFS specification as the access interface in the Data Service layer, Cascading WFS on the Data Integration layer, WMS specification as the query interface of the Portal layer and Presentation Service of the OpenLS as an alternative access interface on the Portal layer.

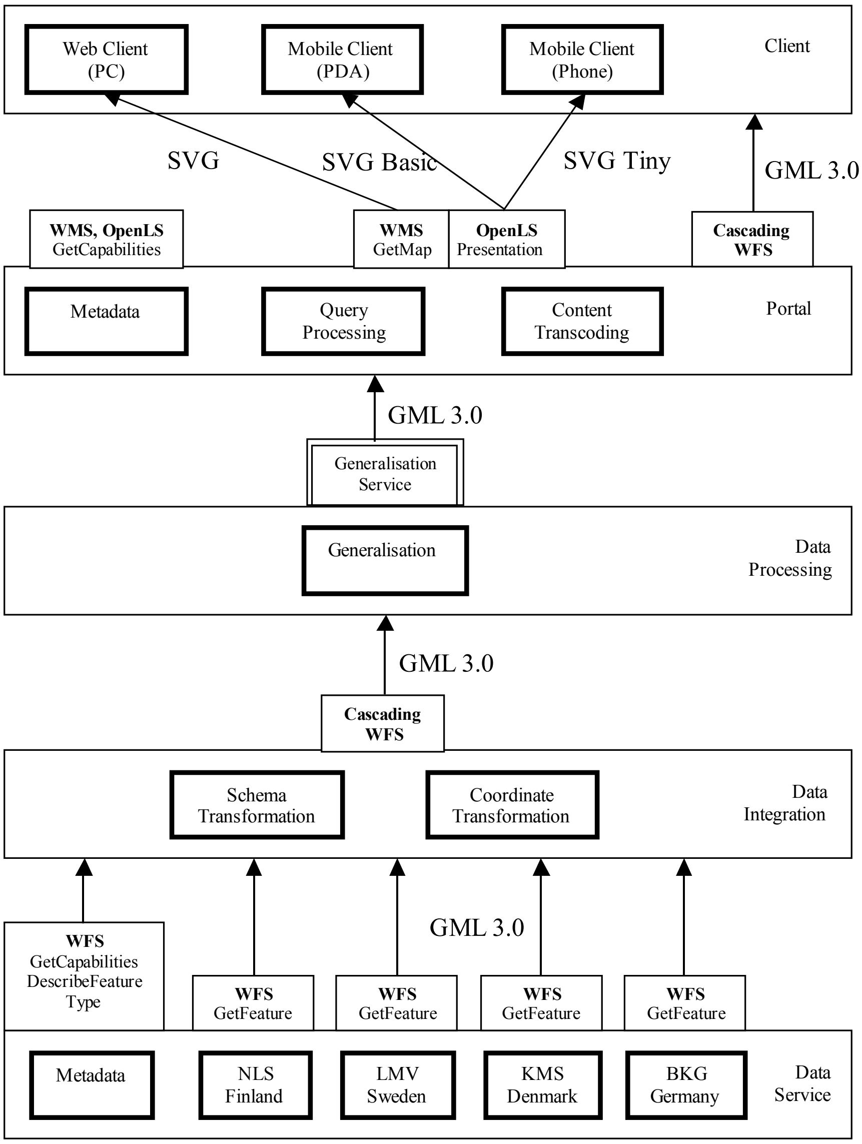

Fig.2: The GiMoDig System Architecture

On the Data Processing layer there is no obvious candidate for service interface specification, because of the wide selection of possible service types to be considered. The OGC's currently open Request for Technology process on the topic 'OGC Web Services' (OWS, 2003) indicates service types like support for sensors, modelling and simulation, decision support and location services. The INSPIRE Architecture and Standards document (INSPIRE, 2002) mentions as possible data processing services Geocoder service, Generalisation service and Geospatial data fusion. Interfaces for some processing services exist (e.g. Geocoder), but further research and development work is still needed in the case of the others.

The use of open, standardised access interfaces in every possible service layer makes the system flexible enough to support clients, or value-added service providers alike, with varying capabilities. Even in an international context the national Data Service layer could still be directly accessed by local service providers to get GML-encoded data expressed in the local Application schema. If the case of a more internationally oriented application the proper layer to access is the Data Integration service layer, where the data is available in the agreed-on common Application schema and transformed into the same uniform coordinate system. The query interface would still be the same WFS, but this time giving access to the datasets from several different countries.

If the processing services available on the Data Processing layer are crucial for the client needs, the value-added service provider could access this level in the service hierarchy. Standards for the communication on this service layer are not yet widely developed, but the work on the issue continues by various parties. The access interface of the Data Processing layer could be designed as an

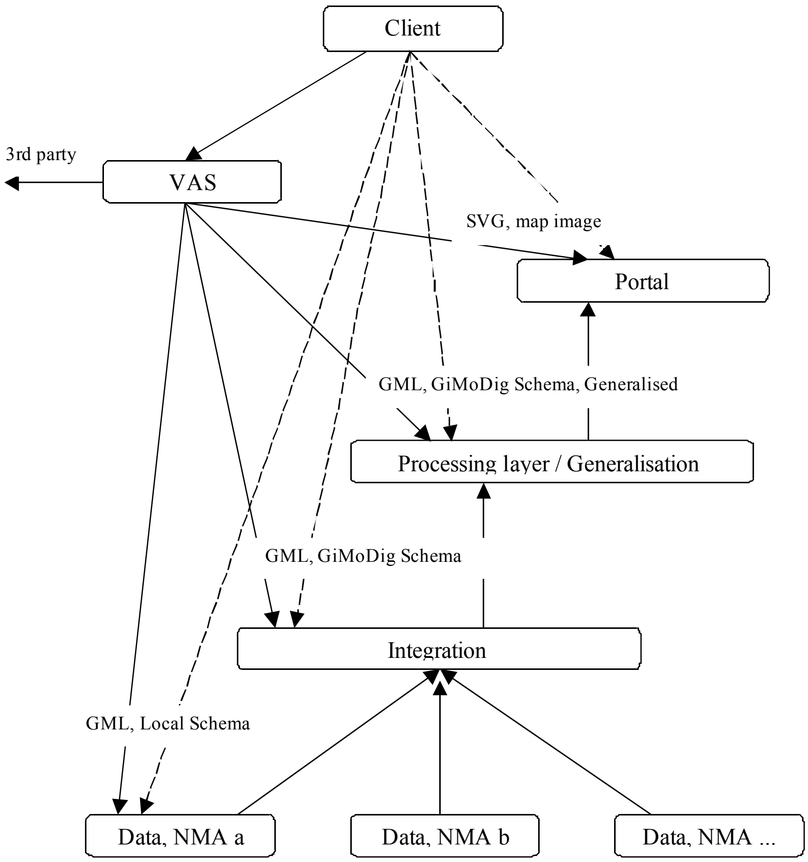

Fig.3: The flexibility of the GiMoDig service access

extended WFS specification, as information about which data to work on must always be part of the Data Processing service query. The output from the Data Processing service is supposed to still be represented as geospatial data, not as a visualised map image.

When the appropriate form of result returned from the service is a visualised map, like is the case in many mobile applications, the Portal layer is the right place to consult. OGC's WMS specification and the OpenLS Presentation Service are good candidates for the access interface on the Portal layer. If the only processing task required from the map service is to add extra information, like POIs or optimised routes, on top of the map, then the OpenLS Presentation Service is an ideal solution for a standardised access specification.

The above-discussed alternative ways to access the service hierarchy are depicted by the various arrows in Figure 1. Also other combinations are naturally possible. For instance, a Portal service application could be developed that requests data directly from a national WFS implementation or from an internationally developed Data Integration service.

5 Case Implementation

The discussed five-layer system architecture is being tested in a European Union funded project: Geospatial Info-Mobility Service by Real-Time Data-Integration and Generalisation (GiMoDig, 2003). The Finnish Geodetic Institute acts as a coordinator for the project. The other participants are the University of Hanover and the NMAs of Finland, Sweden, Denmark and Germany.

The objective of the GiMoDig project is to develop and test methods for delivering geospatial data to a mobile user by means of real-time data-integration and generalisation. The project aims at creation of a seamless data service providing access, through a common interface, to the primary topographic geo-databases maintained by the NMAs in the participating countries. A special emphasis is put on providing appropriately generalised map data to the user depending on a mobile terminal with limited display capabilities. The detailed GiMoDig System Architecture is depicted in the Figure 2 (Lehto, 2003b).

In the GiMoDig system architecture each participating NMA provides geospatial data through the WFS interface, encoded in a country-specific XML-format (local GML Application schema). These datasets are processed by a middleware service on the Data

Integration layer to join the streams of data coming from individual countries into a common Application schema and coordinate system (Sarjakoski et al, 2002a/b). The GiMoDig Application Schema design is based on the availability of the Feature types in the participating NMAs on one hand, and on the demands coming from the mobile use of the datasets on the other (Illert and Afflerbach, 2003). The GML dataset represented in the GiMoDig Application Schema is subsequently generalised on the Data Processing layer. Finally the resulting GML data is transcoded into an SVG image on the Portal layer and made available through the WMS and OpenLS Presentation Service interfaces.

The flexibility of the GiMoDig service architecture in supporting various different client needs is illustrated in the Figure 3. The client or a task-specific value-added service provider (VAS) can access the service hierarchy in a level that best supports the client needs. The levels provide data as a local, national GML format (Data Service), as an integrated dataset represented in GiMoDig Global schema and in a common EUREF coordinate system (Integration Service), in a generalised form (Processing Service) and as a map image (Portal Service). Possible 3rd party data (POIs etc) can be brought in by the VAS and get integrated into the service results making use of the facilities in the OpenLS Presentation Service interface.

6 Summary

Over the last years interoperability of geospatial network services has become an important research topic. The currently existing services are rather closed and heterogeneous. Standardisation activities have resulted in a set of sophisticated access interface specifications, ready to be implemented in operative services. In this paper a five-layer open service architecture was discussed. The communication between the layers is to be based on the existing service interface specifications, facilitating a flexible framework in which clients can consult the service layer that best fits to the requirements of the task in question and to the capabilities of the client platform used. A EU funded project GiMoDig is implementing the proposed service architecture. The main goals and the detailed architecture of the project prototype service were presented.

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Integrating topographic information and landmarks for mobile navigation

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Abstract

To help a mobile user navigating and finding his or her way in a foreign environment there are nowadays more possibilities than only using a paper map, namely using small mobile devices in terms of location based services. But nevertheless, there is need for research and development before using these new technical possibilities in an ideal manner and replacing the traditional paper map. The optimum would be to pass the user the most actual data within a few seconds, representing the data in an understandable, uncomplicated and clear way, meeting the user's needs by personalising the visualisation and filtering the unimportant information. To satisfy all these claims different steps of research are necessary.
The I*nstitute of Cartography and Geoinformatics* deals with two research tendencies related to this field of mobile cartography. One of these projects investigates the needs of a mobile user in different navigation situations. The most widespread navigation systems are in-car systems, navigating with instructions like: "turn left after 300 metres". But user, not only restricted to the car, but also navigating as pedestrian or by bicycle would prefer navigation information that works more human-like using landmarks for the wayfinding process: "turn left behind the church ...". Research work deals with extracting these landmarks from existing geodata sets and finding a more natural form of navigating the user, adapted for example to his mode of moving.
Another research project, the EU-project *GiMoDig*, aims at serving up-to-date geodata, derived from the topographic databases of the European national mapping agencies as well as additional data from other data sources. This project aspires on implementing an user portal which receives a request from a mobile user, collects all the necessary data from different data sources, combines and processes these data for presenting it on the mobile device (PDA, smartphone etc.), depending on the user's needs.
The partners involved here work on different sub objectives like harmonising the different datasets, processing the data for coordinate transformation and data generalisation as well as developing a system architecture for this kind of service. Furthermore the needs and demands of the potential users will be investigated.

1 Mobile navigation

The technical components of mobile navigation systems include a processing and visualisation unit (like PDA or even only a mobile phone), in general a separate positioning unit (GPS as external device or internal card) and spatial data (as visual or textual descriptions). If the navigation system shall work "off-board", an online connection for the data request to the service provider is needed (e.g. via mobile phone). Another possibility would be to store the necessary data on the mobile device, but two disadvantages are connected to this solution. On the one hand there is the limited memory capacity of mobile devices and on the other hand the lack of up-to-dateness of the stored data.

The EU-project GiMoDig, which is partly described on the following pages, assumes such a mobile user and serves topographic data via internet connection. The user should be able to state his actual needs and requirements. Because of the limited display size and resolution it is important to transmit only the required information to the user. This will include the selection of the desired objects and features as well as the desired resolution of the presentation. Due to these requirements, one sub-objective of the project is the development of methods for generalising the graphic representation of geospatial data in real-time, to be suited for display of the data at varying scales on small, mobile devices. The presentation on the mobile display will be dependent on - and adaptive to - the special user requirements i.e. data resolution and content as well as special circumstances like the time of the year etc. These ideas are described in detail by Nivala & Sarjakoski (2003).

1.1 Context-depending mobile navigation

The general needs for navigation systems depend on different, situation-dependent influencing factors, like user skills and experience, mode of movement, reason for moving, and time of day (see also Elias & Hampe (2003)). If the influence parameters are determined, a concept for adaptive visualisation (following Reichenbacher (2003)) can be established:

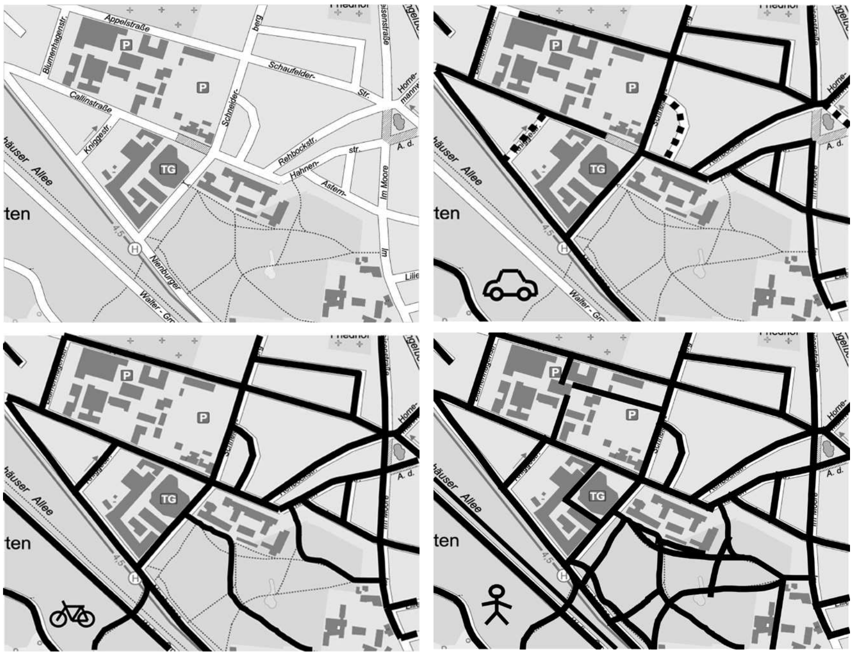

Fig.1: Graphs for route processing depending on moving mode (by car, by bicycle, on foot)

- Skills and experience:
  - experienced with maps, knowledge about signatures
  - abstraction ability (turning the map to north)
  - knowledge about environment
  - familiar to features of map (typical symbols for features, e.g. churches)
  - age, health
- Mode of movement:
  - by car
  - by bicycle
  - as pedestrian
- Reason for moving:
  - direct path to goal (shortest, fastest path)
  - tourist tour (specific distance, most scenery, secure or easy route (e.g. hiking))
- External factors:
  - rush hour, traffic jam, accidents, holidays
  - road restrictions (pedestrian zone may be used by cyclist in the evening hours, road use is prohibited to defined hours)
  - daytime/nighttime (objects cannot be seen in the dark, special objects are illuminated at night)
  - summer/winter (restricted visibility because of trees and bushes in the summer time)

1.2 Components of mobile navigation

In our investigations we concentrate on different ways of navigation. If we single out one factor, for example the mode of moving, there are a few dependencies following, like the route processing, selection of landmarks and the appropriate presentation for the user. The following sections are compiled to an overview in table 1.

1.2.1 Generation of routes

Processing of routes is part of graph theory and needs a linear network to calculate for example shortest paths. To fit the routing to the moving mode, adapted graphs have to be used, because the degree of freedom to move in the environment depends on the mode of moving. If the user is going by car, he is tied to the road network and traffic restrictions (oneways, prohibited turnings, pedestrian zones etc.).

Usually, a cyclist has a few more options, because of additional cyclist paths. (One limitation is the use of motorways). A pedestrian user has the most possibilities to move: he can use the complete open space and all directions to move. (In fact, there are some

	Routing	Selection of landmarks		Presentation			
Mode of Moving	**Degree of freedom**	**Speed**	**Visual field**	**Display / Output**	**Interaction**	**Attention for map**	**Additional information?**
Car	Tied to road network, limitations (oneways, forbidden turnings, pedestrian zones)	50(-100) km/h (15 m/s)	Front shield (+ side windows, driving mirror), predominantly straight forward ca. +/- 60° in driving direction	Voice output (because of distraction) simple graphics, also maps	No interaction while driving (hands on driving wheel), only when car stops	Very poor	Not while driving, restriction to essentials; demand for further information, when car stops.
Bicycle	Roads and cycle paths, additionally: forest and farm tracks, Openings of oneways and (partly) pedestrian zones	20 km/h (6 m/s)	Predominantly in moving direction, take a look in other directions is possible ca. +/- 90° in driving direction	Voice output/ map	No interaction (hands on handle bar)	Eye contact possible	Need increases
Pedestrian	Free in all directions (footpath and roads), Pedestrian under- and overpasses	5 km/h (1,5 m/s)	Directed in moving direction, but in general +/- 180° in line of vision	Map	Hand-operating /-input / -selection possible	Absolute attention, eye contact and interaction possible	Need for additional information and features exists
Conclusion:	**Different data sets for appropriate routing necessary!**	**Different amount of time to look out for landmarks**	**Different visibility analysis for landmarks needed**	**From: dissect complete route in single instructions to: map**	**From: automatic process to: interaction**	**From: simple graphic (arrows) to: detailed map**	**Extend features**

Tab.1: Components of mobile navigation (depending on moving mode)

limitations for this user group like buildings and motorways.) But from this it follows that it is necessary to remodel the graph for the route processing for pedestrians. This can be achieved by assigning weights or possible directions to the graph. Because of the lack of adequate data, the existing data for car navigation systems are used instead. The increasing degree of freedom of the different user types is shown in Figure 1.

1.3 Selection of Landmarks

The landmark-based navigation is the most natural concept to navigate for humans. Landmarks are prominent, identifying features in the environment of the wayfinding human, which enable him to locate himself in his surrounding. In this context, a landmark may be defined by its particular visual characteristics, by its unique purpose or meaning or its central or prominent location (Sorrows & Hirtle 1999). In our view, landmarks are topographic objects that exhibit distinct and unique properties with respect to their local neighbourhood.

The kind of landmarks used in routing instructions depend on the moving mode of the user. Usually, car drivers move much faster through their environment than pedestrians and have a more limited visual field because of the car they are sitting in and the attention paid to the driving. Therefore, different (specialised) ontologies have to be used for different activities (Winter 2002).

Depending on the way of moving a human user chooses different types of objects as landmarks for the navigation description. The study of (Burnett et al. 2002) reveals, that in applications for car navigation the "road furniture", such as traffic lights, pedestrian crossings and petrol stations plays a vital role as landmarks. In contrast, according to the research of (Michon & Denis 2001) wayfinding instructions for pedestrians include objects like roads, squares, buildings, shops and parks. This results can be interpreted as a consequence of the dependencies between moving speed and limitations of the visual field: a car with 50 km/h covers a distance of 15 m per second, while a pedestrian moves only the tenth part of it in the same time. Thus, the pedestrian has considerably more time to perceive his environment and salient features in it than a car driver. Additionally, the driver is confined to the visual field of his front shield (plus side windows and driving mirror). Because traffic and driving actions need most of the drivers attention, only landmarks located near or on the road are observed precisely and fast. Advertisement signs of a shop attached to buildings may be hardly visible for drivers, whereas pedestrians are able to turn round and watch out for the landmarks given in the wayfinding instructions (see overview in Table 1).

According to this, it is necessary to adapt the selection of landmarks to the moving mode. Therefore, the visibility of objects and the duration of it has to be determined to display/announce the turning instructions just in time.

1.3.1 Presentation mode

The form of presentation of the routing with landmarks depends on the available attention of the user: a car driver is mainly occupied with driving the automotive and paying attention to the traffic. There is only a small amount of concentration and time to spend on reading a complex map. Therefore, the presentation for car drivers has to be in a very basic form with quickly perceivable graphic or even as mere audible instructions. In general, there is no interaction with the map/device (while driving) possible and the need to get additional information is very limited (and in case, focused on traffic information about traffic jams, accidents etc.).

As a bicycle user a restricted interaction with the device is possible, as well as an occasional glance towards the map display. Because the driving speed is relatively slow and the attention towards the map is higher, it is possible to convey the routing via a map possibly enriched with additional features (e.g. points of interest, restaurants with opening hours).

The pedestrian is able to spend the most of his attention to the route description. A detailed map helps him to locate his actual position on the map. Because of his slow motion it is advantageous for him to interact with the device. The supply of additional features (different map scales, 3D-views) is possible (see Table 1).

The statements given here are a first approach to categorise the different needs on mobile navigation. Alternatives to the general behaviour depicted here are conceivable (e.g. presentation of complex maps to car drivers via head-up displays).

2 Data processing

2.1 The available datasets

The basic geospatial data can be titled as a part of the geodata, which describes the landscape (topography) and the cadastral information of the earth's surface in an relatively application independent way. These geospatial base data serve as the basis for all possible applications related to spatial context. These data are maintained by the National Mapping Agencies and are available as paper maps or orthophotos and satellite images as well as in digital form. In this context, we talk about geospatial vector data in digital form stored in geospatial databases.

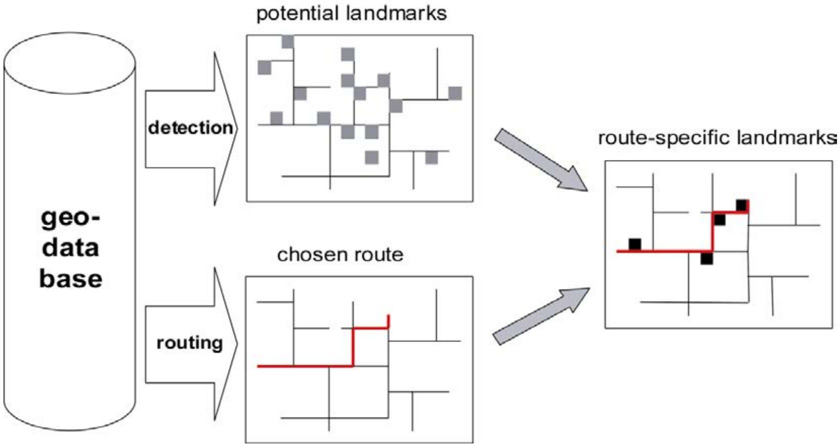

Fig.2: Determine route-specific landmarks

One example of such data is the German *ATKIS* (Authoritative Topographic Cartographic Information System) product. In addition to the traditional topographic map series of the states (Laender) of the Federal Republic this project aims at the provision of digital models of the earth 's surface suited for data processing. In this way ATKIS constitutes a data base for computer-assisted digital processing and analog output forms, but also a base of spatial reference for the linkage to and combination with technical geothematic data. It can therefore be described as a geobase information system (AdV 2003).

Fornefeld et al. (2003) state that these data serve as a basis for the clients applications but have only a minor benefit for the user. Nevertheless in connection with additional data, like navigation information or landmarks, these data get useful for the client. Because of meeting the claims of all possible users it is necessary to provide geobase data as well as additional data and to combine these data individually in one application. The base data, for example topographic maps, are produced for general applications. The user has to pick up the information, which are relevant for him or her. But if these data are customized and enhanced with additional valuable information with spatial reference, the users will be supported in his tasks. The geobase data gain in importance.

Because of this, an application for mobile navigation consists of these three categories of provided data and services:

- Providing geobase data,
- Providing additional data with spatial content,
- Providing user applications using these geodata

2.2 Extracting landmarks

Landmarks are topographic objects with distinct and unique properties. These properties determine the saliency of the objects, which in turn depends on different factors: size, height, colour, time of the day, familiarity with situation, direction of route, etc. Our approach uses the existing data sets ATKIS and the digital cadastral map (ALK) to extract these salient objects automatically and provide them for navigational purposes. At the moment, we focus in our research on a single object group: the buildings from the ALK.

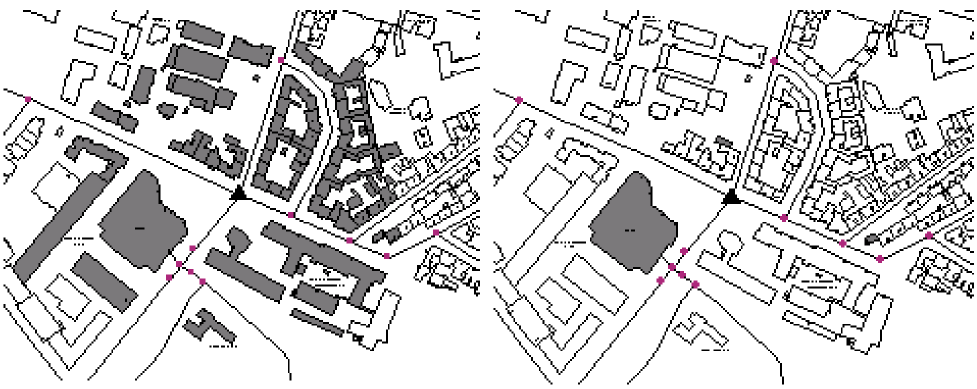

Fig.3: Scene of Hanover (road network with decision points, buildings) – left: "local environment" around chosen decision point (created by a buffer), right: potential landmarks after processing

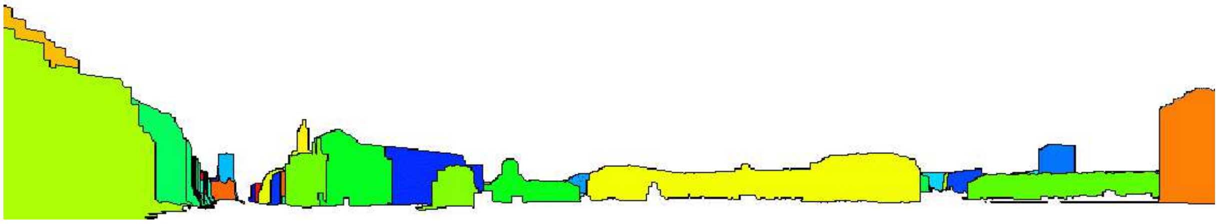

Fig.4: Visibility analysis for a point of view (Brenner & Elias 2003)

We differentiate between two phases of landmark extraction (see Figure 2). First the data base is analysed automatically to detect all potential landmarks existing in the data. In a second step the route-depending aspects such as visibility of the landmarks from decision point (junction), approaching direction, duration of visibility and orientation of landmark towards route has to be investigated.

The procedure to detect the potential landmarks is analysing the data set with data mining techniques to discover unique objects. Data mining methods are algorithms designed to analyse data or extract from data patterns into specific categories. Basic models of data mining are clustering, regression models and classification (Fayyad et al. 1996).

These procedures can be applied to data sets consisting of collected attribute values and relations for objects. For that purpose, all existing information about the buildings are extracted: information about semantics (use, function) and geometry of the object itself (area, form, edges), but also information about topology (e.g. neighbourhood relations to other buildings and other object groups (roads, parcel boundary etc.)) and orientation of the buildings (towards north, next road, neighbour) are compiled in an attribute-value table.

For each potential decision point (that means each junction in the graph network) the local environment for the investigation is determined by means of a simple distance buffer or a 360 degree visibility analysis to determine which objects are visible from that point of view at all. All selected buildings (creating the local environment) are fed into the data mining process to detect the object with distinct and unique properties with respect to all others. For more details about the approach see (Elias 2003).

The result of the process is one or more than one potential landmark for the investigated junction (see Figure 3). If there is no object that fulfils the requirements, a return of no potential landmark at all is possible, too.

The selection has to be narrowed down by route-dependent aspects. For example the visibility of the objects from the walking direction has to be checked. Therefore, a visibility analysis on basis of a DSM from laser scanning data combined with building polygons has to be calculated (Figure 4). As a second step, the visibility of the objects can be tracked while approaching the decision point to determine the advance visibility of the landmarks (Brenner & Elias 2003).

2.3 GiMoDig: Providing topographic datasets in different scales

As mentioned in chapter 2.1 the combination of topographic data and additional information, like landmarks, help the user to navigate. The content of this combinated data is of course dependent on the user, as mentioned in chapter 1. In the case of a pedestrian or bicycler, topographic information supports the user while navigating and orienting.

The EU-project GiMoDig aims at serving these topographic data to the mobile user and additionally tries to integrate third party data like navigation data, points of interest or landmarks on top of these topographic data. The main vision of GiMoDig is a mobile user, travelling within an European country and receiving on-line information of his or her environment on the mobile device, allowing him/her to flexibly inspecting data by zooming in and out.

In GiMoDig a *Multiple Resolution Database* (MRDB) with pre-generalised levels of detail of topographic datasets is established. The main goal is to allow for a realtime zooming from overview information to details and vice versa. The MRDB is populated with topographic information, as provided by national mapping agencies. For adaptation, however, often also additional information has to be included. This leads to the problem, that also this additional information has to be generalised in the different levels of detail. So the challenge is to introduce additional information into an already existing MRDB on the fly.

In our investigations we tackled the problem of introducing Points of Interest (PoI's) or landmark information into an MRDB-dataset. Here the problem is that for such additional information possibly other resolutions or levels are adequate. Therefore, the idea is to consult the MRDB to generalise the area around the landmark object and present the landmark in a higher or its original level of detail.

Fig.5: Two possibilities to visualise landmarks: point presentation(left), detailed building object within generalised environment (right)

3 Visualisation of data for navigation

3.1 Individual maps dependent on the user-situation

If we concentrate on the possibility to navigate the user with the help of a map on his mobile device one can think that there is no need for investigating the map design because there are already numerous experiences in producing maps. But the rules for producing paper maps and even digital maps cannot be transferred to the maps used on mobile devices. On the one hand constricting features of a mobile device like a smartphone or PDA are the limited size and resolution of the display, compared to ordinary computer screens or paper maps. On the other hand the capacity of memory and the possibility to transfer the data to the client are limited. Because of these reasons solutions should be found to compensate these limitations and to serve an understandable and clear map for the user. It is one aspect in the above mentioned GiMoDig-project to investigate and develop new possibilities to visualise spatial data on small displays (Nissen et al 2003).

In cartography the ordinary way to solve the problem of limited space while presenting spatial data is to generalise the data. Generalisation means to simplify the geometries and to visualise only the necessary data for the user to navigate. The user gets the possibility to specify the information he needs for his purpose or he specifies his purpose and the system selects the necessary data and leaves out unimportant details. This is one aim in the GiMoDig-project. Because of this the resulting map contains only the relevant information without any dispensable details.

3.2 Maintaining multiple representation in a database

But generalisation means more than just selecting a certain subset of the available data. There is also the need for manipulating the way how to visualise the objects. In smaller scales geometries have to be simplified, amplified, merged etc. One possibility to serve these different representations of the objects is to maintain certain levels of detail in one database.

An MRDB can be described as a spatial database, which can be used to store the same real-world-phenomena at different levels of precision, accuracy and resolution (Devogele et al.1996, Weibel & Dutton 1999). It can be understood both as a multiple representation database and as a multiple resolution database. In an MRDB, different views on the same physical objects or phenomena can be stored and linked. This variety can stem from different views of the world, different applications, as well as different resolutions. These lead to differences in the objects as such, i.e. in the semantics and in the geometry. Also the graphic representation can be taken into account, leading to geometric, semantic and graphic multiplicities (Bedard & Bernier 2002).

There are two main features that characterise an MRDB:

- Different levels of detail (LoD's) are stored in one database and
- the objects in the different levels are linked.

As mentioned in chapter 2.3 the GiMoDig-service uses such an MRDB-structure to store different levels of detail of topographic data. But the MRDB-structure also allows for new possibilities to visualise additional information, e.g. vario-scale presentations (Harrie et. Al 2002).

3.3 Visualisation of PoI and landmarks using an MRDB

The representations stored in the MRDB can also be used to emphasize important objects like points of interest or landmarks. The ordinary way would be to present the landmark as a point-symbol on top of the map or to highlight the matching objects with an eye-catching colour. The user gets less information of the landmark objects the lower the level of detail of the map is chosen. For example in Figure 5 and 6, the relevant object represents a generalised building consisting of a block of 15 buildings. Instead of presenting generalised objects the landmarks and other objects which should focused by the user can also be presented with its highest level of detail stored in the database. This helps the user to find these objects easily on the map and also supports in

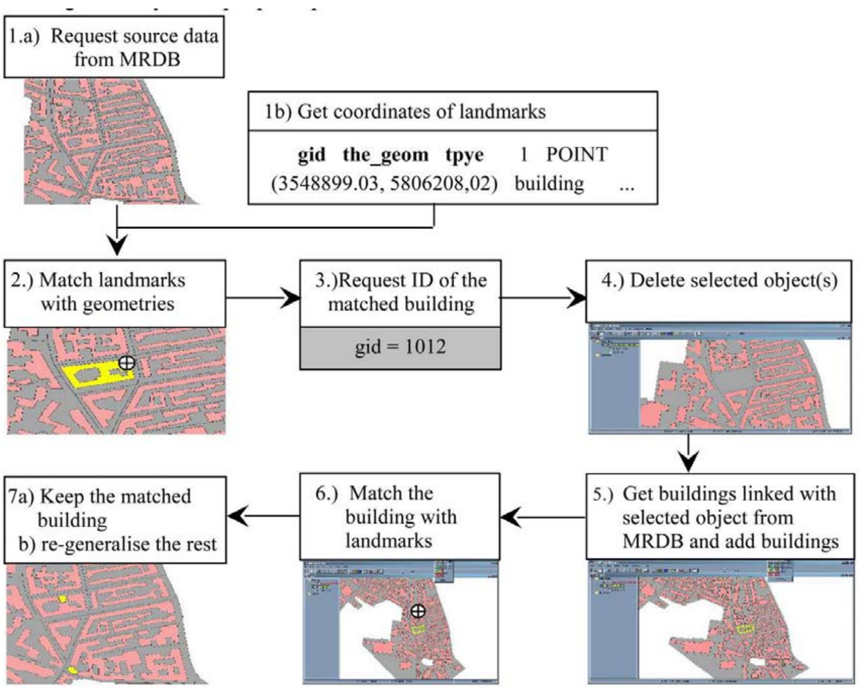

Fig.6: Workflow for visualising landmarks using original shape of buildings

recognising the buildings in the reality more easily. In this way, both detailed information (the landmark object) and overview (the wider environment of the settlement area in terms of building blocks) is visualised in one presentation.

The workflow for generating these kinds of visualisations can be followed in Figure 6. The relevant object, i.e. the landmark, can be matched with its actual representations on the map in the target scale by using the coordinates of the landmark. Using the links in the MRDB the relevant object can then be exchanged by its representation in the highest level of detail. The objects not matching the landmark can be presented in a lower level of detail than the landmark itself.

The possibilities of many different scales or generalisation modes in order to emphasize objects graphically has been investigated by (Sester 2002). Here, the detailed information from the large scales is combined with the course information from the small scale. In order to do so, first the original object is loaded up via tracing the links in the MRDB (step 5), then the landmark object is preserved whereas its neighbour objects are re-generalised again, i.e. aggregated.

4 Conclusion

This article gives an overview of the needs of mobile users while navigating. It shows possibilities to extract landmarks from existing datasets and visualise these objects in an environment of topographic data on a mobile device. Navigating and orienting with the help of mobile devices differs from navigating with ordinary paper maps. The mobile digital version needs and offers at the same time new ways of visualising spatial data and supporting the user while finding the way. We propose possible solutions to derive and serve these data for mobile users and also present the feasibility to integrate landmarks in a topographic map.

The digital mobile maps can be customised, depended on the individual needs of the different types of users and his position. It is possible to serve topographic data in combination with integrated additional data and also visualise these in a way to combine different scales in one presentation. This is one solution to integrate and visualise additional data into an existing topographic dataset designed for a other scale-ranges than the third-party data.

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Notes on the timely presentation of route related information

Sabine Timpf, Zürich

Abstract

Modeling inter-modal navigation for location-based services requires answers to the questions 'what', 'when' and 'how' to present information to the traveler. In this short paper, we propose to derive the information needed (the what) from the information collage and the time of presentation from the action plan. The presentation of the information is dependent on the answers to the 'what' and 'when'. This paper presents work in progress.

1 Introduction

Information needed for navigating in a dynamic environment needs to be presented in a timely fashion in order to be useful to the traveler. This observation is especially true within the context of location-based services. We understand inter-modal navigation as wayfinding (Golledge 1999) with several modes of transportation, i.e., a combination of different means to get from one place to another. This type of navigation can usually be found in urban areas where changing from walking to riding the bus to taking the subway is the normal way of using the transportation system. In inter-modal navigation the traveler uses diverse and maybe even contradictory information to find her way to the goal.

Humans collect information about routes and represent this spatial and non-spatial information mentally. Tversky has suggested that a collage is a fitting metaphor for the mental representation of wayfinding information (Tversky 1993). Our work uses the structure of a collage to represent assorted wayfinding information about a specific route at a specific time. This work is part of the effort of naïve geography, which aims at incorporating human mental models into formal models about space and spatial behavior (Egenhofer and Mark 1995).

The metaphor collage provides a good structure for (at least partial) integration or ordering of heterogeneous information based on the task of the traveler (Kuhn 1993). The information can be spatial (route), temporal (duration of trip), financial (ticketing), or social (dangerous at night). The integration has to be primarily spatio-temporal for wayfinding, but the other information may serve as constraints or additional decision criteria for alternative routes.

The optimal presentation time for navigation information can be deduced in a first approximation from an action plan. This plan depends on the complexity of the route (Heye, Rüetschi and Timpf 2003), the aims and abilities of the traveler, and her familiarity with the environment. An action plan details the spatio-temporal actions that a traveler needs to carry out in order to find a way from a start to a goal. The action plan corresponds in most cases to the route instructions derived in the route planning (Timpf et al. 1992). However, depending on the user's requirements, the instruction can be more or less coarse. Therefore we propose a hierarchical graph containing action plans for a specific route at different levels of granularity.

The paper is structured as follows: section 2 presents the information collage and the notion of cognitive collage from which it is derived. Section 3 explains our notion of an action plan and the corresponding hierarchical wayfinding graph. This graph is needed to derive the time when information should be presented to the traveler. Section 4 presents conclusions and future work.

2 Information Collage

The term information collage (Fig. 1) is derived from the term cognitive collage coined by Tversky (1993). Tversky argues that some spatial information is not pictorial and thus cannot be represented in a cognitive map. She prefers to use the term *spatial mental model* to account for all types of spatial information representations, pictorial and non-pictorial. In the same work, she proposed the notion of a *cognitive collage* to account for the fact that spatial information collected and accumulated over the years is very diverse, has different formats, different levels of detail, shows different aspects or point of views and even allows for erroneous, contradictory, and incomplete information. She also stated the very personal nature of a cognitive collage that included recollections of places and memories, even overlapping (temporally or otherwise) information. In addition the metaphor is most appropriate for knowledge about environments that are not well known.

This metaphor has inspired work by Claramunt (1996) who built a model describing a cognitive map, which represents navigation knowledge. The model includes the notions of spatial view and of *spatial collage*. Each coherent description of the navigation

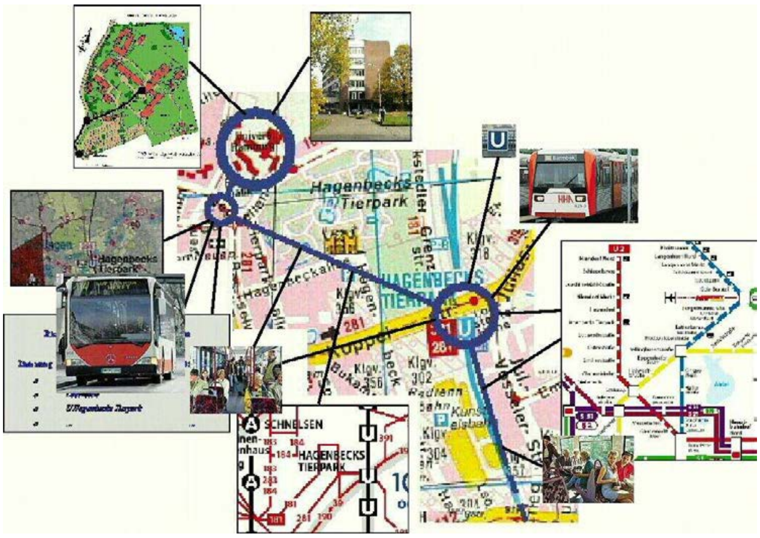

Fig.1: Part of an information collage

process is termed a spatial view on a collection of database objects. A spatial collage is defined as a connection between spatial views. So, for example, the description of a navigation process would use three different spatial views and thus require two collages to connect them.

A cognitive collage for a navigation process is a collection of disparate pieces of knowledge about decision points along a route and the route itself: recollections of journeys through this decision point or along the route, memories of maps, recall of verbal (aural or written) instructions, facts about the decision point or the route, different spatial (might also be historical) views of points along the route and more (olfactory information, associations (meeting with friends, seeing something strange)). The structure of the cognitive collage is unordered, the only combining effect for each of these pieces of information is that they belong to a route and can be 'triggered' through knowledge in the world.

A cognitive collage is highly personal and subjective. However there are pieces of information in a collage that could be termed objective: information on timetables, alternatives of routes, views of buildings, means of transportation, knowledge about decision points, etc. The structure of a collage can be used to associate many different pieces of 'objective' information with a given route.

We are interested in providing a user with a collection of information pieces or fragments associated with a route the user has to travel. An *information collage* is the collection of all the pieces of information that an information system could retrieve at a certain point in time as they pertain to the route, including information on the route itself. Each piece of information is called an information fragment. Instead of trying to integrate all the information fragments and make them consistent, we associate each fragment with the point of the route it corresponds to. These points may be places, locations or time points during an action or operation. Information fragments may be graphical or textual.

3 Action Plan

An action plan details the spatio-temporal actions that a traveler needs to carry out in order to find a way from a start to a goal. The action plan corresponds in most cases to the route instructions derived from the route planning process. However, depending on the user's requirements, the instruction can be more or less coarse. For example, a traveler who knows the urban area might just need a reminder where to go (cf. essential actions in Table 1), whereas a person in a wheelchair might prefer the details presented at the level of the operations (cf. in Table 1).

Our model uses a hierarchical action plan to represent the route action information at different levels of activity. Each level of actions represents in fact a progressive abstraction of more detailed actions (Stell 1999). Actions start at a certain time and place in the navigation process and end again at a specific time and place. Those places are called decision points. They correspond to places where the correctness of the route may be reaffirmed or an alternate solution might be chosen.

Activity	**Wayfinding from Informatikum to Hamburg main station**					
Essential Action			Take bus 181 to Hagenbecks Tierpark		Take U2 to Hauptbahnhof	
Action		1	2	3	4	5
		Walk from Informatikum to bus stop 181	Take Bus 181 to station Hagenbecks Tierpark	Walk from bus stop to platform of subway	Take U2 from Hagenbecks Tierpark to Haupbahnhof	Walk from subway station U2 Hauptbahnhof Nord to Hauptbahnhof front entrance
Operation	A	Walk out of building	Get into bus 181	Walk towards U2 station	Get into subway	Take stairs at front of subway train
	B	Leave the campus	Buy ticket	Take stairs down to the platforms		Turn right at top
	C	Walk straight along Vogt-Koelln Strasse	Ride (4 stops) until bus stop Hagenbecks Tierpark	Walk on right platform with trains in direction Wandsbek-Gartenstadt or Barmbek	Ride (9 stations or 20 min) until subway station Hauptbahnhof Nord	Take next stairs to top
	D	Cross the next street	Get off bus		Get off subway	Turn right and walk 10 meters
	E	Turn left				
	F	Walk to bus stop				

Tab.1. Action plans in wayfinding at different levels of granularity (case study Hamburg)

The hierarchical wayfinding graph (Fig. 2) encodes the knowledge about activity, actions, and operations at the same time as it stores knowledge about the routes at different levels. Each level shows the route at a different granularity, i.e. at a different activity level (cf. Timpf 2002).

Nodes are places (e.g., Informatikum, Hagenbecks Tierpark) and depending on the granularity level also locations (e.g., bus stop at Hagenbecks Tierpark, top of stairs). Edges connect nodes and thus carry information on the action or operation to be performed. Each edge corresponds to exactly one action or operation. In addition, temporal and spatial information can be added to the edges.

The optimal presentation time for navigation information can be deduced in a first approximation from the action plan. It is important to note, that the information presentation should take place just *before* a new action is to be taken by the traveler. The absolute time interval, which denotes *before* is dependent on several factors (this is an open list): speed of travel, complexity of the route, number of potential interactions (may be dependent on the time of day, e.g., rush hour), number of alternatives, complexity of the choice, and potential disability of the person.

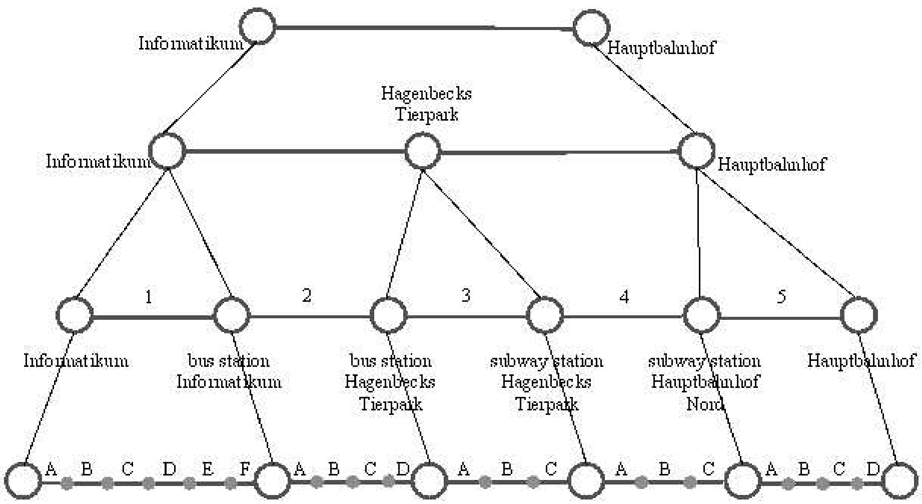

Fig.2: Hierarchical wayfinding graph including action plan

4 Conclusions

In this short paper we present work in progress in the area of modeling inter-modal navigation for location-based services. The focus of the paper is *when* to present *what* information to the traveler. We propose to derive the time of presentation from the action plan (derived from the route plan) and the information needed (the what) from the information collage.

We provide a model for navigation that is very similar to humans' mental representation of wayfinding information. The model takes into account that route information can be given at several levels of granularity and that different levels might be necessary in the course of one trip due to missing knowledge in the world (Norman 1988). The action plan at the appropriate level is chosen and the information presented to the user just before a new action is started.

In addition to the hierarchical wayfinding graph, we use the structure of an information collage to encode contextual information about the route and the navigation process. Information fragments are views on data in distributed information systems, e.g., bus timetables or subway connection information. Within the information collage fragments are associated with route sections, i.e., places or actions. The information collage has many advantages: it uses the same structure and mental model as the human traveler. It can include uncertain and contradictory information without becoming unusable. Through the different levels of activity the model is more adaptable to user needs, can solve the contradiction by providing more detailed information and through the same way makes the information less uncertain. The model also includes redundant information, which provides the user with greater security and flexibility. Redundant information might also solve the uncertainty of one fragment by providing a second one.

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Pedestrian Navigation System for Mixed Indoor/Outdoor Environments

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Abstract

Pedestrians have often ways in unfamiliar urban environment or in complex buildings. In these cases they need guidance to reach their targets, for example a specific room in a local authorities' building, a counter, or an institute at an university. The goal of location-based mobile services is to provide such guidance on demand (anywhere, anytime), individually tailored to the actual information needs and presented in preferred forms. This project is focusing on the information aspect of location-based services, i.e., on the user's task at hand and the support of the user's decisions by information provided by such a service. Specifying a task ontology will yield context-dependent conceptualizations, activities, and references to directions from the user's perspective. These specifications will allow to:

- select appropriate sensor data and to integrate data when and where needed;
- propose context-dependent routes, fitting to partly conflicting interests and goals;
- select appropriate communication method in terms of supporting the user guiding by various multimedia cartography forms.

To test and to demonstrate the approach and results this project takes a use case scenario – guiding visitors to institutes of the Technical University Vienna – and develops a prototype.

1 Mobile Positioning

1.1 Problems and State of the Art in Mobile Positioning

Pedestrian navigation has to work under any environmental condition in mixed indoor and outdoor areas as well as urban environments. Therefore challenging tasks that are dealt with in the project NAVIO are:

- the capability to track the movements of a pedestrian in real-time using different suitable location sensors and to obtain an optimal estimate of the current user's position,
- the possibility to locate the user in 3 dimensions with high precision (that includes to be able to determine the correct floor of user in a building), and
- the capability to achieve a seamless transition for continuous positioning determination between indoor and outdoor areas.

Thereby a navigation support must be able to provide location, orientation and movement of the user as well as related geographic information matching well with the real world situation experienced by pedestrians. Other challenging issues relating to the privacy and security of information about the current user's position, however, will not be addressed.

Nowadays for outdoor navigation, most commonly satellite-positioning technologies (GPS) are employed. Then the achievable positioning accuracies of the navigation system depend mainly on GPS, which provides accuracies on the few meters to 10 m level in standalone mode or sub-meter to a few meter level in differential mode (DGPS). If an insufficient number of satellites is available for a short period of time due to obstructions, then in a conventional approach observations of additional sensors are employed to bridge the loss of lock of satellite signals. For pedestrian navigation, sensors such as a low-cost attitude sensor (digital compass) giving the orientation and heading of the person being navigated and a digital step counter or accelerometers for travel distance measurements can be employed. Using these sensors, however, only relative position determination from a known start position (also referred as Dead Reckoning DR) is possible and the achievable accuracy depends on the type of movement tracking sensors used and the position prediction algorithms adopted.

For indoor positioning different techniques have been developed recently. They offer either absolute or relative positioning capabilities. Some of them are based on short-range or mid-range technologies (see e.g. Klinec and Volz, 2000) using sensors such as transponders or beacons installed in the building. An example are the so-called Local Positioning Systems (LPS) that have an operation principle similar to GPS. The LPS systems claim to achieve of about 0.3 to 1 m distance measurement accuracy (see e.g. Werb and Lanz, 2000; Sypniewski, 2000), but no details are given on the test results and the achievable accuracy on position fixing. Other indoor positioning systems currently under development include so-called Active Badge or Active Bats Systems (Hightower and Boriello, 2001). These systems are mainly employed for the location of people and finding things in buildings. Also Bluetooth, which has been originally developed for short range wireless communication, can be employed for locating mobile devices in a certain cell area that is represented by the range of the device. It can be employed for location determination using active landmarks. Locating the user on the correct floor of a multistory building is another challenging task. For more accurate determination of the user's position in vertical dimension an improvement might be achieved employing a barometric pressure sensor or digital altimeter additionally (Retscher and Skolaut, 2003).

As an alternative, mobile positioning services using cellular phones can be employed in both environments. Apart from describing the location of the user using the cell of the wireless network, more advanced positioning methods are under development. Most of them are based on classical terrestrial navigation methods where at least two observations are required to obtain a 2-D position fix (see e.g. Balbach, 2000; CPS, 2001; Drane et al., 1998; Hein et al., 2000; Retscher, 2002). The achievable positioning accuracy thereby depends mainly on the method and type of wireless network where accuracies are expected to be much lower in the current GSM[1] networks as in the future UMTS[2] networks. First manufacturer tests showed that a standard deviation of 50 m for 2-D position determination can be achieved using advanced methods in an ideal case. Further investigation on new developments and performance test results is especially required in this field.

1.2 Integrated positioning

For guidance of a pedestrian in 3-D space and updating of his route, continuous position determination is required with positioning accuracies on the few meter level or even higher, especially for navigation in buildings in vertical dimension (height) as the user must be located on the correct floor. The specialized research hypothesis of this work package in the project NAVIO is that a mathematical model for integrated positioning can be developed that provides the user with a continuous navigation support. Therefore appropriate location sensors have to be combined and integrated in a new multi-sensor fusion model.

1.3 Selection and test of appropriate location sensors

Newly developed sensors are available on the market which can provide various level of accuracy for position determination in navigation applications (see e.g. Ellum and El-Sheimy, 2000). Due to the obstructions of satellite signals in urban environment (Mok et al., 2000), a methodology has to be developed for position estimation under insufficient satellite availability condition. Besides a GPS or DGPS (Differential GPS) receiver other low-cost navigation sensors have to be integrated into the system design. It is proposed that at least the following relative dead reckoning (DR) sensors should be included: an attitude sensor (i.e. a digital compass) giving the orientation and heading of the person being navigated in combination with an inertial tracking sensor (e.g. a low-cost Inertial Measurement Unit IMU) including a three-axis accelerometer also employed for travel distance measurements as well as a digital barometer (i.e., barometric pressure sensor) for height determination (Retscher and Skolaut, 2003). Their performance and suitability has to be analyzed in detail.

For indoor positioning various technologies are currently being developed or in the development stage (see e.g. Hightower and Boriello, 2001). Further investigation concerning their suitability, accuracy potential and error budget is yet not addressed in detail. In addition, mobile phone location services should be employed. Depending on their availability a comparison with other technologies is required and further investigation on their suitability, reliability and accuracy potential is necessary.

1.4 Development of a Multi-sensor Fusion Model

A Kalman filter approach is particular suited for the integration and sensor fusion in real-time. Extending basic filter approaches, a centralized Kalman filter approach which integrates all observations from the different sensors will be developed. The model must be able to make full use of all available single observations of the sensors at a certain time to obtain an optimal estimate of the current user state (i.e., position, orientation and motion).

Figure 1 shows the concept of an approach for the integration of observations of sensors using a centralized Kalman filter. The concept has been introduced by Retscher and Mok (2001) for the integration and combined position determination of observations of GPS, mobile phone location services (MPLS) and dead reckoning (DR) sensors employed in vehicle navigation systems. An analysis based on simulations performed by Siegele (2001) has proven that this model is suitable for integration of different sensors in mobile positioning. Apart from the last step, i.e., matching of the positions obtained from the filter to a digital road map, the approach can also be employed in pedestrian navigation. A simulation study for the guidance of visitors of our University performed by

[1] GSM stands for Global System for Mobile Communication.
[2] UMTS stands for Universal Mobile Telecommunication Service.

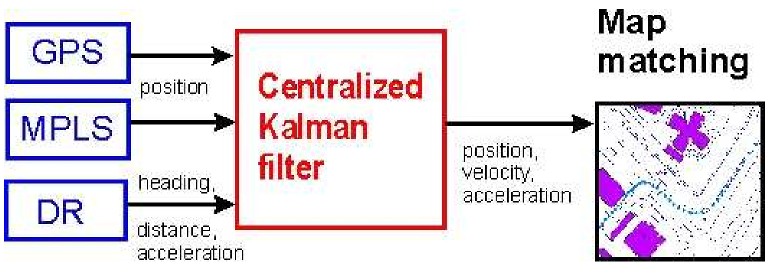

Fig.1: Centralized Kalman filter approach (after Retscher and Mok, 2003)

Skolaut (2002) showed promising results for the adaptation of the filter model for pedestrian navigation. The algorithm is also open for the integration of other sensors than shown in Figure 1 and for further modification.

An improvement of the accuracy and reliability for position determination should be achieved in the model by integrating all single sensor observations available at a certain time (epoch). It is suggested to derive an extended filter model capable to calculate the user state from all available measurement data, also in the case, if only incomplete observations from a single sensor are available (e.g. if insufficient numbers of satellites for GPS positioning are available due to obstructions). Any single observation can then contribute to improve the previous state of a tracked user by updating the prediction in the filter model. This approach would provide the advantage to estimate the user state recursively also, if an individual positioning method would fail by refining the estimate of the solution using single observations (i.e., GPS pseudoranges, attitude parameters, traveled distance, velocity or acceleration and height difference) together with the observations of other sensors (e.g. in the case of availability range measurements to pseudolits[3], transponders, beacons or base transmitter stations of wireless phone networks). Such an extended Kalman filter approach has been firstly introduced by Welch and Bishop (1997) for an individual positioning method (i.e., an optoelectronic 3-D tracking system) and can be further adapted and modified for our application.

The proposed multi-sensor fusion model will be developed in a way that it is open for the integration of future developed sensors. It has to be implemented in a software package and will be analyzed and tested in detail using simulations and real observations from the senor tests. The model is capable to provide continuous information about the user's position required for the route modelling and updating.

2 Pedestrian Route Modelling

2.1 Problem and State of the Art of Route Modelling

Existing navigation services are based on technical feasibility instead on user´s needs. They are difficult to use, do not meet the pedestrian's expectations, and can fail supporting human navigation (Chewar and McCrickard 2002, Geldof and Dale 2002). Mostly they optimize single search criteria or even use arbitrarily predefined routes.

An user-centered design approach will exploit the literature on pedestrian wayfinding behaviour and human route communication from disciplines like cognitive science (Freundschuh et al. 1990; Couclelis 1996), psychology (Lovelace et al. 1999), and linguistics (Herrmann and Schweizer 1998). For instance, Werner et al. summarize research for navigation strategies based on route graphs (2000). Denis et al. report on human subject testing for route communication (1999). Similar is done by Fontaine and Denis for complex built environments, especially in the vertical dimension (1999). People use landmarks in mental representations of space (Siegel and White 1975) and in the communication of route directions (Werner et al. 2000, Maaß and Schmauks 1998, Lovelace et al. 1999). Studies show that landmarks are selected for route directions preferably at decision points (Habel 1988, Michon and Denis 2001).

Davies et al. report from experiences with a catalog of route selection criteria in a tour guide (2001). A pedestrian is interested primarily in the shortest route (Golledge 1995). If alternative routes exist that are not too much longer, but show other qualities (e.g., safer, easier, or more interesting), groups of pedestrians prefer to be guided the other routes. The relevant selection criteria of pedestrians need to be identified (Golledge et al. 1998), and their combination in optimal route algorithms needs to be solved. Multi-criteria optimization, as investigated in Operations Research (Martins 1984; Ehrgott 2000), will be investigated for this problem.

There is a lack of a formal model of the diverse results of this literature. Such a formal model would provide a task ontology (Guarino 1998; Smith 1999) of pedestrians (Timpf 2001), or, in this context, of pedestrians navigating in unfamiliar urban environment to a desired destination. The restriction to specific tasks reduces the complexity of modelling the real world and possible users' intentions in this world. A formal ontology (Gruber 1993; Guarino 1995), represented in a functional language, can be checked for consistency and completeness, and can be used to simulate test cases for cognitive relevance and plausibility (Frank 1997; Raubal 2001).

[3] Pseudolits (short for "pseudo-satellites") are ground-based transmitters at known location which transmit GPS signals.

Data provided by data warehouses were not collected for support of pedestrian navigation. It is structured for the physical large-scale space but not for the every-day space (Freundschuh and Egenhofer 1997; Golledge et al. 1998) or city-size spaces (Downs and Stea 1982). If the categorization of the real world into objects is task dependent (Frank 1997; Fonseca et al. 2000), and changes with the task, e.g., from a pedestrian's perception to the perception of a user of public transport (Timpf 2001), then mappings are needed between objects of different ontologies. Moreover, the different tasks of navigation – planning, instructing, moving – require different models of space (Timpf et al. 1992; Kuipers 2001). The resulting model will be useful to improve (pedestrian) navigation services. Moreover, with a formal approach based on ontology research we pioneer a new approach to modelling services and small GIS in general.

2.2 Route Modelling Ontology

The overall goal of the ontology is a model of pedestrian route modelling, based on the informal and unstructured findings in the research literature on human wayfinding: how do people select and represent routes? The model shall simulate the reported behaviour. The approach is formal ontology design. A formal ontology will identify and define formally the criteria, the actions, and the reference objects used by pedestrians in their reasoning for routes.

The research hypothesis of this work package is based on the idea that pedestrian route selection behaviour and route representation can be simulated successfully. We call a simulation successful if the 'behavior' of the specified model is acceptable for most users, and can easily be realized. The formal ontology, written in a formal language, can be executed and thus, tested for metric and cognitive plausibility. Plausibility of generated routes will be cross-checked with test persons in our use case scenario.

The ontology of pedestrian route selection will identify and define criteria to combine a route. We will develop qualitative and quantitative measures for the criteria that flow into multi-criteria optimization. Partly this work can profit from experience of modelling the generation of hiking trips (Cziferszky 2002, Winter 2002a). Another part of the ontology is the identification and definition of actions in pedestrian movements. This part will be developed by investigating the verbs in human route descriptions. Actions are related to functions and lead us to an algebraic specification of route directions (Frank 1999, Frank 2001). The third part of the ontology consists of the identification and definition of features pedestrians refer to in their mental representation or communication of routes. Here we will profit from our ongoing preparatory work on finding salient features in the urban environment (Raubal and Winter 2002, Nothegger 2002).

We expect that criteria, actions, and reference features will differ for outdoor and indoor navigation. Nevertheless, the commonalities of indoor and outdoor route selection and representation will motivate a hierarchic construction of the ontology. The more abstract level, derived from the common parts, is guiding towards a general ontology of navigation.

3 Multimedia Cartography Route Presentation

3.1 Problem and State of the Art of Multimedia Cartography Route Presentation

Guiding instructions for pedestrian navigation consist of spatially related information (Downs & Stea 1982). The main elements of guiding instructions for supporting pedestrian navigation are usually resulting from a general routing model (cp.1.2), where routing functions and, optionally, guiding functions along predefined routes can be executed. The main elements derivable from such routing models include starting point, target point, decision points, distances and route graphs (cp. FTW Project C1, 2001). In order to communicate the resulting elements they have to be combined and translated into "communicative guiding instructions". Such a translation has to be seen in the context of the problem of matching a guiding instruction with the reality by the guided person, which is dependent on various influencing parameters, including:

- the user´s task/situation;
- the skills of the guided person;
- the "quality" of the instruction in terms of semantic, geometrical, temporarily correctness or usability;
- the "potential" of the communication mode to transmit the information needed by the client; and
- the technical restrictions of output devices.

So far, such "translations" for the usage on wireless mobile devices are rarely based on user-centered approaches but on technical possibilities of existing mobile clients, using textual modes (Webraska 2001, Mogid 2000) or cartographical modes (EML 2001, WiGeoGIS 2001, Benefon 2001) only. The "validity" of the used modes (especially maps) and knowledge about different enhancements by using additional modes (e.g. images, VR-scenes, audio) or combined sets is aimed at in different projects, e.g. Lehto (2001), Hardy et. al. (2001), Wang et.al. (2001), Reichenbacher (2001), Sorrows & Hirtle (1999), Maaß (1996), Stocky (2002) and Davies et.al. (2001).

The FTW Project C1 - UMTS Application Development (FTW 2000, 2001; Brunner-Friedrich et. al. 2001, Uhlirz 2001), where the Department of Cartography of the Vienna University of Technology takes part in a research group (Forschungszentrum Telekommunikation Wien), has produced first results in this context. As a joined issue of the FTW-project, the development of a prototype of a location-based service for an UMTS environment is in progress. The application "LOL@", a guided tour through Vienna's 1st district, is meant as a service for foreign tourists. The user is guided along a pre-defined route or due to individual input to some of the most interesting places in Vienna's city center, where he can get multimedia (audio and visual) information about the tourist attractions via the Internet portal of the service. The application requires a wireless handheld as input/output device. In order to be able to develop a location based service in an UMTS environment, the project has to deal with four main parts: specifications of technical prerequisites as well as conceptual and method development for localization, positioning and routing, application development and application implementation (FTW 2000). The result (cp. Gartner & Uhlirz 2001, Pammer 2001 or http://www.ftw.at/projektC1_de.html) is based on the objective to develop a running prototype. The objectives defined in the NAVIO project have to be seen as closely adding on / taking advantage of the results of the project "Lol@". This is seen in the context of applying multimedia cartography methodology on the transmission of guiding instructions, which is based on the theory, e.g described in Cartwright et.al. (1999), Buziek (1997) or MacEachren (1995), that Multimedia cartography offers various methods and forms of communicating spatially related information with different potential of information transmission and user interactivity (Gartner 2000c).

3.2 Multimedia Cartography for Route Presentation

Telecommunication technologies developments (like GPRS, UMTS) are conceived to offer a wide range of new multimedia services to mobile users. The cartographic part of the NAVIO project aims at demonstrating the feasibility and efficiency of presenting space-related guiding instructions, derived from integrated positioning methods and pedestrian route models, to support pedestrians navigation by various methods of multimedia cartography. The research hypothesis to be investigated is: a multi-purpose defined selection of multimedia cartography presentations supports the wayfinding and navigation of pedestrians via a guidance system.

Within this hypothesis the evaluation of multimedia supported cartographic communication processes within the context of pedestrian navigation is guided by the idea, that the applying of multimedia on spatial communication processes is an improvement in terms of enabling individualization of interfaces and content presentations (Neuman et.al. 1999, Reichenbacher 2001, Bobrich & Otto 2002) and therefore increases the efficiency of information transmission.

In the context of pedestrian navigation the appropriate presentation form is dependent on the particular user situations and the specification of the user characteristics. It is assumed, that the appropriate form of communicating spatial guiding instructions will include primarily graphical coding and abstracting (maps, other forms), but also other kind of information transmission methods. An aim of the project is the investigation on a criteria catalogue of selecting the appropriate combinations of multimedia cartography presentations forms for particular user situations in the context of pedestrian navigation. A special focus is necessary on the role of active and/or passive landmarks and their derivation possibilities. A further aim is to investigate a suitable concept of deriving a metrical and semantic correct and feasible guiding instruction into different forms of multimedia cartography presentations.
In detail the objectives consist of:

- Identification of appropriate multimedia cartography presentation forms and various combinations
- Investigation of the range of applicability of presentations and/or presentations sets in the context of pedestrian navigation by defining characteristics and context/relation to guiding
- Analysis of range and methods of deriving and/or adapting guidance instructions into various communication forms including the role of determining input (user specifications) and output (device specifications) criterias
- Investigation of possible enhancements to the process of pedestrian guiding by embedding active and/or passive landmarks
- Testing of suitability

4 Summary

The described project is aiming to analyze major aspects being important when concepting a pedestrian navigation service: integrated positioning, multi-criteria route planning, and multimedia route communication. As a result, a specific pedestrian navigation service as use case will derive the requirements on positioning, route planning, and communication. A prototype of the service will guide visitors to institutes and persons at the Technical University Vienna. This prototype will allow evaluating and demonstrating the usability of the service, and thus, prove the projects attempts. However, the focus of the NAVIO project is on developing the methodology such that the prove of the hypotheses, not on product development, is possible. Therefore, we will contribute to the integration of location sensors and seamless transition of positioning between indoor and outdoor areas; the ontological modelling of navigation tasks, deriving well founded criteria and optimization strategies in route selection; and models for context-dependent communication modes of route information; and, in general, to improvements in (pedestrian) navigation services.

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APPLICATIONS

Geo-Data Presentation on Mobile Devices for Tourism Applications

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Abstract

Tourism information mostly is geographically related information and therefore, a multimedia presentation of tourism information in spatial context on different digital platforms will offer the opportunity for a comprehensive information service. Based on the rapid developments of the telecommunication industry, several handheld devices are available which allows realising a mobile information system including location aware services.

This paper will briefly describe a prototype of a mobile multimedia tourism information system for outdoor activities and user oriented data management tools. A PDA (Personal Digital Assistant) in connection with GPS device allows us to guide tourists to the desired sights or along hiking and biking tours of a tourism region. For a multimedia visualisation of tourism information pictures, sound, text and video elements were integrated in order to record the effectiveness of the mobile device. Cartographic illustrations using satellite images and digital maps are the base for an innovative presentation of tourism information in their spatial context. Mobile devices offer the possibility of an innovative presentation of tourism information with a high usability and fulfil user desires for information provision.

1 Introduction

The ongoing competition in tourism economy demands new and innovative strategies for the presentation of the tourism regions. The existing tourist information systems of Central Europe showed clear shortcomings concerning the existing technical opportunities for the presentation of spatial information (Zeiner H. et al. (2002)). An innovative tourism information system has to offer the opportunity to present information on different output devices and has to consider the spatial context of the relevant data in order to reach important tourist target groups. The rapid technological progress in the telecommunication industries supports in a strongly way the integration of mobile devices in the daily life of the people. Therefore, handheld mobile applications will become a driving economic factor both for further developments of telecommunication industries and for the acceptance of and public response to the EU initiative Galileo.

User-related presentation ("Customisation") and location awareness will play a crucial role in the acceptance of the digital tourism information services (Fritsch D. (2001)). Therefore, today and increasingly more in the future mobile devices such as cellular phones, PDAs and GPS devices are used by many people to get mobile access to information. The combination of PDA with GPS devices allows the user to relate information individually to his present position and to obtain, unlike a regular Internet user, a geographically interesting piece of information and offers him a "Multimedia Location Based Service".

In order to achieve a broad acceptance for such a mobile system by the addressed target groups e.g. tourism boards and tourists, the data management for the geo-multimedia information should be easily feasible by non GIS experts. Therefore, a management system has to be designed as a user-friendly and also adaptable tool which fulfils the data handling and the data pre-processing for the presentation on a mobile device.

Both the development of the concept presented in this article and the creation of the prototype were realised in close cooperation with the company "RuFHer" and within the 5th EU Framework Programme project "ReGeo" (Multimedia Geoinformation for e-Communities in Rural Areas with Eco-Tourism).

2 User requirement analyses

In order to develop a user friendly mobile information system a study was carried out to analyse the user demands for such a system. The study was guided by the idea of the company RuFHer to develop a mobile multimedia tourism information and safety system. The basic concept behind the system is that people engaging in out-door activities need various (actual) information about the region for making their hobby safely and enjoyable.

Information needed	Skier	MTB	Hiker
Tour Destination	+	++	+++
Tour	++	+++	+++
Characteristic of the Tour / Aerea			
Variety	+++	+++	+(+)
Beautiful Surrounding	+(+)	+++	+++
Rest / Silence	+	+++	+++
New Tours	++	+++	+++
Number of Visitors	+++	++	+
Route / Ski-run Infos			
Difficulty	+++	+++	+++
Duration	+	+++	+++
Altitude	+	+++	+++
Profile	-	+++	++
Steep	++	+++	++
Distance	-	+++	+++
Condition	+++	+++	++
Open / Closed	+++	++	-
Marking	+	++	+++
Securing / Protection	+	-	++
Variants (Alternatives)	+++	+++	+++
Weather			
Forecast / Long Term	+++	+++	+++
Actuall	+++	+++	+++
Regional	++	++	++
Orientation			
Position / Location (Determination)	++	++	+++
Destination	+	+++	+++
Tour Description (howto come there)	+	+++	+++
Remaining Distance	+	+++	+++
Needed (Accessories) Equipment	+	+	++
Way Up Aids			
Open / Closed	+++	++	+++
Office (Working) Hours	+	++	+++
Waiting Period	+++	-	-
Starting Point	+	+++	+++
Approach / Arrival	+	++	+++
Public Transportation	++	+	++
Cottage / Refuge / Shelter			
Contact	-	++	+++
Position / Location	+	+++	+++
Howto Reach	+	+++	++
Overnight Stay	-	+++	+++
Open / Closed	+	+++	+++
Equipment	+	++	++
Service	++	+	++
Prevention / Safety			
Avalanche Situation	++	-	-
Refuges / Shelter	-	+	++
Emergency (actual)			
Call for Help	+++	+++	+++
Shelter	-	+	++
Alpine Registration Office	+	+	++
Emergency Way	+++	+++	+++
Warning Information			
Bad Weather Warning	+	++	+++
Avalanche (Danger Zone)	++	-	-
Falling Rocks	-	-	+
Information / Hints			
Closed Areas	+++	++	+
Alpine Ground / Terrain	+	+	+++
Nature Information			
Peak Notification	++	+(+)	+++
Regional Plants	-	+	++
Regional Animals	-	+	++
Speciality of the Region	+	++	++(+)
Documentation			
Altitude	+	+++	+++
Distance	+	+++	+++
Tour / Route Profile	-	+++	+
(Ø) Speed	+	+++	-
Pulse Rate / Heart-beat	-	+	

Tab.1 : *Information requirements of target groups, Legend: - not relevant; + rarely important; ++ important; +++ very important information*

However, as the ideas about specific features of the system were vague and primarily built on individual experiences of the RuFHer group a PINN-Project[1] was assigned to get a market perspective on that issue (Eder, M. and Eder, H. (2003)). The aim of the research was the determination of relevant information domains, problem areas and specific system functions from the perspective of possible users and important stakeholders.

Because of the primary applied focus of the study and the limited timeframe the study it was not designed to satisfy academic standards. Nevertheless it can be argued to reflect good new product development standards as the well established method of semi structured qualitative interviews was used with a mix of various techniques like sequence oriented problem identification, critical incidents technique, laddering and open probing (for review see i.e. Easterby-Smith, Thorpe et. al. (2002)).

The selection of potentially relevant users (skier/snowboarder, biker, and hiker), and stakeholders (hotels, refuges, tourism-boards, rescue services, lifting and tourist experts) rested on personal knowledge and experiences of the involved persons. For this investigation 45 users and 25 stakeholders in three major tourism regions in Austria were interviewed. The interviews lasted from 20 to 40 minutes and all were recorded, transcribed and content analysed. Table 1 summarizes the major information requirements of the tree target groups.

The Table above indicates specific information requirements of the three target groups. In addition the relative importance of each information is indicated. The red circles highlight areas of major differences between skiers and the other two target groups. Apparently skiers consider information regarding to the tour/route, orientation, cottages etc., emergencies, and documentation as not really important. One reason for that might be that relevant information in “organized areas” such as ski-arenas is readily accessible. The respondents clearly indicated that in organized areas such as ski- arenas multiple information sources such as signs, cell-phones, flyers, info channels, etc., and slope maps are already available and easy to access. This seems to be in contrast to less organized areas in the back country where hikers and hikers commonly pursue their activities. In these areas the information search seems to be more effortful. Accordingly, it has been concluded that hikers and bikers need more information and have less options to obtain them which makes them a more attractive target group for the NavIs system.

The major outcome of the study is that a mobile tourism information system needs to provide, in order to fulfil user desires, the following information:

- Actual Tour Description & Guide
- Route / Tour Characteristic & Infrastructure
- Refuges - Location / Facilities & Open Time
- Weather Report - Forecast
- Actual Regional Weather – Warning
- Emergency & Safety Information
- Orientation / Positioning & Location
- Location Based Services

To overcome user desires and to gain customer amazing, the system has to additionally provide the following information:

- General Tourism Information
- Events / Entertainment.....
- Hotels / Restaurants / Special Offer etc.
- Transportation / Schedule
- Points of Interest
- Natural Environment
- Tour Recording

The realisation of a prototype for demonstration purposes focused on the target group hikers, the one with the highest potential, and especially for this user group functionalities were implemented to present a subset of the above mentioned information. The developed prototype is designed to show the effectiveness of the RuFHer mobile multimedia tourism information and safety system.

3 Test-area and content for the prototype

In the framework of two research projects a close co-operation with the tourism board “Ramsau am Dachstein” tourism region was suggested. (Almer et al., (2000)). This region is a well-known skiing resort (world championship in Nordic skiing 1999) and is one of the most attractive hiking regions in Austria. The region offers a wide network of hike routes and mountain trails and therefore, this region was an ideal test-area for the development of a prototype system.

[1] PINN (Patenschaftsmodell Innsbruck) is a transfer center at the faculty of social and economic science of the University of Innsbruck. For more information see http://info.uibk.ac.at/c/cb/cb19/haupt_e7.html

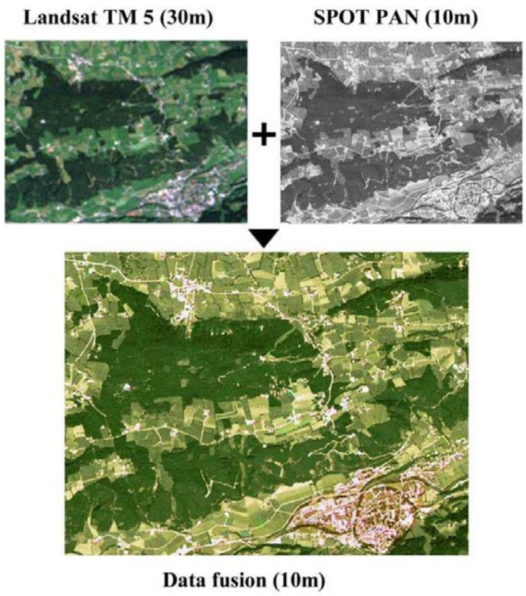

Fig.1: Data fusion

Fig.2: Data fusion vs. digital map

The presentation of geo-data on a mobile device, and tourism information is mainly spatial information, requires a geographical reference. Depending on the desired scale the reference data for a demonstrative and interactive presentation can be created on the basis of aerial and satellite images as well as of existing maps.

In order to produce coloured ortho-images with a high resolution, panchromatic data with a high resolution (e. g. ortho-photos, SPOT PAN, IRS-1C/D PAN, etc.) are fused with multispectral data (e. g. Landsat TM) with a lower resolution. For a data fusion different algorithms can be used depending on the original data. Useful visual results are produced, for instance, with the help of a data fusion on the basis of satellite data of SPOT PAN and Landsat TM (see Figure 1), the result of which is a 10m true colour image (ref. Almer A., Stelzl H. (2002)).

The maps and satellite images mentioned above form the background for an innovative spatial presentation of tourism information. For data acquisition a close cooperation with the local tourism boards is essential. Depending on the orientation of the information system the following data are relevant:

- Tours and tour points: the coordinates of a hiking or biking tour, the most important waypoints, refuges and viewpoints along the route.
- Tourist infrastructure: info points, public facilities, sports facilities, etc.
- Places of interest: castles, palaces, museums, excavations, etc.

These examples demonstrate the fact, that tourism information is mainly spatial information, which can be split into point, line and polygon information. In terms of the presentation every object is a point with coordinates, which can be linked with a great number of multimedia information. Such data range from texts and photos to videos and 3D animations. This link makes possible the interactive presentation of a tourism theme as well as a fascinating journey through a tourism region. The acquisition of the coordinates of single objects can be realised by means of GPS measurements (single point positioning with pseudo ranges) or digitalisations on precise reference data, such as ortho-photos.

4 Technical concept

In order to design a detailed technical concept for a mobile location based information system, the technical framework including the potentials and restrictions of modern information technology as well as customers demands have to be considered. Two different customer groups have been identified: Operators like tourism boards, which want to offer a user friendly location based service in rural areas, and end users. The following focal points have to be considered: *Data presentation* on a PDA with multimedia capabilities, individual *data acquisition* with the PDA in combination with a GPS device and *data management* with a desktop application which provides import and export functionalities for the PDA.

Data presentation contains the presentation of geo-multimedia information on a mobile device. The application to present data on a mobile device is based on a geographical information system with basic functionalities like map browsing and zooming but implements additional features such as multimedia data integration, GPS navigation functionalities as well as visualisation of tours and infrastructure.

The next major part of the mobile tourism information system apart from the spatial visualisation of tourism relevant information is the opportunity of *data acquisition*. The implementation of data gathering functionalities enables the user not only to get access to spatial information but also to integrate his personal tourism information such as places of interest and tours into the system. The opportunity to gather geo-referenced tourism information is essential for a seamless data build-up in such an information system and demonstrates the systems high efficiency.

The third part of the system is, as mentioned above, *data management*. The data management tool represents the link between data acquisition and data presentation, as it provides functionalities to integrate and update geo-referenced tourism information. The overall concept of a mobile tourism information system is shown in the following figure.

5 Data management tool

An important prerequisite for the usage of a mobile information system is a user interface which allows non experts the data handling and the data pre-processing for the presentation of geo-multimedia information on a mobile device. Therefore, the Data Management Tool (DMT) was designed as a user-friendly, easily adaptable, offline tool in order to provide all essential functionalities to fulfil the task of managing the contents of a mobile tourism information system. In an ongoing second step of the development of the DMT, relevant themes for the web presentation will be integrated to realise an online data access based on wireless technologies as well as the opportunity to download actual data via internet on the PDA.

DMT was written in Macromedia Shockwave in combination with server-side running PHP scripts and allows the user to view and manipulate different multimedia information of two dimensional objects (hotels, sights, etc.) and tours (e. g. hiking and biking tours). This application bears the advantage that it is completely customisable. Depending on available maps and themes it can be adapted for different areas of application by editing the configuration XML file, allowing thus a wide range of applications. Although being an offline tool, it can be updated via the Internet or a CD ROM so that the customer may use the latest available data.
The DMT can be split into the following three main modules:

- The data-import/export module (interfaces for connecting the mobile device and other external databases)
- The data-visualisation module (including the 2D map an ortho-images with different information layers)
- The data-manipulation module (includes tools for adding and editing geo-multimedia data e.g. tracks, points, text, images, audio, video)

The data import and export module provides interfaces to the mobile device, GPS devices and external databases. Thus, data acquired via a mobile device can be integrated into the database of the tourism information system. In addition, the user may export

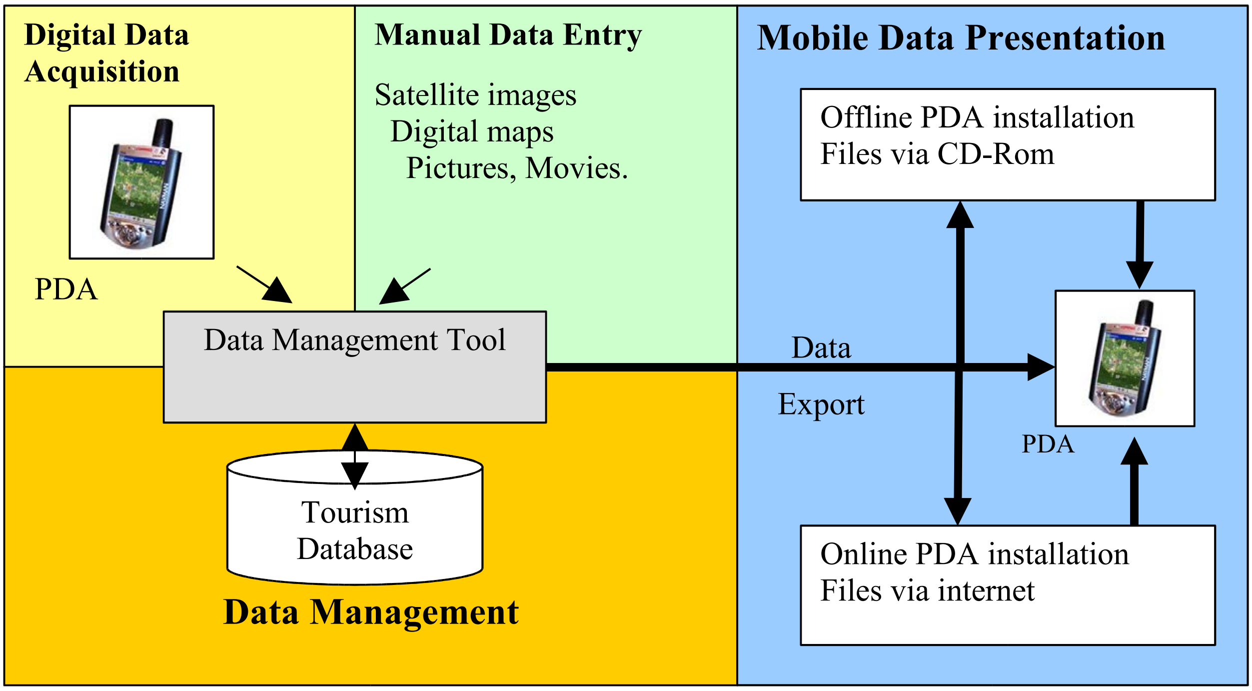

Fig. 3: Overall concept for a mobile tourism information system

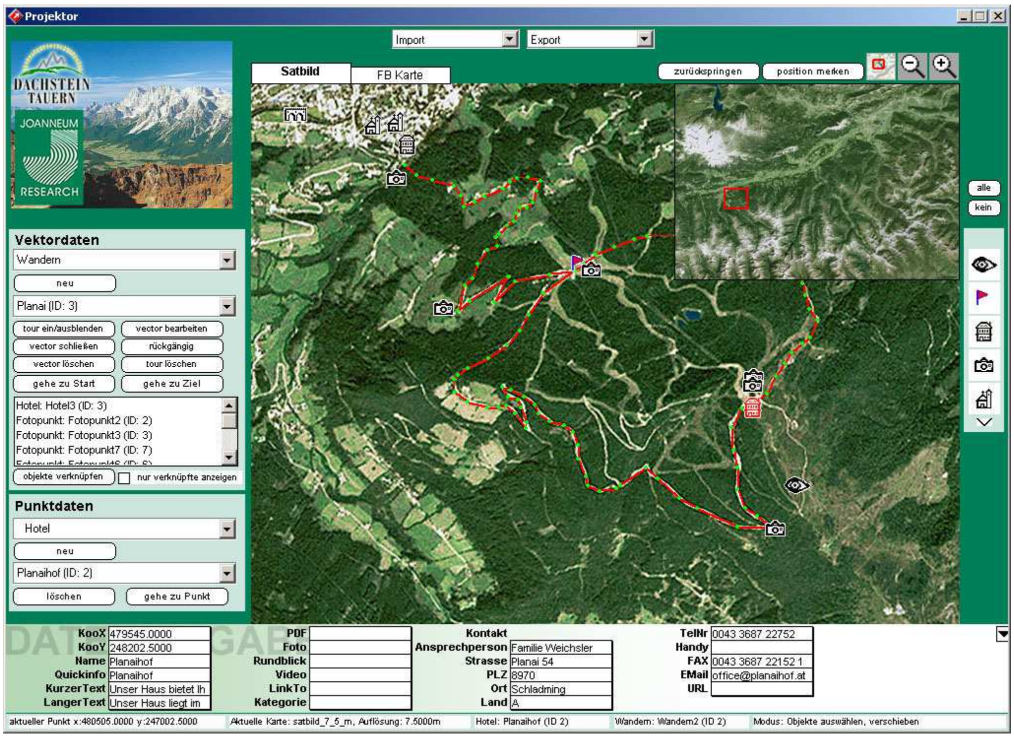

Fig.4: Data Management Tool

existing data to a hand held device, and GPS devices can be accessed to transfer stored points and tracks into the DMT. In order to be more flexible the DMT uses an XML structure for storing all relevant data. With the implemented interfaces it is possible to connect other external databases and exchange data easily. By using the data visualisation module the user can view available tourism information on two dimensional maps. As shown in Figure 3, different types of maps are available. An overview map shows the user's current position within the accessible area. The different themes are visualised by the employment of symbols, and which symbols are used can be set in the configuration file. In order to get an optimal view of particular objects, the user can easily navigate on the map, zoom in and out as well as cycle through the available maps. Another important module is the data-manipulation module as it allows the user to incorporate new information into the system and to edit or delete existing multimedia information. Besides point objects also tracks can be digitised on the map and in addition it is possible to associate points with specific tracks.

6 Mobile device – application

The prototype of the mobile tourism information system was developed for a Pocket PC (HP's iPAQ) in connection with a GPS device (a receiver in the "iPAQ" jacket format) and a mobile camera (see Figure 5). Pocket PCs are high performance mobile multimedia computers with high resolution colour displays working with the operating system "Microsoft Pocket PC 200x". In addition, a memory card was used to expand the internal memory of the Pocket PC.

Since the deactivation of "Selective Availability" the accuracy of the GPS positioning is more than sufficient for outdoor navigation and the European program "Galileo" will realise a perfect availability of positioning information over Europe. Within the private sector of GPS devices we distinguish basically three different types of GPS receivers, which can be used in combination with a PDA:

- GPS receivers as a jacket plugged directly to a PDA or connected via a cable
- GPS receivers with wireless interfaces (e.g. Bluetooth) and a own power supply
- Handheld GPS receivers with a display and map information

The mobile system has, as discussed in the technical concept in chapter 4, to cover two focal points of the overall concept. Firstly, data presentation and secondly data acquisition.

Fig.5: Mobile Information System

Fig.6: Data presentation on the mobile system (screenshots)

Data presentation. This first prototype is realised as a complete offline mobile solution, so only the GPS functionality can be permanently available (see Almer A., Luley P., Nischelwitzer A. (2003)). In an ongoing second step online themes like an event calendar and communication modules will be integrated, based on wireless technologies as well as the opportunity to define a user profile for an individual access to the desired information. The main theme of the prototype is the presentation of outdoor activities e.g. hiking and biking tours, etc., on the basis of ortho-images and digital maps. All pieces of information about the tours, region, impressions, infrastructure and info points are to be shown in a multimedia presentation (video, audio, animation, text, images) and to be linked to the user's current position. At present, the prototype offers the following information levels and functionalities:

- 2D visualisation of different spatial information using satellite images and common maps with the opportunity of interactive navigation and zooming.
- 3D image map for each tour to get an impression of the third dimension, which is important information for biking tours etc.
- General information about and impressions of the region – multimedia representation.
- Infrastructure database with detailed infrastructure information, thematic and geographic search functionalities for hotels, restaurants, leisure facilities, etc.
- A list of outdoor activities, e.g. hiking and biking tours with detailed information related to the tours like coordinates, descriptions, audio and movie objects, etc.
- Interactive selections of different layers for the spatial presentation, as there are tour course or infrastructure layer for the 2D representation.
- Supporting the actual position using a GPS module and shown in the 2D map and satellite image with the selected tour.

The following application screenshots show the prototype's multimedia data presentation capabilities.
The figure above shows three examples of the "Graphic User Interface" (GUI) of the Mobile Tourism Information System. On the left side you can see the 2D map with the itinerary shown on the screen, the position marker and the opened GPS menu. The figure in the centre gives detailed information on a hiking tour and on the right side you can see a media player, which is integrated into the application, playing a video.

Fig.7: Data acquisition on the mobile system (screenshots)

Data acquisition. The second focal point of the overall concept, which has to implemented on the mobile device, is the individual data acquisition, which allows the integration of one's personal tour-tracking coordinates and detailed tour and point information including photos and videos which can be captured using a mobile camera (see Figure 5). The following application screenshots show the data acquisition capabilities of the prototype.

7 Outlook

The rapid technological progress in the telecommunication industries has strong influences on daily life. This fact is confirmed by the selling rates of PDA's and multimedia cellular phones. Location-based services appear to be a major key to the development of mobile networks and the services they provide, since a mobile user's location opens up new possibilities for creating value-added services. Therefore, an innovative and user-friendly mobile system including the location awareness is a logical step for the presentation of tourism information.

User-oriented indoor and outdoor applications on a mobile device offer a wide range of themes providing tourism information. By using current technologies such as GPRS, UMTS and WLAN both online-solutions and precise indoor-positioning have become realizable. The integration of these technologies in the described prototype offers the opportunity to provide a complete "Multimedia Location Based Service" for the visitor of a tourism region.

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Flight Tracking and Potential Cell Phone Applications

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Abstract

Aircraft flying under Instrument Flight Rules (IFR) is continuously monitored by air traffic control over most of North America and the North Atlantic. Data on the position of all aircraft are made available by the U.S. Federal Aviation Administration every four minutes. Flight monitoring software using this data is available from several vendors. Most provide a website in which a specific flight can be monitored in real-time. The webpage will include a map and ancillary data including height and speed of the aircraft. In this study, specialized software is used to display the position of flights in various ways. Animation is used to evaluate the amount of traffic. Suggestions are made for how the information might be displayed with a cell-phone enabled PDA.

1 Introduction

Most commercial and many general aviation aircraft fly under Instrument Flight Rules (IFR). In contrast to Visual Flight Rules (VFR) in which pilots keep their distance from other aircraft under "see and be seen" principles, aircraft under IFR are tracked by radar and positioned in the sky by air traffic control (ATC). The pilot will control the attitude, altitude, and course of the aircraft by watching the flight instruments. In airspace where air traffic control services are available, an IFR flight plan must be filed, and the pilot must maintain voice radio communication with ATC. The major purpose of air traffic control is to separate aircraft to avoid collisions.

Contact with ATC is normally maintained using VHF (very high-frequency) radios. On trans-oceanic flights, HF (high-frequency) is used because of its ability to communicate over long distances. In areas where ground-based radar service is available, IFR flights are provided with radar separation from other aircraft by ATC. In airspace where ATC service is available but not radar service, the course flown must be along published routes called airways, or along courses specified in published instrument approach or departure procedures.

The peak of traffic is just before 11 AM Central Time (12 Eastern) when over 5300 flights are being tracked by air traffic control. Less than a 1000 flights are tracked during the early morning hours (see Figure 1). On average, there are 3415 flights per hour over the U.S. and Canada.

Data on the position of each aircraft under IFR are made available every four minutes through the National Aviation Administration. Several venture capital companies have implemented software to track flights in various ways. All of these companies also maintain websites to track individual flights. These websites are used by thousands of people on a daily basis to track flights of a relative or acquaintance. Figure 2 depicts three displays generated by three different companies of Northwest/KLM flight 67 from Amsterdam to Detroit on Nov. 22, 2003. The display includes a map and information in table form including the current speed and the elevation of the aircraft. FlyteTrax II, a product from FlyteComm, Inc., includes a background map from Microsoft's MapPoint (see Figure 3).

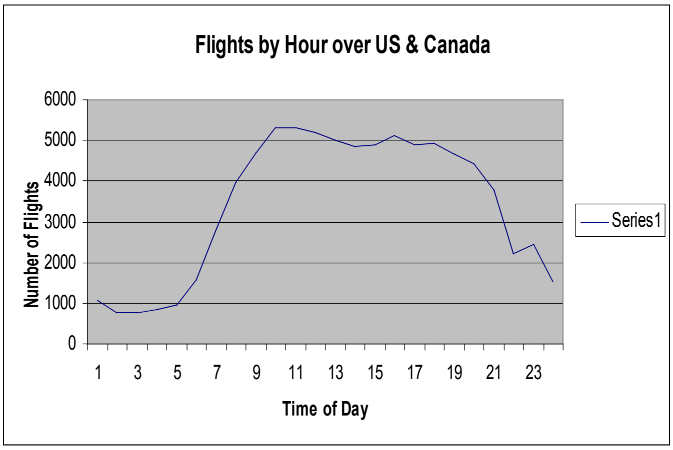
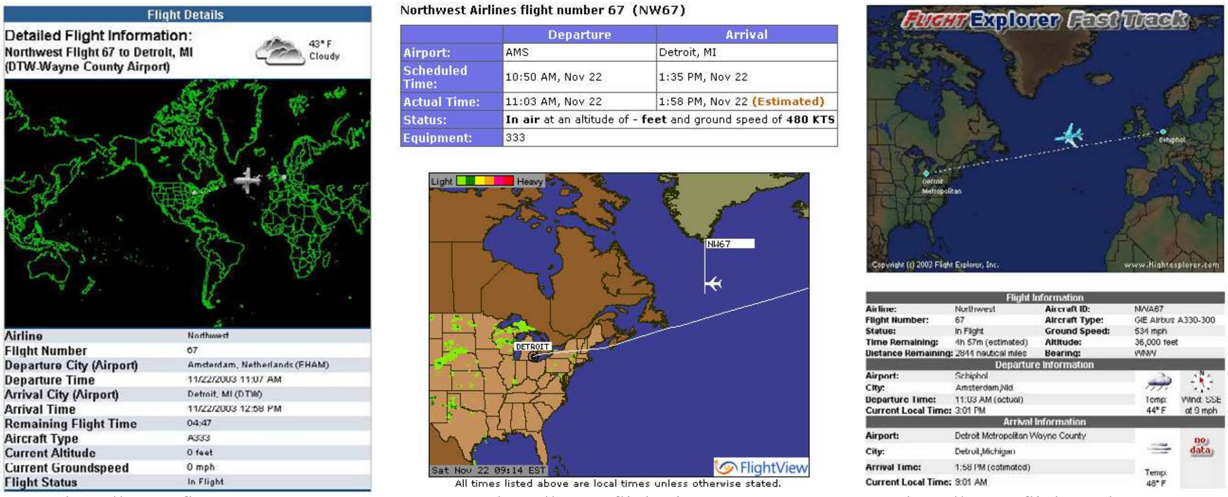


Fig.1: Number of flights using air traffic control by hour over the US and Canada. The time of day is in Central Standard Time.

2 Aircraft Situational Display

Twenty Air Route Traffic Control Centers (ARTCC) across the United States control the airspace. Each ARTCC communicates with the terminal air traffic facilities within its boundaries and neighboring Air Route Traffic Control Centers. The map in Figure 4 displays the ARTCC zones for the three regions across the continental United States. Data from these regions is coordinated at the central Air Traffic Control System Command center (see Figure 5) near Washington, D.C.



http://www.flytetrax.com http://www.flightview.com http://www.flightexplorer.com

Fig.2: Three displays of the current position of an aircraft that are available from three different companies that process and present data available from the National Aviation Administration. These services are currently offered at no cost.

An ARTCC airspace is split up into smaller, manageable pieces of airspace called "sectors." Sectors have vertical as well as horizontal boundaries. A few sectors extend from the ground up, but most are stratified, with the lowest sectors defined from the ground to 23,000 feet, with another sector above from 24,000 feet and up. In some cases, a third sector may be defined for 37,000 feet and up. One or two controllers are directly responsible for separating the aircraft within their sector. Each sector has a unique radio frequency which the controller uses to communicate with the pilots. As aircraft transition from one sector to another, they are instructed to change the frequency to the next sector. Data is passed from one ARTCC sector to the next as a plane flies across the country. These data messages, called Flight Movement Messages, are the same messages are used for Aircraft Situational Display to Industry (ASDI).

ASDI has been available to the airline industry since 1991. The National Business Aviation Association (NBAA), the General Aviation Manufacturers Association, the Aircraft Owners & Pilots Association, the Helicopter Association International and the National Air Transportation Association petitioned the FAA to make ASDI information available on a "need-to-know" basis in 1995. Subsequently, NBAA advocated the broad-scale dissemination of ASDI data. In 1997, NBAA began working with the FAA and ASDI vendors to develop a Vendor Code of Conduct that would help protect the privacy of general aviation operators that fly under IFR. All ASDI Vendors signed the voluntary Code of Conduct in September 1998 that would block ASDI data at the request of the operator.

Aircraft Situation Display to Industry (ASDI) data are now available to private subscribers through several vendors. The ASDI information includes the location, altitude, airspeed, destination, estimated time of arrival and tail number or designated identifier of air carrier and general aviation aircraft operating on IFR flight plans within U.S. airspace. Subscribers to this service include flight departments, charter operators, limousine firms, aircraft producers, air carriers, and research firms.

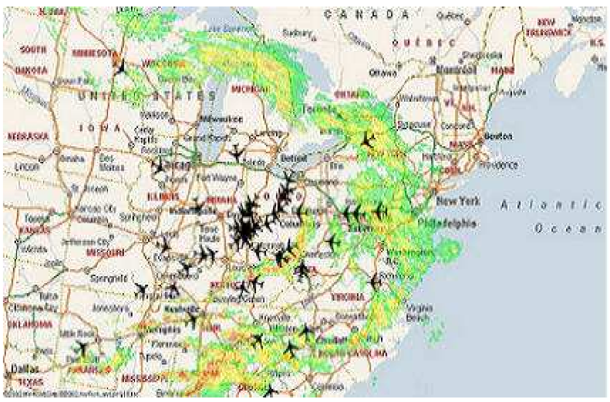


Fig.3: A display from the web-based application, FlyteTrax II. The background map is from Microsoft's MapPoint product.

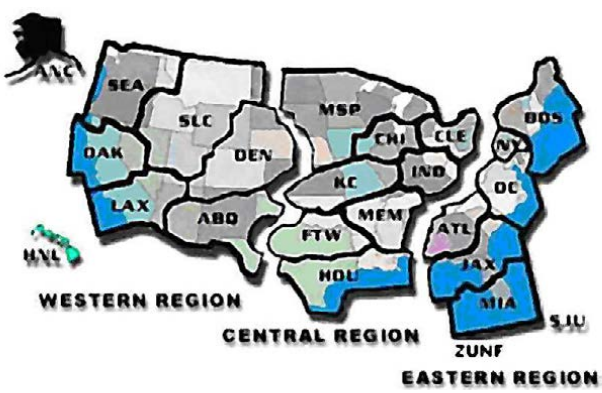


Fig.4: Air Route Traffic Control Centers and corresponding regions in the United States. Source: http://www.vatusa.org/eval/evals.htm

3 FlyteTrax

FlyteTrax is a product of FlyteComm, Inc. (www.FlyteComm.com). The version of the program used here is FlyteTrax 2002, a Windows-based program for displaying the geographic location of airborne IFR (Instrument Flight Rules) air traffic anywhere in the FAA air traffic system. The program can overlay the traffic with a wide selection of maps such as, geo-political boundaries, air traffic control center boundaries, high altitude jet routes, satellite and cloud radar imagery.

On start-up, the program connects to the FlyteComm server through the Internet and receives the current database of air traffic activity. Once the initial database is downloaded, aircraft movement messages are directed through the Internet to the FlyteTrax 2002 program once a minute. For most customers, the actual data is delayed by five minutes for security reasons.

Fig.5: The central Air Traffic Control System Command center near Washington D.C. The facility regulates air traffic when weather, equipment, runway closures, or other impacting conditions place stress on the NAS. (http://www.fly.faa.gov/Products/Information/Tour/tour.html)

FlyteTrax 2002 has two major parts: the Flight Table Manager (FTM) and the FlyteTrax 2002 Display (TRAX). The FTM receives the individual aircraft movement messages and checks to assure that they are valid and complete. Once the flight is found, the status and position of the flight is updated. If an existing flight cannot be found for a message, it is assumed that the flight has just originated and new flight record is activated. Information is updated in the flight record as aircraft movement messages arrive. The entire database is searched and each flight's position is updated every minute based on the last known speed and direction.

3.1 Updating of Flights

FlyteTrax receives a radar position report on each aircraft once every 4 minutes when they are in the ARTCC (Air Route Traffic Control Centers) airspace. The system receives a radar position report every minute for aircraft within 40 miles of the destination or departure aiport. If the system goes for 7 minutes with no position report, a hollow depiction of an airplane is shown to let you know that the position of the aircraft is based on dead reckoning from a radar position received more than 7 minutes ago. The dead reckoning system is based on the last radar position report, the established ground speed at that position report, and the direction established by the prior two position reports. The aircraft's depiction will become solid once a new radar position is received.

Reports of flights over oceans are issued only when crossing every 10 degrees of longitude and can be as much as an hour apart. Therefore, many of these flights will appear dead reckoned (hollow). The Aircraft Situational Display for Industry (ASDI) system is only in operation for the United States, Canada and the North Atlantic. As more countries make their flight tracking data available, ASDI coverage area will continue to expand.

3.2 Weather Information

FlyteTrax can also display weather information (see Figure 6). This weather information consists of a national radar mosaic with 1 kilometer resolution and 48 colors. The 48 colors represent 16 colors of liquid precipitation or rain, 16 colors of mixed precipitation, and 16 colors of solid precipitation (snow or ice). The radar mosaic is updated every 15 minutes, beginning 5 minutes past the hour. The satellite cloud cover imagery is also provided. This image is 1 kilometer by 1 kilometer in resolution and is updated hourly. The image is received on the half hour for the current hour. The half hour delay in receiving the image is due to the processing time necessary by the data provider, Data Translation Network (DTN).

3.3 Map Projections

FlyteTrax offers two different map projections, the Lambert Conformal conic projection, and Mercator projection. Both projections are conformal meaning that lines of constant direction are shown as straight lines (over small areas). This is an important characteristic for flight mapping. The Lambert Conformal conic projection was used for the animations because it corresponds more to the depiction that most people have of the United States and Canada.

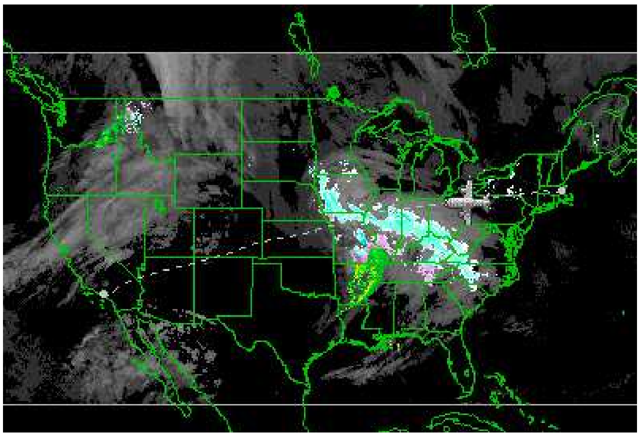


Fig.6: FlyteTrax display with weather information. The central part of the US is experiencing snow and rain conditions. The flight depicted from Boston to Los Angeles will fly over the storm.

Unfortunately, flights do not follow of line of constant direction. The shortest distance between two points is the great circle, which would be depicted as a curved line on a conformal projection. Some of the flight mapping programs overlay a straight line between the two locations. Because of the great circle routing, an aircraft flying long distances would not be on this line for most of the flight (see the FlightExplorer maps in Figure 2 and 8). The problem with this representation is that people could easily be misled into thinking that a particular flight they are following has a problem because it is off-course.

3.4 Time and Time Zones

All times used in FlyteTrax 2002 can be displayed in either Universal Coordinated Time (Zulu time) or local time (12 hour AM/PM) based on your geographic location). The current time is depicted in the lower-right corner of the screen.

3.5 Commercial and General Aviation Flights

FlyteTrax 2002 displays commercial or general aviation flights, or both together. Commercial flights are all scheduled airline flights and any other aircraft operator who has a designated FAA three-letter operator code. With an operator code, the aircraft operator files his flight plan using his operator code and a 2 through 4-digit trip number that he assigns to the flight. GA (general aviation) flights are those flights that fly using their aircraft registration number rather than an operator code. These aircraft are primarily private or company owned aircraft not operating for hire. In some instances, these aircraft owners have requested that their registration number be blocked so that they cannot be identified. In those instances, the data tag with the aircraft will show a call sign of "GA" instead of the registration number. When fights are displayed on a background in excess of 1000 miles across the screen, the flights will appear as dots. As you zoom-in to less than 1000 miles across the screen, the flights will become small aircraft icons. Each icon will be headed within 20 degrees of the direction the aircraft is flying.

3.6 Data Tags and Filtering

Data tags can be displayed for individual aircraft. The display includes the flight number, the aircraft, the departure time, the arrival time, the remaining flight time, the altitude and the speed of the aircraft. This feature has been disabled for most of the animations.

Flights may be filtered in one of a variety of ways using the filter dialog. For example, to display all United Airlines Boeing 767 aircraft flying between 30,000 and 40,000 feet that departed Chicago and are arriving in Los Angeles, the following is done: A. In the Depart field ORD is selected from the scroll down list; B. In the Arrive field LAX is selected; C. In the Operator Code field UAL is selected for United Airlines; D. In the Aircraft Type field B767 is selected for Boeing 767 aircraft; E. In the Minimum Altitude field "300" is entered; and F. "400" is entered in the Maximum Altitude field. Multiple filters can be created by simply clicking on the Add New button to display a new filter input dialog box.

When selecting either arrivals or departures, flights are randomly colored by airline. This means that the color assigned to each airline will change between the different views.

4 Animating Flight Traffic

The animated maps presented here were used to determine the amount of air traffic. They depict flight traffic over North America and the north Atlantic corridor. All animations were collected on weekdays, unless otherwise indicated, during the period of March to September of 2003 using FlyteTrax 2002. The program allows the "filtering" of flights based on the aircraft type, elevation, airline, and the departure or arrival airport. The actual locations of the aircraft is accurate to within five minutes.

A single animation displays flights for a 24-hour period. A separate program was used to capture the FlyteTrax display every minute. This resulted in 1440 frames (60 minutes x 24 hours). The animations were created in Adobe Premiere and saved as ".avi" files encoded with the Divx codec.

A single frame of the animation for Minneapolis/St. Paul (MSP) is shown in Figure 7. One of the airplane symbols over Canada is hollow indicating that a radar position report for this airplane has not been received for at least seven minutes. The graphical user interface for FlyteTrax is shown in the upper-left. Airplane symbols are assigned a random color to indicate the different airline. The Minneapolis/St. Paul airport is a hub for Northwest Airlines and one can see that is airline has been assigned a greyish-green color. The current number of departures and arrivals is shown in the lower-right, along with the current time. The time is always provided for the Central Time Zone.

Each animation was output at three different speeds. One animation, designated as "SLOW," shows the 24-hour day in 1 minute and 40 seconds, corresponding with an effective time-lapse ratio of 1:867.5 (867.5 seconds are shown in 1 second). The "NORMAL" animation depicts the 24 hour period in 1 minute and 12 seconds for a ratio of 1:1,200. A third "FAST" animation shows the 24 hour day in 30 seconds for a time lapse ratio of 1:2,880. The animations effectively convey the amount and pattern of air traffic.

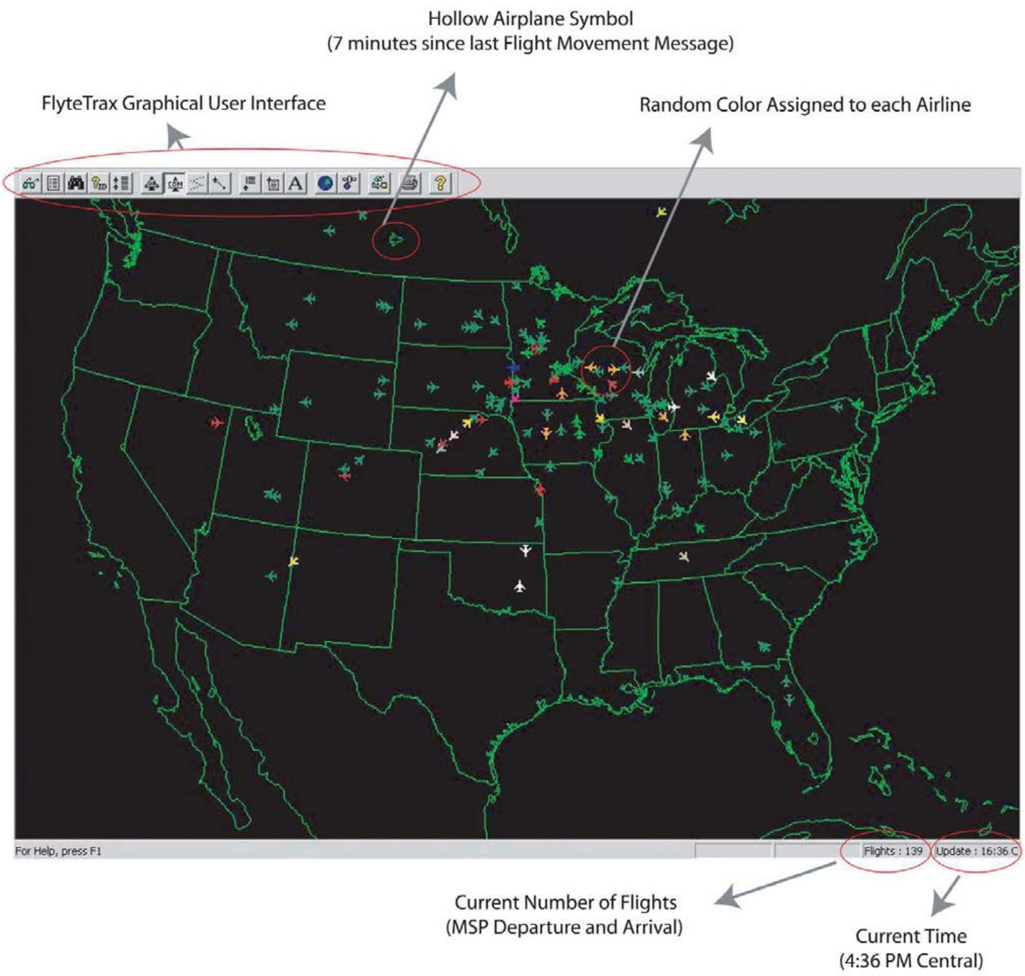


Fig.7. A single frame from the FlyteTrax program showing arrivals and departures for the Minneapolis/St. Paul airport. The program updates the positions of all IFR flights once a minute based on 4-minute FAA position reports.

5 PDA Display

A cell-phone or cell-phone enabled PDA could easily be used to display information about the current position of a flight. This information could be presented in both map and table form. For example, the FlightExplorer display shown in Figure 8 would easily fit on a current 640x480 PDA display. The web page presentation would have to be altered slightly to make the maps and table available on the smaller screen size of a PDA. More modifications would be necessary for even high-end cell phones that may display only 208 x 320 pixels (the $600 Sony Ericsson P800).

The three main flight tracking companies were contacted to determine if they were planning to introduce a cell-phone or cell-phone enabled PDA application. According to the company spokesperson, Lorraine Gaglione, there are no plans to release a PDA-enabled version of their product (Gaglione, 2003). James Bunker of FlyteComm reports that they have a “product running internally” but it “hasn’t made it to production yet.” He goes on to report that: “We just haven't seen enough market demand for this type of application yet. Hopefully in the near future that will change” (Bunker, 2003)

6 Conclusion

Data on the positions of all flights over the United States and Canada has been available to the airline industry since 1991. Since the last 1990s, this data has also been available to companies and private individuals. It is used by a variety of companies to monitor the location of flights. A major application is the tracking of flights by individuals. Three companies make such displays available through the Web.

Fig.8. Dimensions in pixels of the flight status map and table from FlightExplorer.com. Both would fit within a 640 x 480 PDA display but would be too big for current cell phone displays.

There are a large number of flights over North America, peaking at just above 5000 around 11AM US Central time. These flights can be displayed in a number of ways, including departure or arrival airports, airline, aircraft, elevation, speed, and flight number. The animation of these flights helps to examine flight frequency and air traffic patterns.

Currently, there are no commercial flight tracking applications for cell-phones or PDAs, although FlyteComm, Inc., has developed a prototype system for use in-house. Certainly, a great deal of time is wasted by individuals because they don't know exactly when a flight is departing or arriving. A cell phone application would serve the needs of many people who need to know this type of information.

In practical terms, the best method to deliver flight information is to use a small map along with information presented in table form. Current implementations through the Web use a small GIF or JPEG file. The map could be transmitted more quickly using the new SVG mobile format (W3C, 2003).

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Obstacle-free mapping services

Gábor CSEMEZ, Tamás PRAJCZER and László ZENTAI, Budapest

Abstract

The objective of the service is to provide information for handicapped people depending on their location with the help of available information-Communication technologies.

1 Introduction

One of the basic rights from the aspect of giving disabled people equal opportunities in society is the right to the built environment free of obstacles, which is also recognizable and safe. An environment is free of obstacles, when people suffering from different handicaps can move in it freely, easily and safely on their own. This environment may be a building, a part of the town or even the whole city.

The basic guidelines for obstacle-free environments:

- place for horizontal traffic,
- adequate entrances (width, height, enough room for opening and closing),
- utilities helping vertical traffic (elevators, ramps),
- enough room for adequate use,
- easy handling.

Under the word „obstacle", we mean a series of tools, objects and things in general that are out of reach of a person using a wheelchair because of differences in elevation, lack of room or too narrow passages (push buttons in elevators, door knobs, etc.).

You do not see people in wheelchairs in the streets of Hungary. When going abroad, we are surprised to see how many handicapped people are on the streets, a lot more than in our country. Of course, we have as many disabled people as they do, the difference is in the fact that in Hungary, because of the obstacles in the environment, handicapped people are forced to stay home and live a hidden life in contrast to people who live in better places from that aspect, where they can lead a changed but still close to normal life.

2 Location Based Services for Handicapped People

Handicapped and blind people are especially location-sensitive, so the spatial and location-based information are very important for them. The LBS (Location Based Services) can help handicapped people to map unknown areas from point of view of accessibility and it looks after them by monitoring their movement alarming the emergency services in case of troubles. So Dorucher's "Three Laws of LBS" is more important in case of handicapped people than in case of others.

1st law: location, through its availability or non-availability, must not allow a human being to come to harm.
2nd law: the availability of one's location must be in one's complete control, except where such control would conflict with the First Law.
3rd law: the providers of location-based services must be allowed to create a profitable business from these services as long as such business does not conflict with the First or Second Law.

3 Act on Ensuring Equal Opportunities and the Rights of Handicapped People

„The already existing administrative buildings have to be made obstacle-free gradually, but until the 1st January 2005 the latest."[1]
„The ministries have to examine and propose solutions in order to render public administration services within reach for the sake of disabled people, from both a communication and from an architectural point of view."[2]

[1] Act XXVI. Of 1998 on insuring equal opportunities and the rights of handicapped people.
[2] 1057/2001. (VI. 21.) Governmental decree on the development of public administration in 2001–2002.

This right is acknowledged, the legal background was established in Hungary, but the achievement of the obstacle free environment has not yet finished.

4 Obstacle Free Mapping Services

4.1 Aim of the Project

Handicapped people do not simply want to map unknown areas, but they want to know if a service can be found in their proximity or not. The objectives of AMT services are

- to map unknown areas (to show the "quality" of streets),
- to find the nearest, reachable place, where they can manage their business,
- to track them from one place to another.

The AMT service is an information platform that is accessible free of charge for all of those who are concerned. The database behind the maps and services are continuously developing – controlled by those who are involved – by the handicapped people (as well) or their friends and the ones who enter and update the information.

4.2 Maps

The obstacle free maps are available for Budapest, the department capitals (Békéscsaba, Győr, Debrecen, Eger, Kaposvár, Kecskemét, Miskolc, Nyíregyháza, Pécs, Salgótarján, Szeged, Székesfehérvár, Szekszárd, Szolnok, Szombathely, Tatabánya, Veszprém, Zalaegerszeg), as well as for Hévíz, Keszthely, Nagykanizsa, Sopron és Tokaj. The maps indicate as follows:

- the obstacle free sidewalks ,
- the sidewalks temporarily obstructed (e.g. by construction works, parking vehicles),
- the usable or useless roads in the lack of sidewalks
- not usable sidewalks (bad surface),
- elevated street sections or hills,
- built crossing places,
- usable, but not built crossing possibilities (car exits).

In case of other settlements only the border of the built-up areas and main roads are displayed from the ArcHungary database.

4.3 Services

The AMT services can be accessed by anyone having an Internet connection or a mobile phone that can receive and send SMS.

4.3.1 Service via Internet[3]

On the Web, the user gives the address of the surroundings about which he would like to now if the streets and roads are obstacle free, or where he wishes to find some services.
The functionality available via internet is the following:

- to find an address and to map its surroundings,
- to find a service near a certain place/address,
- to send information about new service or changes of the street quality.

4.3.2 Mapping Unknown Areas

As a result of the address finding the surroundings of the address with thematic attributes will be displayed in case of the above mentioned 24 settlements. For the other settlements only a overview map is provided (Fig.1).

4.3.3 Finding Services

Another task of the service is to find obstacle free objects near a given location (Fig,2). The objects can be divided into three main groups:

- commercial units (banks, hotels, supermarkets, etc..)
- units of the local public administration,
- units of the regional (county or lower level) public administration.

[3] The ASMAP map server provides GIS functions: map display, pan, zoom in/out. The ASPMAP is a product of the VDSTECH (www.vdstech.com).

The inventory of status of the buildings was based on the owners' own declaration[4]. Only the commercial units with nation wide network have been surveyed.

4.3.4 Adding New Objects to the AMT Services

The users of the ATM services can add new objects to database or modify the attributes the existing ones.

4.3.5 Services via mobile phone

For the mobile phone owners the search for the near accessible objects is proposed. The user gives the type of the searched object (restaurant, bank or pharmacy) and its own position. The user may give in sms:

- a precise address,
- a settlement, or a district within the city limits of Budapest.

If the user has a mobile phone with GPS, it is not necessary to give its position, the central system automatically requests it.
The user will receive the following objects which are:

- in the searched type (restaurant, bank or pharmacy. etc.)
- the closest to him,
- accessible for handicapped people as well.

4.4 Tracking

Following the registration the member of the tracking group can send an sms to the central system to ask its position regularly, save it and upload it into a website. The member's track appears on the website like a public or a private track. At the moment of the registration the member can decide about the status of the track (private or public). People familiar with the user can monitor his/her movement, if he/she initiates the tracking service and publishes it on the public site (Fig.3).
Besides the continuous tracking the member of the system can be positioned occasionally. The user – who has got right from the member to track him/her – can initiate a positioning of the member via mobile phone from internet, desktop mapping application or simply from the GPS by sms (Fig.4).

4.5 Hardware

The ATM services require only common mobile phones, but if we want to use the advantages of GPS a special equipment is need in addition to the GPS (Fig.5).

5 Acknowledgements

The obstacle free mapping services are realized in the framework of the project entitled: „The amelioration of life of people living with handicaps, their integration into the information society with adequate rehabilitation" with the R&D support for 2001 (reg.Num. 1/028).

[4] All local government (3145) and public administration organization (cca. 2000) has received a questionnaire about the accessibility of their units/buildings.

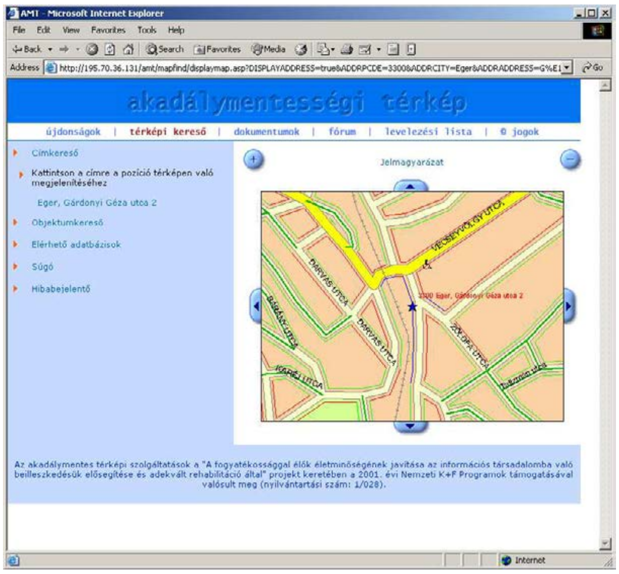

Fig.1:Address and its surrounding with attribute data

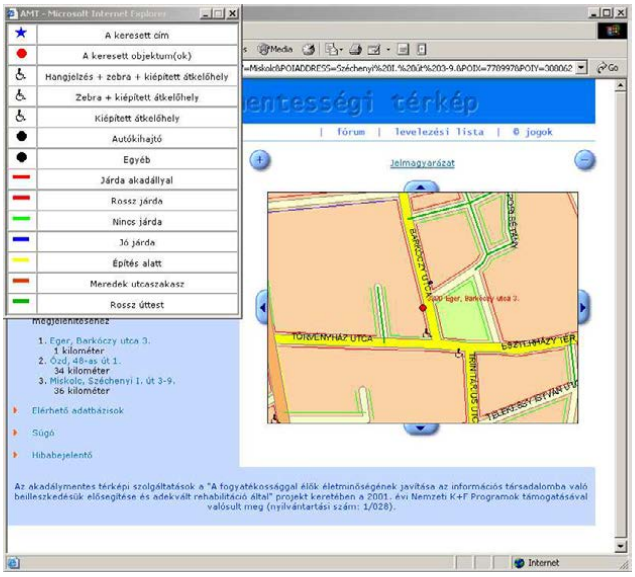

Fig. 2:Address and its surrounding with attribute data

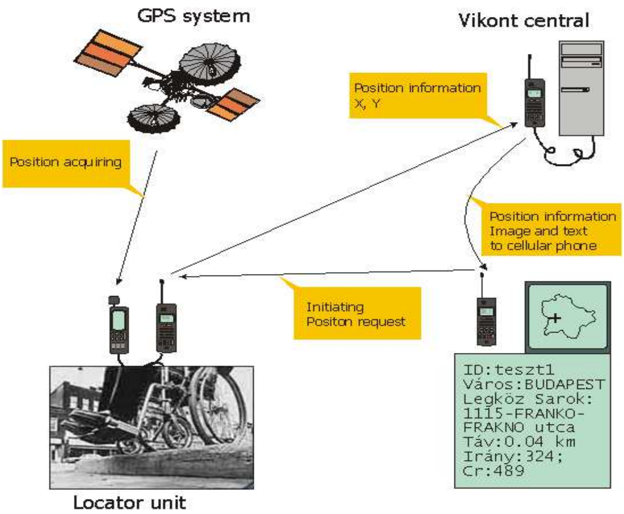

Fig.3: Positioning from GSM via sms

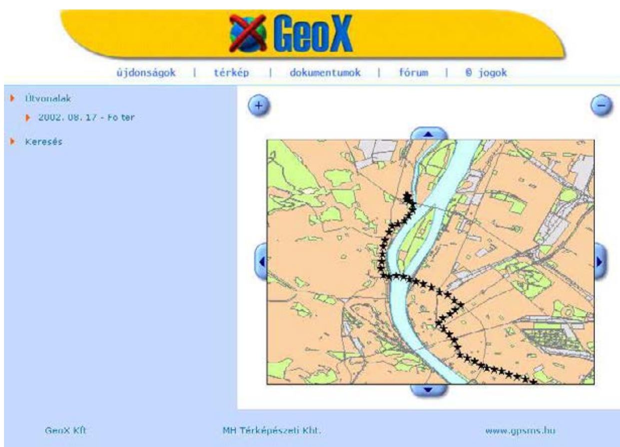

Fig.4: TRACMAP's webpage

Fig.4: Mobile phone, GPS and controller units

RIMapper
A test bed for online Risk Indicator Maps using data-driven SVG visualisation

Barend Köbben, Enschede

Abstract

This paper presents results of a test bed application called *RIMapper*, that was used to look into the possibilities of generating Risk Indicator Maps (RIMs) from online databases, using Java server technology (JSP) to generate light-weight, versatile maps in the Scalable Vector Graphics (SVG) format. These maps are to be part of an urban risk management system, and therefore need to fit a multitude of use cases, ranging from providing the general public with information about risks to providing local authorities an interface to the underlying risk assessment databases and models. Furthermore, the maps need to be usable on a wide range of platforms, from the office systems of the local authorities to hand-held devices providing location based services to field personnel. This paper will present results of the second phase of this test bed project, in which the central issue was the online generation of the RIMs by a web application from a spatial database back end, implemented using Open Source standards and software: OpenGIS Simple Features stored in mySQL Spatial Extension, extracted by a JSP Tomcat server application and delivered in SVG format to web clients.

1 Introduction - the SLARIM project

The test bed this paper discusses is part of an internal research project at the International Institute for Geo-information Science and Earth Observation (ITC), called "Strengthening Local Authorities in Risk Management" (SLARIM). The objective of this project is the development of a methodology for the implementation of risk assessment and spatial decision support systems for risk management by local authorities in flood and earthquake threatened urban areas in developing countries [1]. Risk information, presented spatially, is needed by local authorities to take decisions on how to reduce the risk for particular areas, either by reducing the hazard probability (eg. structural measures like dikes) or by reducing the vulnerability (eg. restrictive zoning, building codes). Risk information also forms the basis for a proper emergency response planning. The project focuses on the two types of natural hazards that cause most damage in urban areas: flooding and earthquakes. The methodology will be developed in a number of case study cities in different countries. The case study cities are at the moment: Kathmandu (Nepal), with a focus on earthquake and flood risks, Naga City (Philippines) for floods and Dehra Dun (India) for earthquakes.

The project is structured as a series of work packages, dealing with analysis of the institutional setting; user needs assessment, evaluation of the spatial data infrastructure, hazard assessment, and generation of databases of elements at risk, vulnerability assessment and risk assessment. One of these work packages deals with the spatial data infrastructure and base data aspects of a flood/seismic risk assessment system, directed towards the needs of medium sized local authorities in developing countries. The activities within this work package include the development of a methodology to handle interoperability aspects. Distributed processing, interoperability research and the impact of the OpenGIS specification will play an important part in this activity. The author of this paper is responsible for "recommendations concerning the methods for the online mapping and presentation of risk indicators".

For this work, visualisation will be considered as part of a system of interoperable web services. The reason for this is that such a system could support online, distributed data from various local authorities, and it can be scalable (ranging from in-office planning to rapid response in the field) and time-aware (supporting comparisons, real-time views and extrapolation into future scenarios). All these requirements, plus the intention to comply to open standards and use open source, have led to the decision to use XML-based solutions in this work package, and thus GML for spatial data exchange and SVG for visualisation.

2 The RIMapper test bed - a lightweight GDI?

It was decided to try out the concepts developed in the work package in a test bed application. The implementation of this test bed has been started in March 2003. This first phase concentrated on the cartographic design of maps that visualise real and perceived risks and some preliminary tests to realise these in SVG format suited for multiple platforms. The results of this first phase were presented in July 2003 at the 2nd Annual Conference on Scalable Vector Graphics [2], and the output can be seen at the RIMapper website [3].

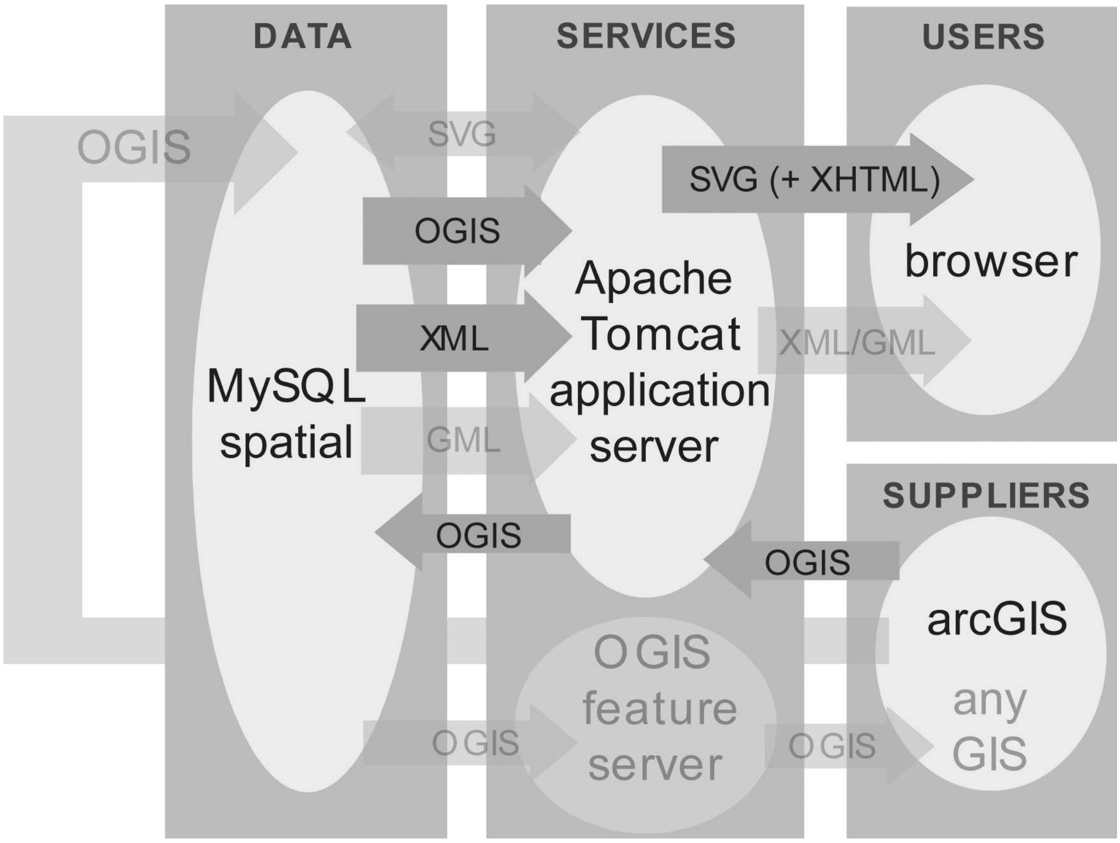

Fig.1: Conceptual set-up of RIMapper test bed.
Faded elements are not part of the current implementation;
OGIS stands for OpenGIS Simple Features.

This paper presents results of the second phase, in which the central issue was the online generation of the RIMs by a web application from a spatial database back end. This focus can be seen outlined in the conceptual set-up for the overall test bed in figure 1. The main building blocks of this system are:

- A spatial database back end that stores the geometry and the attribute data; For this part both PostGIS (a spatial data extension to PostgreSQL) and mySQL were under consideration, finally the choice has been made to use mySQL. From the onset it was envisaged that spatial data should be stored using the OpenGIS (OGIS) Simple Features specifications.
- A (set of) web application(s) that extract data from the database and delivers it in SVG for visualisation purposes and other XML formats (such as GML) for data exchange. In first instance this will be done real-time, although it is foreseen that performance issues might require various types of pre-processing in a later stage. These are developed using the open source Java server technology.
- A web-based user interface enabling access to the maps and data for both desktop browsers as well as mobile platforms (PDA's). The original data providers initially will have data access through this same web-based interface. In a later stage however, they should also have more sophisticated clients, for example by providing the data through an OpenGIS Web Feature Server to GIS clients.

Using the setup described, the RIMapper test bed would provide the local authorities that the SLARIM project addresses with a relatively simple, low-cost, yet powerful way of sharing data amongst various distributed offices and institutions as well as the general public. As such, the system could be considered the technological heart of a lightweight Geospatial Data Infrastructure (or GDI). The term GDI might be more usually connected with (very) large regional or national spatial data warehouses, but it is defined more generally (in [4]) as "the networked geospatial databases and data handling facilities, the complex of institutional, organizational, technological, human and economic resources (…) facilitating the sharing, access to, and responsible use of geospatial data at an affordable cost for a specific application domain or enterprise". For the test bed to rightfully earn the title "light-weight GDI", the most obvious addition needed would be a clearing house component [4, ch.9.5]. Although this is not being pursued in the

current test bed, such a component could be part of the larger SLARIM project, and would be relatively simple to add, using existing standards and software solutions (see for instance [4], [5] and [6]).
In the following paragraphs, the components of the test bed application will be described. The emphasis will be on the on the technological solutions chosen and the reasons for these choices. As this is very much a work in progress, there is as of yet not much insight into the effectiveness and performance of the system and there is no "real user" experience at all. These questions will have to be addressed at a later stage in the project.

3 Database backend - mySQL spatial extension

If one needs a database to serve as the backend of a geospatial service such as RIMapper, the most obvious choice is a so-called *spatially enabled* database, that has special data types, column types, functions and operators to deal with geometries. Such *spatial extensions* or *spatial cartridges* as they are sometimes called, provide access to the geometry through a standardised interface (SQL). Other solutions are possible, such as storing the data in arbitrary binary objects (BLOBs) and providing the geometry "intelligence" in the application tier instead of in the database itself. But such solutions are non-standardised and often proprietary. As the RIMapper project set out to comply to open standards, there was the need to use a database that supported the OpenGIS Consortium (OGC) standards. The OGC is a member-driven, non-profit international trade association that is leading the development of geoprocessing interoperability computing standards [7]. Among (many) other things, the OGC has set the Simple Features SQL Specification that provides for publishing, storage, access, and simple operations on Simple Features (point, line, polygon, multi-point, etcetera) through an SQL interface.

There are several databases with OGC-compliant spatial extensions, of which *Oracle* is probably the most prominent, but as another goal was to use open source software, only two databases were under consideration: *Postgre*SQL is a database system with *Post*GIS as an extension, that supports OGC spatial geometry, spatial queries and simple analysis [8]. It is available for many platforms, however currently not in a native Windows version. The *my*SQL database server is available for free under the GNU General Public License (besides being sold under a commercial license) for all major platforms including Windows. MySQL claims to be the most popular open source database server in the world [9]. The most recent version (4.1.0) includes OGC-compliant spatial extensions, but it is currently in the alpha stage, thus not a fully reliable production release.

Both do not adhere to the full set of OGC specifications, the most obvious being the lack of Spatial Reference Identifiers (SRID) support in mySQL. Its geometry tables do, however, already include an SRID field, making it easy to prepare for the projection support in a later version. The reasons for the choice of mySQL for the RIMapper project were the native Windows support and the simple "lightweight" character of the software as compared to the complicated though more fully-featured PostgreSQL. Furthermore, as far as we know, at the time of writing there is no publicly available work using mySQL as a database backend for (SVG) mapping, whereas this is the case for PostGIS (eg. using Perl, as described in [10]). By adhering strictly to the OGC standards it should be straightforward anyway to change or even mix database platforms in the future.

The database setup of the current RIMapper system, as realised in mySQL, can be seen in figure 2. The "features" table is the central place where all geometric objects available to the application are stored. Initially and most importantly, the features are stored

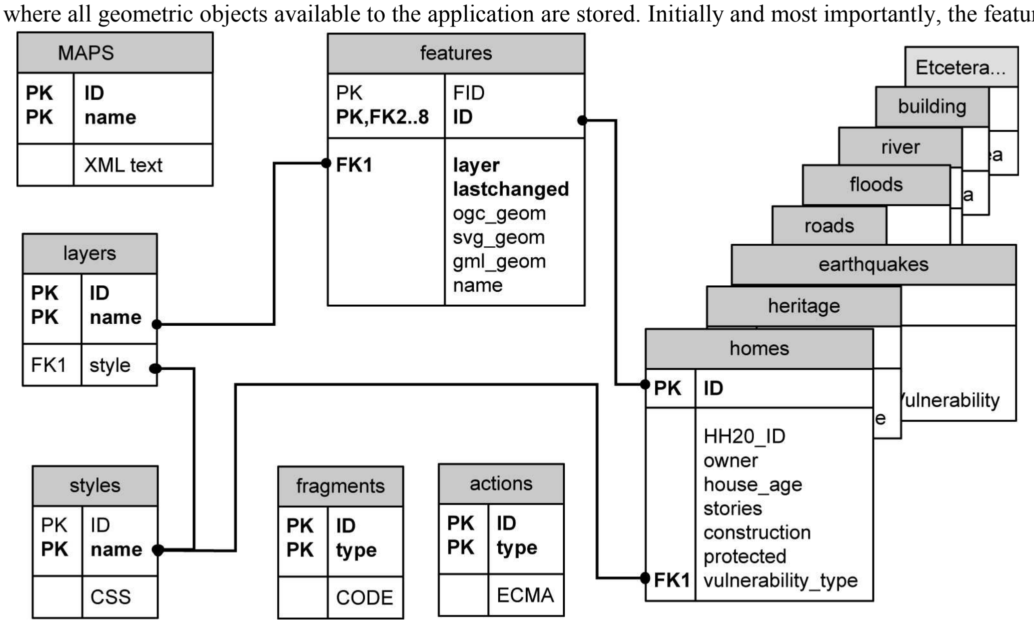

Fig.2: Setup of a the current RIMapper database
(dot-terminated lines indicate relations specified in the database)

as OGC Simple Features geometry and transformed to other formats at run-time, when needed by the application tier. At a later stage, for performance reasons a strategy might be adopted with various types of pre-processing, where for instance database triggers make sure SVG and GML expressions of the geometry are (re)calculated whenever a change in the OGC geometry takes place.

The non-spatial attributes of the features are stored per category (or layer) in specific tables (“homes”, “roads”, etcetera), related with the “features” table through their ID. A “layers” table is provided as a per layer link to the “styles” table, for layers that should be styled uniformly (eg. all roads sharing the same visualisation). Whenever the visualisation should depend on some data attribute per feature (eg. for a chorochromatic map of homes viewed by vulnerability type), the link is made from the data specific attribute table directly to the “styles” table. The choice for the visualisation type mentioned above is directed by the XML map description file (stored in the table “MAPS”), that is processed by the application tier (see next paragraph). A further two tables, “fragments” and “actions” are also for use by the application tier, storing SVG code fragments and ECMAscript event listeners, respectively.

4 Services - Tomcat Java application server

The heart of the RIMapper system are the services provided by a set of Java Servlets and Java Server Pages. In our case, the application tier runs on Tomcat, a well-known open source servlet container from the Apache Software Foundation [11], but the applications should run on any standards-compliant servlet container.

As described earlier and seen in figure 1, the functionality at the moment is focussed on providing end users with RIMs in the form of SVG-formatted files. Providing SVG files from a Java Server Page is very straightforward: One basically takes the desired SVG output and adds little bits of Java code to it to provide data-driven visualisations. Take for example the SVG fragment:

```
00  <circle id=”12” cx=”100” cy=”100” r=”
01  <%if (someData == true) {%>
02     10
03  <%} else {%>
04     20
05  <% } %>
06  ” />
```

The bits between the `<% %>` tags will be processed by the Tomcat engine before being delivered to the client and therefore this will result in line 02 being in the output if some data value (eg. coming from a database) is true, and line 04 if false, resulting in a circle with either radius 10 or 20. This approach is fine if one aims at delivering maps that are largely similar for all cases and clients, and only have small differences in visualisation. For our purposes it is, however, not generic nor flexible enough, more so because it is foreseen that in time the applications should also enable output in other formats.

The RIMapper system therefore uses a set of much more generic Java classes to do recurring tasks like extracting OGC features and attribute data from the database, translating these into fragments of SVG and ECMAscript, collecting and structuring these fragments into valid output and delivering this output to the clients.

The glue provided to make all these parts act together are the XML *map definitions*. These are basically XML-formatted text files, but like all data for the system they are stored in database tables. They are parsed to get a description of the map needed and all its component parts. Take for example the XML map description below:

```
<?xml version="1.0" encoding="iso-8859-1"?>
<RIM ID=”999” TYPE=”SVG_STANDALONE” DB=”RIMapper_DB” UN=”user” PW=”pass”>
 <TITLE>A Risk Indicator Map</TITLE>
 <AUTHOR>Somebody</AUTHOR>
 <HEADER>
   <FRAGMENT ID=”001” NAME=”standardRoot” TYPE=”SVG_ROOT” />
   <FRAGMENT ID=”143” NAME=”opacityGradient” TYPE=”SVG_GRADIENT” />
   <FRAGMENT ID=”14” NAME=”roadMarker” TYPE=”SVG_MARKER” />
   <FRAGMENT ID=”56” NAME=”citySymbol” TYPE=”SVG_SYMBOL” />
   <FRAGMENT ID=”33” NAME=”dropShadow” TYPE=”SVG_FILTER” />
   <STYLES>
     <STYLE ID=”100” NAME=”defaultText” TYPE=”CSS” />
     <STYLE ID=”101” NAME=”defaultPoint” TYPE=”CSS” />
     <STYLE ID=”102” NAME= defaultLine” TYPE=”CSS” />
     <STYLE ID=”103” NAME=”defaultArea” TYPE=”CSS” />
   </STYLES>
   <FRAGMENT ID=”534” NAME=”” TYPE=”ECMASCRIPT” />
 </HEADER>
 <BODY>
   <LAYER ID=”1098” NAME=”floods” TYPE=”single” PARAMS=”none”>
     <ACTION ID=”12” NAME=”changeSymbol” TYPE=”feature” EVENT=”onmouseover”
   PARAMS=”flood_type” />
```

```
21   </LAYER>
22   <LAYER ID="354" NAME="houses" TYPE="chorochromatic" PARAMS="vulnerability_type" >
23     <ACTION ID="12" NAME="showLayer" TYPE="layer" EVENT="onclick" PARAMS="null" />
24   </LAYER>
25  </BODY>
26  <FOOTER>
27   <FRAGMENT ID="002" TYPE="SVG_FOOTER" />
28  </FOOTER>
29 </RIM>
```

Line 01 indicates the connection parameters for the database and the type of RIM output that will be generated. For this phase of the test bed, the only types supported will be "SVG_STANDALONE" and "SVG_EMBEDDED".

The former will result in an SVG map with all style information, scripting and data incorporated in the one file. The SVG generated will adhere to the SVG-Basic profile and this type of map will be suited for the broadest range of clients, including PDA's. The user interface is limited to standard SVG viewer capabilities such as zooming, panning and querying data by clicking or moving the pointer to mapped elements.

With the latter type, the result will be an XHTML file in which one or more SVG's, formatted according to the SVG-Full profile, are embedded. Although this limits the possible user platforms (see next paragraph), it offers a fully-featured user interface with additional possibilities, such as downloading geometry and attribute data, queries by data attributes or layer, printing, and brushing through time-series. The SVG_EMBEDDED type is still under development at the time of writing.

In the HEADER section several fragments of SVG code are loaded to define gradients, symbols, markers and filters. It is important to point out that the XML definition is not something that is necessarily processed by the RIMapper applications line-by-line in this order. This is for example important for the first fragment (line 05), that defines the SVG_ROOT, ie. the ECMAscript to add event listeners to the DOM tree, and the size and the viewbox of the map. For this last item, the system needs to know the spatial extent of the data, and thus it will be defined only after processing all geometric information in the layers. The same is true for the styles item, because the list of CSS styles to be loaded from the database as seen here will be expanded with further styles needed, as found in the layer definitions.

The last part, the FOOTER section, simply declares the closing part of the output.

In between is the BODY section that lists the actual layers of information to be mapped. Per layer the NAME is used to retrieve the attributes from the table with that same name and the geometry from the "features" table. The TYPE indicates how the layer should be visualised. With some types, such as "single" in line 19, one style will be used to visualise all features in this layer in the same way, and the link to that style will come from the "layers" tables in the database. With others, such as "chorochromatic" in line 22, the style needed will be determined based on the value found in the database attribute stated in PARAMS. Layers can have one or more ACTIONS that define the interactivity. Here the TYPE determines if the action uses the same parameters for the whole layer (type "layer" in line 23), which will result in an ECMAscript eventlistener being attached to the enclosing SVG group, or if it needs different parameters (PARAMS) per feature depending on some attribute (eg. the "flood_type" attribute in line 20). The latter will result in an eventlistener being attached to all features in the layer separately. Lastly, the EVENT item determines which event will trigger the action.

Several strategies were considered to extract the OpenGIS geometry from the "features" table. One possible solution, chosen for example in [10], is to make use of the Well-Know Text (WKT) expression of the geometry. This WKT is designed as the OpenGIS standardised way to exchange geometry data in ASCII form. After issuing an SQL SELECT followed by the appropriate conversion function to retrieve the geometry of the feature as WKT, one can then parse the resulting (usually very long) string to extract the geometry type, the component points, lines and polygons and their co-ordinates. This method is very straightforward, but the resulting code can be very confusing and the parse process has to be different for every geometry type.

For RIMapper, a more database-centric and transparent method was chosen, making full use of the spatially enabled SQL functions and without using the WKT format. As can be seen in the pseudo-code below, a first query is done to find out the geometry type of the features (= the table rows) for a particular layer, and the number of geometries in the feature. This last item is needed because many OGC geometry types are complex, such as the MULTILINESTRING geometry that is a collection of LINESTRINGs. For every geometry type the feature is further dissected into its component parts by nested loops of SQL queries. In the code shown this is worked out for the MULTILINESTRING case only, where one can see that for every geometry found, a second query finds the number of points in that geometry and for all these points the X and Y co-ordinates are found by a third loop of queries. The part in line 13 that stores the feature data is done by another Java class, dependant on the type of output needed.

```
00 SQL Query 1 = SELECT FID, ID, GeometryType(ogc_geom), numGeometries(ogc_geom),
   FROM FEATURES WHERE layer=[LAYERNAME];
```

```
01 while RecsFound {
02    if OGC_geometry Type = POINT {
03      […deal with POINT…] }
```

```
    else if OGC_geometry Type = MULTIPOINT {
      […deal with MULTIPOINT…] }
    else if OGC_geometry Type = LINESTRING {
      […deal with LINESTRING…] }
    else if OGC_geometry Type = MULTILINESTRING {
      for (j=1; j<= numGeometries; j++) { //loop through NumGeoms
         SQL Query 2 = SELECT NumPoints(GeometryN(ogc_geom,[j]))
         FROM features WHERE FID=[FID];
         for (i=1; i<=NumPoints; i++) { //loop through NumPoints in this Geometry
            SQL Query 3 = X(PointN(GeometryN(ogc_geom,[j]),[i])),
            Y(PointN(GeometryN(ogc_geom,[j]),[i])) FROM features WHERE FID=[FID];
            […store X and Y coordinates and other data for the Feature…]
            } } }
    else if OGC_geometry Type = POLYGON {
      […deal with POLYGON…] }
    else if OGC_geometry Type = MULTIPOLYGON {
      […deal with MULTIPOLYGON …] }
    else {
      [Unknown Geometrytype: Error] }
}
```

This setup provides a very flexible and standardised way to extract the geometry, but compared with the WKT-parsing method it uses many more database queries. Because mySQL is known to be one of the fastest database engines, and the current test data set is not very big (roughly 2000 features, ranging from single points to multipolygons with hundreds of points), the currently the system performs satisfactory, but it's clear that serious performance tests should be conducted at a later stage.

When all data needed has been collected by the system, the output is composed and handed over to the web server (that role is also played by Tomcat) for delivering to the client.

5 Clients - SVG enabled web browsers and PDA's

As the output maps are to be part of an urban risk management system, they need to fit a multitude of use cases, ranging from providing the general public with information about risks, to providing local authorities an interface to the underlying risk assessment databases and models. Furthermore, the maps need to be usable on a wide range of platforms, from the office systems of the local authorities to hand-held devices providing location based services to field personnel.

As explained earlier, in the XML map definition the type of RIM will determine if the map is to be a standalone SVG file or embedded in an XHTML page. The reasons for this lies in the current viewer situation: only standalone files, with all their styling and scripting incorporated locally, can be constructed in such a way that they'll function in almost all SVG viewers in a similar fashion. For these standalone files, the choice was also made to use not the full SVG feature set, but the SVG-basic profile. They will therefore also run in more lightweight viewers, such as the BitFlash mobile viewer, shown in figure 3 in its WindowsXP incarnation but also available for PDA's running on WindowsCE, Symbian and some other mobile platform operating systems.

Fig. 3 (above): Example of a RIM dynamic risk symbol showing the modelled risks (blue for floods, red for earthquakes) at the current pointer location.

The SVG_EMBEDDED type under development will have to allow for the different ways that browsers have implemented plug-in embedding and more importantly the inter-document communication to allow scripts to work across XHTML and SVG. It is therefore foreseen that various versions for specific combinations will be needed, eg. for Internet Explorer + Adobe SVG viewer or for Mozilla Firebird + Corel SVG viewer.

The actual cartographic design and user interfaces are not part of the RIMapper test bed described in this paper. It is however an important part of the SLARIM project as the work package "Visualization and Use of Risk Indicator Maps". This work package aims at making recommendations concerning the methods for the online mapping and presentation of risk indicators suitable for the use in assessment procedures by the public, commercial and government agency planning activities. It encompasses among other things the analysis of geospatial risk data coming from other work packages and research into the cartographic grammar for visualisation of real and perceived risks.

6 Data suppliers - shp2mysql loader

At the time of writing, there has been only limited attention given to the 'suppliers' part (as seen in figure 1) of the test bed. The focus has been on providing a way to easily and quickly get useful test data into the database. Most of the data used in the

SLARIM project is either available directly in the ESRI ArcGIS environment or can be imported into it easily, and can therefore be made available in the much-used shapefile format. It was therefore decided to take the existing “shp2postsql” shapefile loader by Jeff Lounsbury, available on the PostGIS site [8] (based in turn on the ShapeLib library by Frank Warmerdam) and rewrite the C code to provide a shapefile loader for mySQL. The resulting “shp2mysql” program was then used successfully to transfer the test data for the case study city of Kathmandu (Nepal) into a text file of SQL CREATE and INSERT queries which can be run in the mySQL command line interface. The next step will be to port the code to Java and include it in the project as a Tomcat web service to provide a more robust, better integrated and user-friendly way of inputting data for the “supplier” users of the RIMapper system.

7 Conclusion

The RIMapper test bed described in this paper is first and foremost exactly that: a test bed. As such, it is and will remain to be a work in progress and not expected to result in a fully-functional production system. However, from the use of OpenGIS standards in a database backend and the building of Java services to provide client browsers with SVG mapping, useful insights were gained into the possible deployment of these techniques in the future SLARIM GDI to be build. Furthermore, the setup has proved to be so flexible and powerful that it is expected that it can be used to provide access to data for several other applications and projects currently under development at ITC.

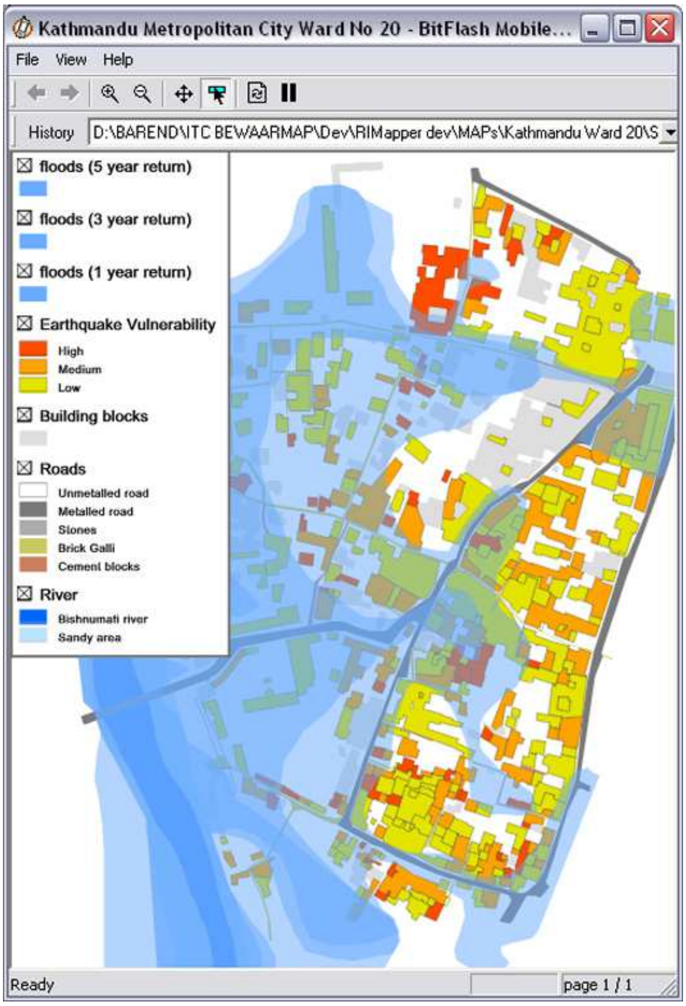

Fig. 4: Example of a RIM screen dump from the BitFlash SVG mobile viewer

8 References

[1] *Westen, C.J. Van (2002):* STRENGTHENING LOCAL AUTHORITIES IN RISK MANAGEMENT (SLARIM. Enschede, ITC; Internal report. http://www.itc.nl/research/policy/spearhead3/vwesten.asp

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Mobile Internet GIS based Flood Warning and Information Systems

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Abstract

The recent flood disasters showed that available warning systems do not fully fulfill their requirements and potentials. This paper examines these regarding web-based and mobile GIS based flood information and warning systems. We present first prototypes that are being developed at the University of Applied Sciences Mainz for a pilot area at the Rhine and give an outlook on the state of art and potentials for mobile disaster management systems. Environmental disasters are spatiotemporal events, so only GIS can fulfill the needs of the disaster management staff, e.g. updates of the spatial extent of the disaster wich must be made available very rapidly to all interested parties. We discuss the scenarios for a mobile flood warning system and give an overview of system architecture.

1 Introduction

Geo information systems are valuable and powerful tools for the collection, management and analysis of flood-relevant geoinformation. The crucial disadvantage of danger management systems such as PoldEvac or the dyke information system North-Rhine/Westphalia is that these are built as desktop solutions, therefore specialized systems, which run as isolated solutions only on a limited number of computers. The possibility to send the information and results of analysis of these systems rapidly and efficiently to a large number of users is missing. So if we postulate that distributed component based systems are a more suitable approach we have to discuss the scenarios in which these shall be used in order to derive the properties of such components.

2 Scenarios

We found the following main scenarios for a distributed GIS-based disaster management system for floods:

1.) Prevention and Information

Awareness of potential risks through floods needs to be strengthend in order to minimize future impact. So dangered areas need to be clearly identifiable for citizens.

2.) Flood prediction and warning

Flood information systems need to integrate environmental data relevant for flood warnings (e.g. water levels, weather, thaw...) with existing forecast models (e.g. water level models) which need to be computed dynamically. In the case of an predicted or measured emergency, warnings need to be triggered on various media (SMS, PDA etc.).

3.) Flood and Crisis Management

In case of emergency crisis staffs, rescue forces and citizens not only need to receive information, but need also an information and planning platform e.g. in order to update data directly at the location.

3 Requirements and Architecture

These scenarios have to be mapped on requirements and a general system achitecture. As there are no standard solutions regarding the integration of heterogeneous data & services, the system needs remain open for further extension (functional, regional, technical). A distributed and component based architecture is necessary to realize the identified scenarios. A GIS-based disaster manamagent system (DMS) for floods needs to be realized on basis of a geodata infrastructure (GDI), communicating over Internet-protocolls. It is therefore possible from each computer on the Internet to enter the system. Based on that we identified the following top requirements with respect to disaster management systems:

- maximum robustness / high scalability
- decentralized architecture, open standards
- handling of geodata on mobile client
- integration of external data and simulation models
- support for heterogeneous terminals

4 State of the art of Warning and Disaster Management Systems

After having identified the scenarios and some first requirements (more details on the requirements of mobile geodatabases for disaster management can be found in Zipf and Leiner 2003), we hwill have a look at the current state of art of these kind of systems. Warning and crisis management systems for floods are offered by different companies more and more since the catastrophic flood in August 2002. In many cases these solutions are based on content management systems (CMS) and/or technologies, which were already offered for the area of project management and offered now under another name. However so far only few systems are tailored to the special requirements of a flood event. For example the systems HowISS (Flood Information and Protection System), used in Heidelberg, Cologne and Bad Friedrichshall for some years, supports in general the planning and execution of measures on basis of level forecasts with flood events.

The projects and systems within the area of flood protection cannot easily be combined to groups on the basis their services and applications. Nevertheless we try to give a rough overview:

- Automated collection and transmission of environmental data
  Automated systems for the collection of current environmental information, e.g. the level measuring net of the HVZ equipped with long-distance data transmission or the satellite-based remote sensing systems of the DLR
- Environmental data bases
  Systems for the input, collection and administration of environmental data data e.g. an environmental information system (UIS).
- Geographic Information Systems
  Geographic Information Systems (GIS) take an intermediate position. On the one hand they manage the geodata by providing database functionalities, on the other hand they present the data in form of digital maps. As they also offer different analysis tools they also take over functions from systems for danger simulation (4.). Examples of GIS applications used in the range flood and/or danger warning are e.g. PoldEvac, DISMA, the dyke information system North-Rhine/Westphalia or the GIS Zurich.
- Systems for disaster/danger simulation
  These are computer-aided models, which try a concrete danger situation to simulate and/or predict. If spatial processes are to be simulated, a GIS is always a component of such a system. In the case of FloodArea e.g. by proprietary programming for the GIS ArcView.
- Management systems
  Such systems have to support the task of decision makers with their decisions. The system submits suggestions for actions which are triggered on the basis the received information (e.g. predicted water level) (e.g. HowiSS).
- Communication platforms
  The task of a communication platform is to distribute the available base data, evaluations and simulations, forecasts, action plans, reports on the situation, recommendations or procedural instructions purposefully to the respective addressees. A communication platform is independent of the kind of data. For example the information generated with an outdated simulation model can be exchanged at any time with the information from an improved model.

While a GIS is only meaningfully usable, if the necessary data is implemented - which in practice is one of the largest problem after Dombrovsky 2001 - a communication platform is usable even in principle without background information. However the usability rises with the quality and completeness of the available data. The information can be distiributed over different media (e.g. Internet, phone, fax, SMS) depending upon the desires of the user. There are no communication platforms tailored to flood disasters availbale so far. Only in the research project OSIRIS first demonstrators for a such system have been developed. For an overview of the current state of the mobile geo information technology see [ZS02].

5 Earlier work

Already in our earlier projects we offered interactive inundation maps on historic flood events with further information. For example in the tourist information system Deep Map WebGIS [ZI00,02] it was possible for the interested user to request geographical information on Heidelberg, amongst others also flood maps and the appropriate aerial photographs. The system was based on a coupling of ArcView and ArcIMS and the flood information was found by database queries. The geo data originated from our own digitization of the flood areas on basis of airial photos taken during the floods. However there were no such things like prognosis models for flood, dynamic level inquiries or warning systems integrated in this system. First prototypes of the Deep map WebGIS consisted of an applet for representing an interactive map offering seamless zooming (fig. 1 [ZI02]). A special challenge of seamless zooming was - and still is with - a dynamic optimization of the map labeling and symbol placement, which had to be realized using extensive programming. On the map it was not only possible to click on objects of interest (to which information from the database then was presented), but vice versa various search functions allowed to search in the multimedia database. Result objects of the database search could be presented on the map using the function “Show on map”. While this is not new, the interesting thing is, that this applied not only to spatial objects (e.g. buildings), but also to e.g. events or persons because of a comprehensive and also indirect geocoding of such kinds of objects in the database [WE99].

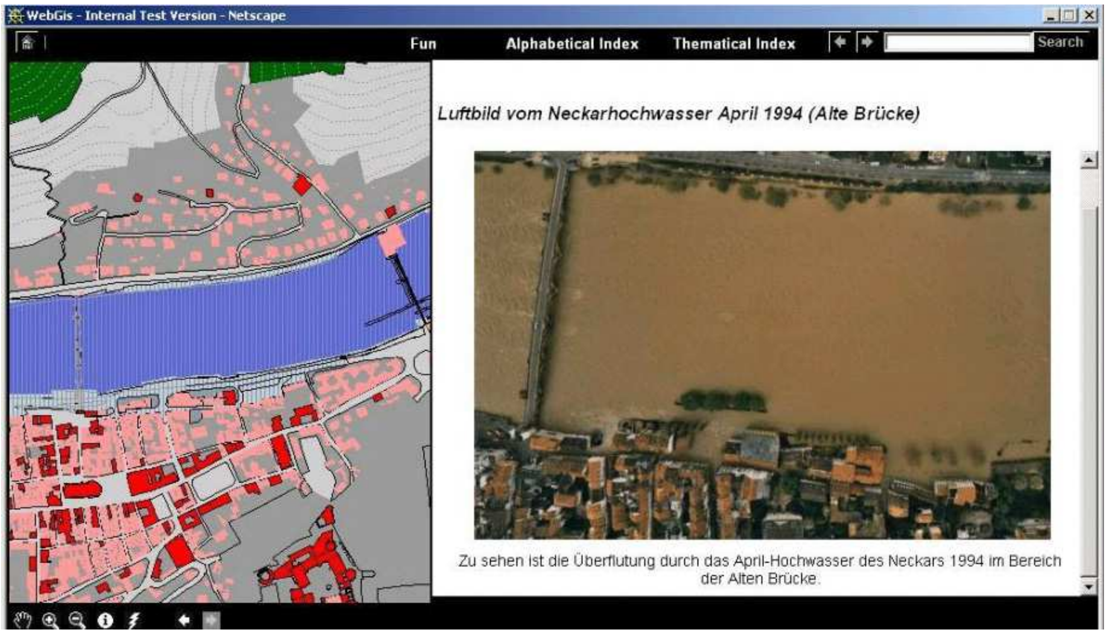

Fig.1: Flood information in the Deep Map WebGIS – the flooded area of the Neckar in Heidelberg April 1994 (stripes) is presented as map layer, right hand the according aerial photo.

6 Web-based Flood Mapping - the example of the upper Rhine

Using the inundation surface model of [LE03], Web-Mapping applications are being developed at the University of Applied Sciences Mainz for the spreading by flood information for an pilot area on the northern upper Rhine. A goal of the project is the Internet-based spreading of interactive maps of the flood dynamics of the investigation area. This encloses besides empirical data of the flood dynamics and forecasts derived from these and geographical background information e.g. the change of the land use or settlement growth in the investigation area, and also areas with a high risk of inundation water. The extent of the inundations which can be expected can be predicted based on the water level forecasts of the flood forecast centre available online.

7 Studies on flood dynamics

For the section of the Rhine in question (fig. 2) there exist detailed investigations of the flood dynamics [KI02; LE03]). Based on inspections of the area and flights, water level measurements and soil probes the spatial and temporal change of the recent inundation surfaces from 1997 to 2001 was seized, mapped and documented additionally by photo and video. Furthermore aerial photographs were analysed, which were taken briefly during and/or after flood events of the 1970es and 1980es. Based on this information the extent of the inundations was simulated as a function of the water level at the level Speyer on the basis of a high precision DGHM [HI01]. Because of previous intense field work a lot of inundation maps were already present for a majority of the water levels and could be used for the calibration and/or adjustment of the model.

8 Special case of inundation water

During the flood of 1999 it became obvious that within landscape and town planning the problem of the pressure water has been neglected. The majority of the damage to buildings and harvest losses resulted not from a water spilling from the river, but from the underground swelling water (pressure water or „Qualmwasser") in the old river beds ("Altaue") protected allegedly by the main dam of the Rhine against inundations.

Since the models used far for the simulation of inundation surfaces care only for flow dynamics above the ground (e.g. FloodArea [AS03], and as there is nearly no data for a simulation of the underground flow processes (e.g. distribution of water-leading sediments, tight groundwater measuring net), pragmatic solutions were searched for, in order to make at least a rough estimation of the areas potentially endangered by pressure water.

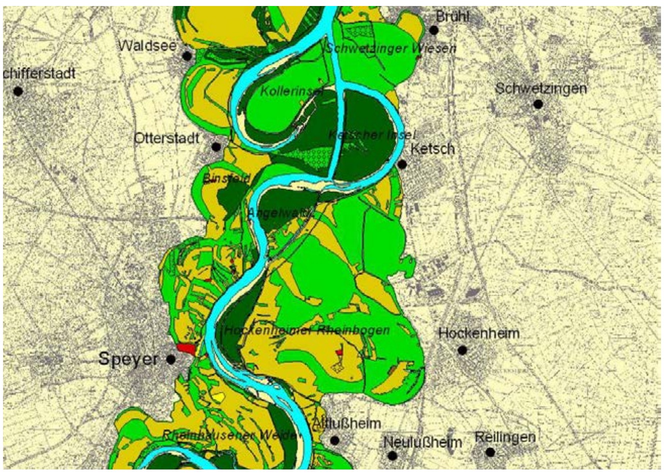

Fig.2: part of a first map of the pilot area

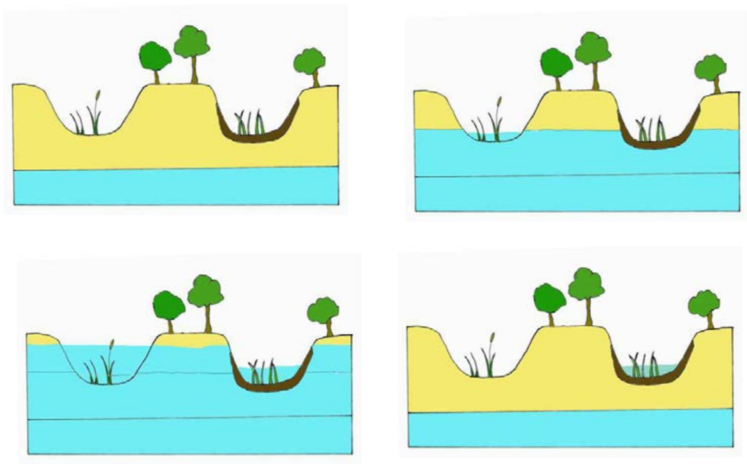

Fig.3: the process of inundation – causing floods without breaking of dams etc.

So numerous inundation water surfaces could be identified by the interpretation of harvest damage in aerial photographs taken in shortly after flood events. Remarkably numerous of these areas have been cultivated and used for buildings meanwhile. Furthermore the historic Rhine Atlases of the “Großherzogtum Baden” have been geo-referenced and analyzed in a GIS [JA02; LE03]. Through that it became clear that the areas that have been used only extensively in 1856 because of the still higher ground-water level at that time correlate strongly with the current pressure water areas.

For the pilot area the following flood-relevant data could be generated and collected on basis of the study of the inundation dynamics discussed earlier:

- empirical, water level-referred inundation surface mapping
- digital terrain model (1:5000; TIN)
- flood areas simulations derived from the digital land model related to the level Speyer
- historical land use 1856 and 1875
- perpendicular aerial photographs (* img)
- aerial photographs and terrestrial aerial photographs
- measurement series of the development of the pressure water during the flood 1999

9 Technology

A web map server (WMS) produces maps either as raster graphics, e.g. in the formats GIF, JPEG or png, or WBMP (WAP bit-map). Scalable Vector Graphics (SVG) is an increasingly used vector graphic format based on XML. In the project the open source map server of the University of Minnesota is used (UMN Web map server) [UM03] with his well-known features. Parallel in a current prototype for an on-line flood information system interactive vector maps on basis are tested using SVG. Beside SVG-plugins for the Web also first SVG browsers for mobile devices [e.g. BR02] are being developed.

Technologically there are meanwhile several practicable solutions for the development of WebGIS or Web Mapping for the Internet and Intranets. In order to improve the interoperability between the systems most of the necessary interfaces are standardized by the OGC. Beside commercial solutions one can use different free implementations (e.g. the deegree framework [DE 03] we used in another part of the project). The latter seem to be developed far enough today, in order to be used also in productive systems. While several products are called OGC conformant, there exist still obstacles for a genuine interoperability - among other things because of manufacturers heavy use of vendor specific parameters, which need to be used in the different products more or less obligatory in order to obtain reasonable result. But this make an exchange of the products more difficult [PA03].

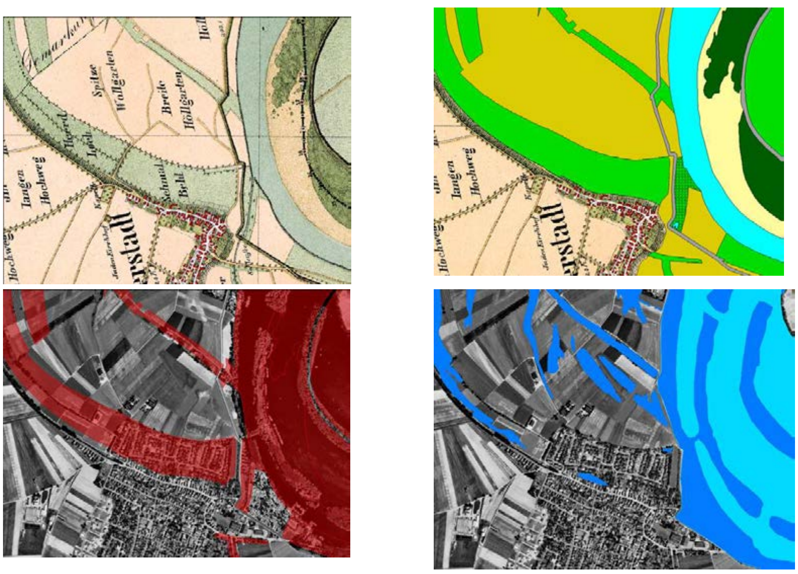

Fig.4: results from the analysis of historic maps (Rhine Atlas 1828, 1856, 1875) with recent flood areas and aerial photos (1999).

10 Collection and Analysis of flood-relevant data

Apart from the access to dynamically updated environmental data important for the disaster management (e.g. ground water conditions and predictions, maps for current and predicted flooding areas, precipitation data) the decision maker need access during a flood event to a

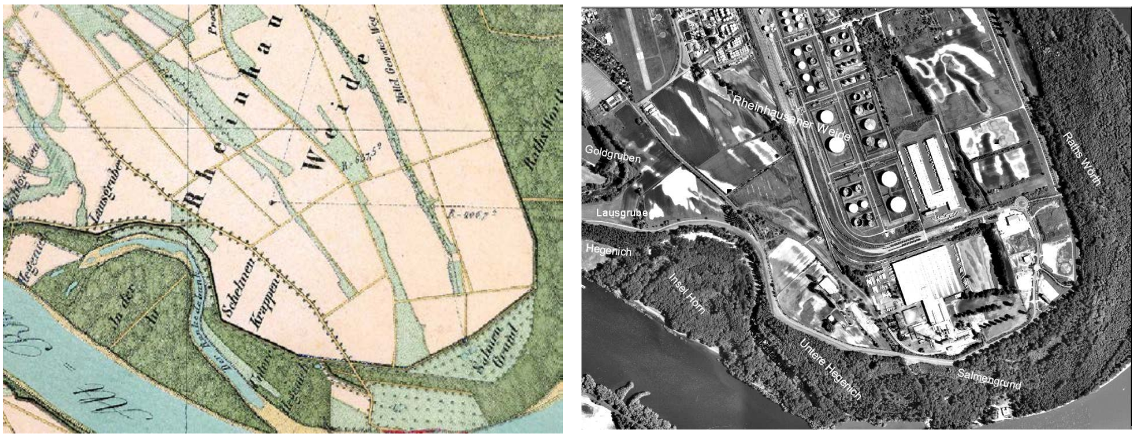

Fig.5: comparison detail of historic map with aerial photo

range of further information e.g. infrastructure data, locations of environmentally hazardous materials, partners and responsible persons at the task forces etc. Therefore it must be ensured that these information is coleected and prepared in databases and/or a GIS. A substantial component of the work of recent projects in the flood precaution dealt with the production and management of such flood-relevant data. For example in one of the earliest projects, PoldEvac, the focus of the German-Dutch project was put on the question, which information decision makers need at all. While the information technology used in that is out of date meanwhile, the final report of Dombrovsky (http://www.compuplan.nl/deutsch/pe indexd.htm) still gives valuable input. Similar a whole set of application-oriented research projects were started with the goal to improve the data situation in the case of crisis after the catastrophic flood of 1997. As a further example of such a typical GIS solution is the “Deichinformationssystem” NorthRhine-Westphalia.

11 User interface

In order to provide in a crisis situation a helpful and fast tool for the provision and transmission of information, the usage must be intuitively, simply understandable and reliable also for untrained users. In order to avoid faulty operations the usage must be straight and simple also in stress situations such as disasters. Different user roles with different information and requirements for interaction need to be differentiated: from the the citizen, headquarters and authorities to the rescue forces. Special attention is necessary on roviding a suitable cartographic representation of the spatial data by means of maps [ZI02] optimized forf the substantial goals (tasks) of the user [ZH03].

From a user point of view the system consists of a public and a internal (i.e. password-protected) area. While the information of the public DMS is freely accessible for all citizens, the internal area is reserved to the closed communication between the authorities, crisis staffs and task forces. The internal part of the system hass to be restricted to authorized users. The different roles of the users (e.g. administrator, operator, crisis staff...) determine the range of the information and services made available (e.g. read and write rights) within the system. Furthermore the preferences of the individual user (e.g. the standard attitudes of maps and user interfaces) are stored in individual user profiles. For mobile terminals (Tablet PC, PDA handheld) these modules beed to be developed and adapted according to the special hard and software requirements of the devices.

12 Future Work: 3D digital terrain model

A 3D representation of the available DEM [HI01, LE03] with further geo data overlaid is planned (e.g. using vrml/X3D) for a future part of the project. However a dynamic production of the entire model as multi resolution TIN depending upon the to be visualized focus area as in [ZS03] appears as too complex for the first prototypes. In particular due to the extraordinary requirements in an emergency further work would be needed to support a better scaling. This still offers several interesting possibilities for subsequent research.

Client side vector-based 3D-worlds are still less well accepted and somewhat more complicated because of the necessary plugins or additional components like applets. A new standardisation suggestion of the OGC named Web terrain server (WTS) offers another possibility: the WTS is very similar to the concept of a WMS by offering the possibility to produce 3D-Views as raster graphics from 3D-GeoDaten, which can be represented then within usual WebBrowser. An appropriate reference implementation of [DE03] is planned as base for future realizations of such possibilities. This is in particular also for the transmission on mobile clients a promising and pragmatic basis.

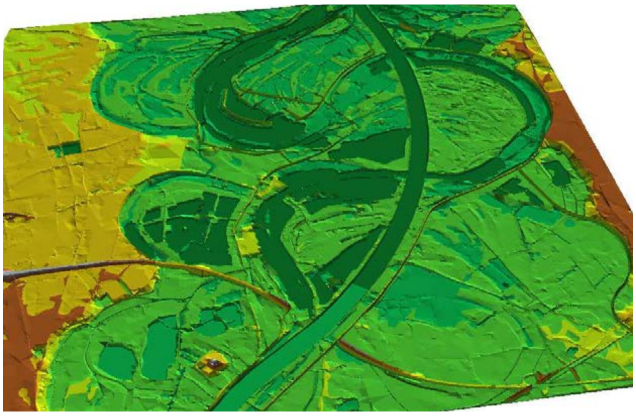

Fig 6: 2.5D digital terrain model of the pilot area

13 Summary

Systems based on SDI (Spatial Data Infrastructures) admittedly offer large potential for communication, support with various tasks. On the one hand they offer gains in efficiency, on the other hand they offer new possibilities through the intensified integration with other distributed IT systems, which represented isolated applications before. Through the combination of dynamic forecast models with WebMapping and mobile devices a new quality within the range of the flood information systems is reached. The possibilities arising from mobile communication seem to offer at least the same – and in many cases quite larger – potential. But still the technology is not ccompletely accepted, not yet fully available and therefore the actual realization still has technical problems to solve [ZA03]. In order pick only one example, which concerns also our current work concerning the evaluation of SVG, e.g. still improved of compression algorithms of vector-based geo data are necessary in wireless nets, e.g. by [BE99, CE00, SH02]. See [CO02] for mobile 3D-maps. Another topic is the accuracy of the positioning e.g. in emergencies [ST02]. Within this paper we cold not touch the area of data and system security or privacy, which represents a fundamental aspect in particular with mobile solutions and positioning [HO02]. A further step regards the integration of up to date remote sensing data [PE03] into such systems (whether for Web or mobilely) for floods. With the presented map-based flood information systems we illuminate the potential of Web-based communication of new media and improved the availability of flood prognosis information for both the population and rescue workers.

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Location Based Services in the EU-funded project OPIUM
OPIUM – Open Platform for Integration of UMTS Middleware

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Abstract

The growth of the mobile telecommunication has had a major impact on the European Community. Mobility has become an essential requirement in today's society. While the major growth has been in voice communication there is an increasing demand for more sophisticated services. The successful rollout of Pan European 3G services is not purely an issue of providing a set of advanced multimedia services to support end-user business and leisure requirements. There is also a need to demonstrate seamless application access and delivery across a Pan-European 3G network that meets customer expectations. The availability of Pan European testbeds, to validate the technical feasibility of the merging 3G networks and service environments prior to their commercial rollout, is crucial for the deployment of new and innovative services which should be successful. This focus is covered by the OPIUM project.

The following pages give at first an overview of the OPIUM project. It describes the overall goal, the objectives and the expected output. In the second section the trial sites are presented. A detailed description of demonstrated Location Based Services in the project is shown in the third section which is followed by an conclusion of the experience gained in this project.

1 Introduction - The OPIUM Project & Consortium

The EU-funded project Open Platform for Integration of UMTS Middleware with the Project acronym OPIUM started in June 2002. It runs for 22 months and involves 19 partners from 9 countries out of 2 continents. At that time this funded project was the greatest one with Chinese participation. The consortium mix consists of partners from the area of application service providers, platform providers, operators, equipment providers and standardisation (see Fig. 1). Siemens Austria takes the role of a platform provider. An Irish institute, WIT-TSSG with strong experience in telecommunication and EU-funded research projects, does the co-ordination of this project.

OPIUM key facts:
Contract number: IST-2001-36063
Duration: June 2002 – March 2004
Budget: 8.470.986 €
EC Funding: 3.977.000 €
Person Months: 671,36
Partners: Waterford Institute of Technology, University Carlos III of Madrid, Motorola Ltd UK, Nortel Networks Hispania, Siemens Austria, Vodafone Spain, Portugal Telecom Inovação, UH Communications, ATOS Origin, IKV++ Technologies, Mail morph, ETSI Interoperability Service, TTL Lab (China), Planeta Actimedia, Broadmedia, FHG/Fokus, Cork Institute of Technology, Siemens Portugal, Aepona

Project Goals
The overall goal of the project is to support the accelerated rollout of commercial 3G services within Europe by addressing some of the key issues that need to be addressed, such as roaming and Billing, prior to the delivery of commercial services.

To achieve this goal the project has defined a development plan that will ensure the delivery of meaningful, strategic results to the wider European service and network provider community.

The project gives the opportunity to anyone in Europe to access the test beds through large interoperability events organised by ETSI. In addition to a User Forum has been set up within the project whereby project results will be made available.

Fig. 1: Partner Categorisation

The principal objectives of the project are as follows:

1. To validate the introduction of the new wireless based applications in Europe - based on a combination of new wireless protocols (GPRS and UMTS) and internationally standardized open network/service APIs (3GPP OSA, Parlay). To achieve this objective OPIUM is demonstrating the operation of a subset of innovative multimedia and m-business services across the pan European network exploiting the capabilities of 3GPP OSA / Parlay APIs. These services include lLocation Based Services, unified messaging services, multimedia access services and m-commerce (Accounting) services.
2. To build a Pan European network of interconnected 2.5G and 3G platforms, from multiple platform manufacturers and operators, to demonstrate and validate commercially applicable network and service interoperability, and roaming solutions. It is vital that the equipment providers, network operators and services providers establish a consensus on how roaming, service migration and accounting will be implemented. To achieve this OPIUM has brought together key players from the emerging 3G-market environment to cooperate and build the Pan European network and to demonstrate their 3G services across this network.
3. To test through live trials the seamless end-to-end provision of advanced 3G services across the Pan European network. In the second phase of the project partners will demonstrate seamless end-to-end provision of a set of advanced business and multimedia services across this Pan-European test bed and will demonstrate the operation of advanced services capable of providing the following functionality:
   - Connectivity and coverage, anywhere and anytime – getting access to business critical information (e.g. e-mail, critical corporate apps, shared information) when users move around the European Union (or Worldwide countries).
   - Effective management of personal information.
   - Enhanced communications – multimedia applications (including video, music and messaging).
   - Demonstration of Location Based Service.
4. To implement and demonstrate mobile accounting and advanced multimedia services based on industry standards. The project is demonstrating federated charging solutions for Pan-European 3G services by applying state of the art solutions derived from IP and ATM based service solutions. In particular, the project is validating the IPDR specification for 3G-service accounting.

However, the objective is not just to operate a set of service trials but also to use the availability of a Pan-European 2.5 and 3G network and service infrastructure to validate a number of innovative solutions to a number of the remaining technical challenges.

Expected Outcomes
The expected outcomes for the project are:

- Provide the industry with important intelligence and guidelines on the rollout of Pan European 3G mobile applications.
- Provide recommendations on technical solutions for network interoperability and service roaming in 2.5 and 3G environments.
- Provide recommendations on VHE /Mobile Portal service delivery.
- Key position papers to the 3G standards bodies (ETSI and 3GPP).

2 Trial sites

The trial sites, which are realized and operated, are located in Swindon, UK, Madrid and Barcelona, Spain, Lisbon, and Aveiro, Portugal, Berlin, Germany and Nanjing, China. In phase 1 of the project the trial sites are set up and the services are tested on these single sites. In phase 2 of the project the sites are interconnected and services across Europe are demonstrated.

As stated above not only Location Based Services also different types of services with different types of aspects like multimedia, VHE and roaming are tested at the trial sites, whereby Location Based Services are tested on the sites in Portugal, Spain, Germany and China. The description of the trial sites is given below:

Trial site 1 Portugal: Siemens Portugal is providing and managing this trial site. It consists of a UMTS network, deploying the Open Mobile Internet Platform OMIP, the Location Enabling Server LES and the Location Platform LP and using on top of this the IKV enago platform for providing a customer care service that needs the position of the user.

Trial site 2, UK: Motorola provides and manages this trial site. It consists of a GPRS network incorporating an OSA/Parlay gateway. The Test Network allows extra servers to be added and tested with the GPRS test net. This site provides real wireless GPRS experience.

Site Trial site 3, Spain: Vodafone and Nortel Networks are providing and managing one of the trial sites through the interconnection of the Vodafone UMTS core network to Nortel Networks applications laboratory which allows for a set of identified terminals to access a set of 3rd party applications that use the OSA Gateway for enhancing the application functionality, like location capabilities, terminal identification, notification.

Trial site 4, Germany: As part of its "3G-beyond" activities, the Fraunhofer Institute FOKUS has set up a 3G-beyond test bed that comprises several technology playgrounds. One of these is the OSA/Parlay playground, bringing together different vendor products and applications. Within OPIUM, the FOKUS Test bed supports various parlay applications, such as the IKV enago Portal and Smart Messenger.

Trial site 5, China: The fifth trial site located in China is provided by TMC and ZTE Co. The site is composed of 3 layers. The network access layer includes MSC and SGSN, giving access to the UMTS core network. The middle layer is the ZTE Parlay Gateway, which is connected to the original network entities and provides an interface to the application layer which is composed of two parts, where first the ClientHUB provides encapsulation for some completed Corba-related invocation and the Parlay Framework and second the User applications where Location Based Services and Unified Message Services are provided.

For the second phase of the OPIUM project the trial sites were interconnected with focus on

- Interoperability testing across different middleware implementations
- Testing of various roaming scenarios
- Testing of service provisioning in distributed environments
- Testing of accounting and charging in distributed environments.

In phase 2 Location Based Services are tested between Spanish and Portuguese trial site in a real roaming situation.

3 Location Based Services in the OPIUM Project

This chapter presents the tested Location Based Services. Some of these services are operated a fairly long time, e.g. iMaps from Actimedia. The services from Broadmedia are also operated for a while but are extended with the functionality of using the position of the mobile service user within the OPIUM project. The aim is to get a first understanding of the use of location in different applications. The Customer Care Service from Portugal Telecom Inovação is not a commercial service. It is used for validating the concepts, the realization and introduction of new and innovative services using new possibilities like multimedia and the position of the mobile service user. The Chinese partner validates the interoperability issues and the general conditions to make Location based services successful. The DocAvatar is a set of several potential commercial services facilitating flexible communication between customers and a medical doctor, where in case of emergency the location of the mobile user can be submitted to request medical aid.

iMAPs
Actimedia offers its iMAPs service in the OPIUM project. It includes a mapping service (atlas and city guides), car routing services and content services (points of interest, accommodations, tourist guides, ...) based on information provided by the user (address, city, ...) or based on the current user location. All of these services are online in some of the Actimedia distribution channels (Internet, Wireless, traditional). This mapping service has been operated since 1996 and currently supports 2,5 million requests per month with an answer time of less than 1 second.

The mapping and content services include following

- **Mapping services**:
  - Europe & World Atlas
    - All countries of the world
    - European cities with more than 1.000 citizens
    - 4.000 cities of the rest of the world
    - All major roads: highways, national roads, secondary roads, …
    - All major geographic items: mountains, rivers, lakes, beaches
  - Spain Atlas
  - City Guides
    - Spain: 1.400 municipalities (75% of the population covered)
    - More than 350 important cities in Europe
  - Europe Router
- **Content services**:
  - Geo Ski
  - Points of Interest Searcher
  - Accommodation Searcher

This services allow users to find a country, city or address (street name + house number) over the world, visualize it on a map, navigate through it and locate Points Of Interest (POIs) of the area. Also a searching functionality is offered, where the user can type the name of the city or country to find. Also a map navigation is offered which includes the following functionalities:

- Zoom in and zoom out
- PAM and re-center
- Resize
- Request information of a POI
- Customize the map (place a text on the map)
- Locate Points of Interest (POIs) of the area

Broadmedia services
Broadmedia tests three applications in the OPIUM project. These are AgilBanner, PushServices and Mobile Portal. Mobile portal is a customized web page adapted to mobile handsets browsers with a broad amount of content where users can access to different information. There are 2 pages where location information is used: *maps* and *weather*.

When the users access the *maps*, the BM platform contacts AePONA Parlay Gateway to get the location of the user (X,Y coordinates). This information is sent to Actimedia, which in turns provides us with the Map of the location of the user, plus any additional information related to that location (Undergrounds, Trains, Hotels, Restaurants, etc). The user can ask for any of this additional information clicking directly in the map in the appropriate icon.

When the users access the *weather page*, the service requests the corresponding Base Station code. This code is matched against a database of BS location, and the user will be provided with the local weather forecast directly.

An *Alert Service* portal is offered to mobile users where they can configure their own alerts.
The local weather forecast can be used in combination with the AlertService portal. This service offers the mobile user a flexible configuration of different kind of alerts. The triggers for the alert can be time or position of the service user.

An *AdServer* that allows configuring advertising campaigns on Internet based on location of the user. This is a major breakthrough in the advertising market as from today the location is based on countries according to the IPs. With this application, the advertising agency can filter the campaigns in order to show certain creativities only to users in an area defined by the advertiser.

Customer Care
The aim of the Customer Care service is to support customers of a company, independently of the user location. The users, usually using mobile terminals, have the possibility to request information about specific products or services and also to request personal assistance from an expert. This is realized by means of:

- *Interactive Product Tutorials* - An interactive product tutorial enables the customer to access updated information about products and services from his service/product supplier. Product tutorials are organised in a tutorial way and presented as interactive "slide show" presentations that guide a user through the different installation/configuration/use steps of a product. The user has the possibility to control the presentation by means of general commands like go forward, go backward or repeat the contents of a slide.

and

- *Online Help* – The support is given by an online operator through an audio/videoconference session. After the online help request from a user, the Customer Care service will request the online-expert and the user locations, using the Parlay Location API, to determine which is the most adequate online-expert to supply the online help. The user does not need to know about the online operator location or availability. The user may require online help from the Customer Care service from the beginning or from inside the product tutorial feature when he detects some problem that he cannot solve without the help of an online expert.

The user of the customer care service the possibility to chose the online help during the interactive product tutorial presentation. In case of using the online-help, the service tries to obtain the location of the user and the available online expert. With this information, the service determines the nearest available expert and sends him an SMS, notifying about the users request. In addiction, the service sends the online experts contact information to the user so that he can contact the expert. Originally it was planned that a call will be established between the user and the operator (like click-to-dial) but the corresponding 3GPP recommendation was published in spring 2003 and therefore this functionality is not available in the mobile communication systems.

Besides these features the Customer Care service also allows the user to personalise the way they use the service, defining both:

- *Specific service characteristics*, such as the tutorials language, products to receive support, product support depending on the location, daytime or month of the year, level of support or default online operators contacts.
- *Look & feel characteristics*, i.e., the way the service looks to him, in terms of background colour, font size and colour, sound volume, icons, toolbars, etc.

By using the personalisation of this service the user has the possibility to insert directly specific values to the profile items or select alternative values. After selecting the user specific values the user requests to change his profile by using the Change Profile button. The list of profile items will be updated with the chosen characteristics.

The Customer care service and its offered functionality will be demonstrated in combination with the Spanish trial site in the second phase of the OPIUM project. For this the mobile service user will be in a roaming situation. This means that a Spanish mobile subscriber booked into the Portuguese mobile network resp. a Portuguese mobile subscriber booked into the Spanish mobile network is using the Customer care application.

As an example of how a trial site is built up the Portuguese trial site is shown in Fig. 2. The UMTS trial network resides in the premises of Siemens Portugal in Lisbon. The Customer Care application is deployed on the enago OSP platform which is located in Aveiro, Portugal. This platform also manages authentication and authorization of the service user. The application is connected via Internet to the middleware OMIP/LES which is in premises of Siemens Austria in Vienna. The service uses SOAP/XML to communicate with the middleware. This middleware offers e-mail, SMS and Location Information functionality to the Customer Care application. OMIP/LES is connected via Siemens Intranet to e-mail server in Vienna, Location Platform in premises of Siemens Portugal, Lisbon and public Internet to the SMS-C in Porto, Portugal. The Location Platform is connected via an SS7 connection to the UMTS trial network. This entity requests via the MAP_ANY_TIME_INTERROGATION procedure the cell-ID of a dedicated mobile subscriber and converts the cell-ID via a mapping table into coordinates. These are the coordinates which are provided to the application. The figure shows that the operation of the customer care application takes place in an heterogeneous and distributed environment spread across Europe.

Location Based Services on Chinese trial site

With LBS, two modes to access location information are provided. The user can access this service through SMS or voice and can get his GIS information through short message or web. It is also possible to get other user's location information if permitted. The positioning method is cell-ID based, so the accuracy depends on the size of the cell, but longitude/latitude information is provided. Detailed geographical information can be provided in combination with GIS (Global Information System). GIS is based on MapInfo Corporation's product. The following is detailed information of two LBS applications.

Query of neighbour building

When users need help on location of buildings, they may invoke the application through SMS. In the short message they can input which building they want to search for and send the message to a called address that denotes the client LBS application. After the application gets the user request, it first gets the user location from Parlay Gateway through Mobility API and then it gets the information about the closest building from its GIS database.

Vehicle monitor system

The vehicle monitor system is a vehicle monitor center by which the vehicle manager can easily get the location information of his vehicle from a pre-set map. The application periodically gets location information by requesting it from the Parlay Gateway which is connected to the mobile communication network. The vehicle manager can set the number of vehicles to be monitored and also the periodical query timer.

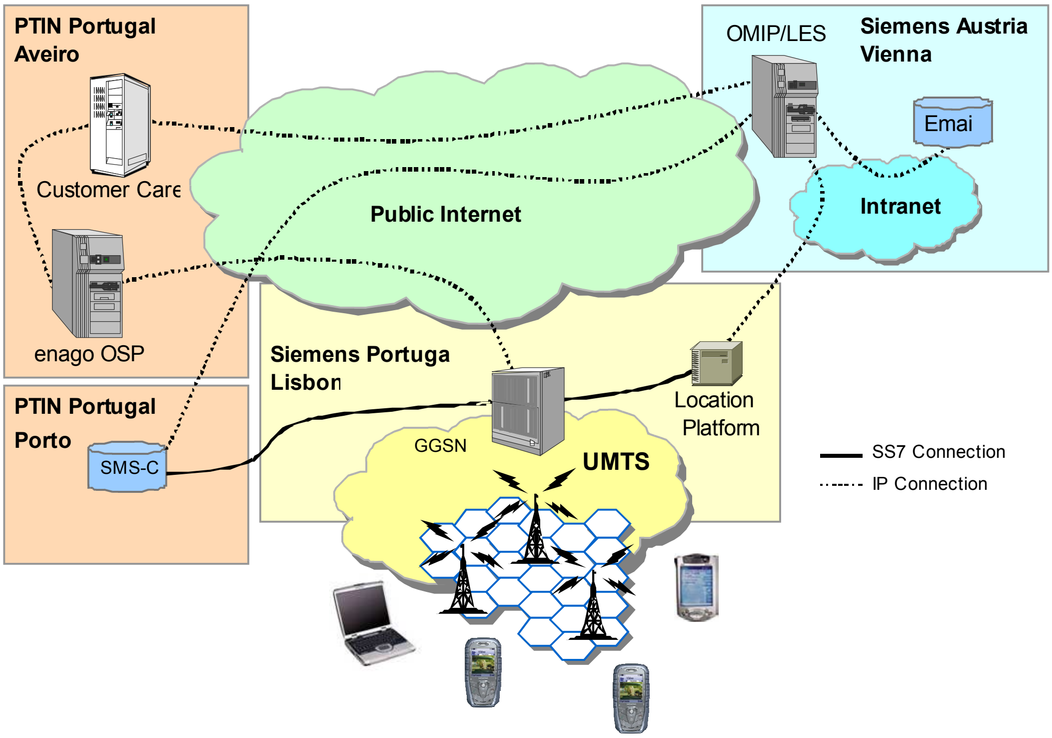

Fig. 2: Customer Care demonstration architecture

The Doc Avatar

DocAvatar is a set of several potential commercial services, which was cooperated by Fraunhofer Institute FOKUS, IKV++ Technologies AG, Medicine Worldwide, HealthXXL, E-spaces Initiative and Teknia Ltd. Kupio, Finland. The final target of this application is to provide an independent, reliable, trustworthy e-health/m-health service solution, which enables flexible communication between customers and a medical doctor via Web Services. Customers can use their mobile telephones, browser on the PCs or laptops to access the services of DocAvatar.

The DocAvatar technology, a first-aid tool that has been officially accepted as part of the Digital Olympics framework 2008 in Beijing, serving the Chinese and international citizens via medical information retrieved from the emergency center in Beijing.

DocAvatar includes the following services:

1. Send Location
   This service will enable the customers to get their geographic location information and send the information as an SMS to a call center, which may then alert medical aid. Without doubt this service is useful for those customers, who meet the emergency case without additional devices to identify their location.
   This service will demonstrate the cooperation between Location Service and SMS Service in ParlayX Web Service. After being invoked by the customer, it will use the Location Service at first. After the geographical location information has been retrieved, it will directly invoke the SMS Service to deliver the customer’s location information to the specific target device.
2. Call to Doctor
   This service will enable the customer to talk with an expert at a call center. This service is useful for getting expert opinions in case of an emergency should the displayed information be not sufficient. It also may be used to get information about doctors in the near vicinity, which will describe the doctors’ skills in different major branches and languages. Call to Doctor Service will invoke the ThirdPartyCall Service to manage communication between customers and doctors.
3. Animation Help
   This service helps the customers by providing the emergency help to customers and/or patients. This service depends on the UMTS network, and provides multi-language animations to the customers in different countries, for instance, German, Chinese, etc.

4 Conclusion

At the moment only few applications using location information are offered to the mobile users. The position and its accuracy is based on the corresponding cell of the mobile communication system where the service user resides. A lot of companies are interested in getting experience with the topic “Location based services”. Their interests cover the aspects of technical realization of new and innovative services, enhancements of existing services with location features, billing strategies, positioning accuracy and the introduction to the market.

5 General information on OPIUM

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Dynamic Off-Board Navigation Systems in a Rapidly Developing Mobile Market

Oren Nissim, Herzlia Pituach

1 Introduction

The cellular and PDA market is bursting with new applications designed to do just about everything from send you your emails to enable you to download photos and videos. One of the most popular and useful applications to hit this marketplace is navigation application designed for both the PDA and the cellular phone.

With In-car navigation systems increasingly becoming the norm in new vehicles across Europe, mobile device users of every kind are keen to get in on the action - in a less-expensive and more accessible way.

A user exploring the market today for a navigation system will come across two kinds of applications – 'On-Board Navigation' and 'Off-Board Navigation'. On-Board Navigation systems are the most common to date and can be found in many luxury cars in the form of embedded systems reliant on geographical data stored in the car. These systems are usually offered by car manufacturers upon purchase of a new car.

Off-Board Navigation is the 'next-generation' in navigation systems and is designed mainly for the handheld device such as PDA or cellular phone. Off-Board Navigation systems offer lighter, cheaper, ASP (Application Service Provider) model applications for a wider-scale consumer market, providing wireless device users with continuously updated, real-time content and geographical data via the wireless network. Consequently, a key player in the Off-Board Navigation market is the cellular carrier, who can now use its networks for the transfer of real-time turn-by-turn navigational information over the wireless network.

However, the navigation systems market is not as straightforward as it may first appear. In order to provide a working product to an end-user, many alliances and partnerships between application developers, device manufacturers, GPS unit suppliers and wireless network providers need to be made. In addition, bandwidth restrictions, network limitations, continuous technology breakthroughs and a constant stream of new devices flooding the market make the Application Developer's life an interesting one, if not easy one.

Finally, the introduction of Off-Board Navigation into a previously car manufacturer-dominated navigation marketplace brings with it an extremely challenging question – who will become the new leading players of this new marketplace - car manufacturers or cellular carriers?

One thing *is* clear; both entities hold an almost identical interest in Off-Board Navigation. As far as they are both concerned, navigation really is a 'must-have' application as each party fights to stay competitive, reduce churn and keep an all too easily distracted audience of consumers as loyal as possible.

This article takes a look at the issues mentioned above with emphasis placed on how navigation systems differ, what's available now and what can be expected in the future.

2 What is a Navigation System?

A Navigation System is an in-car device, system or application that guides its driver from any starting location to a programmed destination by use of automatic directions with GPS (Global Positioning System).

Drivers can search for destination cities, junctions, streets and POIs (Points of Interest), while the system calculates the requested route. The user will receive a map and turn-by turn directions to his or her selected destination together with a combination of voice or text instructions based on GPS-assisted location, prompting him or her to "Turn right in 500 meters", "Take the second exit at the approaching roundabout", or "Turn right at McDonalds", until arrival at the desired destination.

3 On-Board Navigation Systems

On-Board Navigation systems consist of an On-Board embedded computer, a GPS antenna and a storage device such as a CD ROM containing digital maps.

The GPS antenna receives signals from GPS satellites, which in turn enable the system to follow the whereabouts of the vehicle. The application provides street, junction and city searches along with various POIs such as railway stations, airports, gas stations and restaurants etc. Users 'type' in an address, press 'enter' and receive a planned route leading to their destination.

The main benefits of On-Board Navigation are that the system is not reliant on any outside source of information. However, this can also be a disadvantage. The advantage is that all geographical data resides in the users' car providing the driver with rapid and reliable route and map downloads. But, robust On-Board navigation systems are expensive to buy and geographical data needs to be re-purchased every few months in order to keep mapping and routing data current. And, the On-Board POI data is static, so users cannot receive real-time information such as updated theatre and cinema showings etc.

This brings us to Off-Board Navigation, the next step in navigation technology and the foreseeable future of navigation systems.

4 Obstacles and Challenges in the Development of Off-Board Navigation Systems

Up until recently, On-Board systems where the only choice in the navigation application market mainly due to large obstacles encountered by the developers of Off-Board navigation applications. These obstacles included cellular network data bandwidth restrictions, voice-focused mobile devices, cellular operators concentrated mainly on voice-services and a lack of technology in delivering real-time navigation instructions.

Today, cellular carriers are investing heavily in the facilitation of data transfer over the wireless network. As a result, networks and devices are improved, upgraded and re-designed to accommodate data as a joint priority with voice. The arrival of GPRS (General Packet Radio Service – a bandwidth that enables continuous flows of IP data packets over the system) and UMTS (Universal Mobile Telecommunications System - implementation of the 3G wireless phone system designed to speed up wireless data for GSM) has also helped make high-speed data transfer a reality, opening up the door to applications that where a mere vision only a few years ago.

In tandem with the development of wider bandwidth, mobile phone manufacturers have also begun to develop their phones accordingly, with the latest cellular devices being designed with larger, user-friendlier screens in order to be able to continue to offer end-users a wide range of value-added services and stay ahead of fierce competition.

5 The Introduction of Off-Board Navigation

With most of the key obstacles conquered, the way is now open for the development of Off-Board Navigation Systems for handheld devices such as PDAs and cellular phones. All information displayed on the end-device is received via high-speed, real-time data transfers over the wireless network, providing users with up-to-the minute routing and map data together with real-time traffic information and incidents. Users with Off-Board systems can enjoy receiving the best route possible *at the time of request*, to any chosen destination.

The main advantage of Off-Board systems is that all information received by the user is updated and in real-time. This means that all new roads will be included in route consideration by the system as will traffic jams or accidents. Additionally, POIs are not necessarily static. Depending on the content provider, users can effectively view the latest movies, shopping deals etc., in real-time on their wireless device. Of course, there is also a downside to being dependant on the supply of real-time content and geographical data - each application works differently, some with faster data downloads than others and there is always the problem of cellular network breakdowns and tunnels. Unless the system is advanced and prepared for disconnections, users may find themselves having to start the route over again from scratch - a big inconvenience to drivers having to pull over on the hard shoulder in the middle of the motorway to re-enter their destination in order to continue navigation. However, with the advancement of technology, cellular networks and bandwidth capabilities, this problem is fast becoming obsolete.

6 Whose Market is it?

As mentioned above, both the cellular carrier and the car manufacturer hold a vested interest in the navigation systems market. Cellular carriers are pleased to jump in on the Off-Board Navigation market, eager too provide their consumers with as many data applications as possible, significantly increasing ARPU (Average Revenue Per User) and locking-in customers for the long term.

As such, today, it is the cellular carriers that have taken the first steps and the lead in PDA and phone navigation with several launches soon to be seen by several carriers this year.

Conversely, car manufacturers are already well established in the navigation market and have been supplying On-Board navigation systems for years without any involvement from the carrier. However, in order to remain up to date with developing in-car technologies and supply a system that provides real-time, updated information, they too are turning to Off-Board Navigation.

The Off-Board Navigation market is still young and although the cellular carriers *have* seemed to make the first moves, it should be noted that car manufacturers are investing a great deal of money and effort in order to narrow the gap between the two entities and eventually, lead in the Off-Board Navigation world.

In conclusion, it would appear that the future of Navigation Systems lies in the hands of a consortium of parties who are for the most part, reliant upon each other. Application providers can only provide what the cellular carriers can accommodate and cellular carriers can only sell to an audience willing to buy user-friendly applications on devices that are built to accommodate them. On-Board Navigation does have its advantages but in a world always hungry for the next technological breakthrough before the current one has even hit the shelves, it looks like Off-Board Navigation Systems could soon become a mass consumer product.

Additional papers

BPS – Bata Positioning System

D. Boekestein, S.P. Ekkebus, P.G. Uithol, Enschede

Abstract

Modern technology makes it possible to develop applications that determine the position of any object. There are a lot of projects focusing on new techniques, with implementations aiming to show what will be possible in the future. Our project, however, was focused on realizing a system with affordable off-the-shelf components, which could consequently be used in practice by us.
In this way, we developed the BPS (Bata Positioning System), a real-time tracking system, accessible through the Internet. It has a focus on accessibility to the user and system scalability. This system combines the power and flexibility of mobile telephony (GSM), Satellite positioning (GPS) and the Internet in an unique way, and was first applied at the Batavierenrace in April of 2003, the world's largest relay race.

1 Introduction

The BPS is developed by three telematics students (part of the Computer Science department) of the *University of Twente* and one student of the *Hogeschool of Utrecht,* both of which are located in the Netherlands.

The idea for the BPS came when we first participated in the *Batavierenrace*; this is the world's largest relay-race, with participants from the Netherlands and other countries throughout Europe. This race is held annually, starting in Nijmegen. The finish line is located about 175 kilometers further in the city of Enschede. Every year there are approximately 7000 participants, most of them students. For most of these participants, the race is just leisure; there is also a University competition though, in which the best runners of each university battle for the fastest total time.

With all these people moving from one checkpoint to another, one can imagine the potential for chaos: teams have no idea where their current runner is at the moment. With this experience in mind we started thinking of a solution that could provide us with the location of our runner in real-time during the race. The idea for the BPS was born.

This paper will describe the Bata Positioning System and some of the theory behind it. Section 1 gives an overview of the first Bata Positioning system, its requirements, architecture and the implementation. Section 2 describes some improvements for the upcoming second edition of our system. The final section is about further improvements that can be applied to the system in the future.

2 System

This section describes the requirements and architecture of the BPS 1 system, launched in 2003 as a pilot project.

2.1 Requirements

As stated in the introduction, the BPS was designed to track runners during a relay-race. Since the race takes place mostly in rural area, and goes on continuously for about 24 hours, it is very hard to visualize the race, both for the teams themselves and other people interested in the race. The system must be able to deal with this problem by providing real-time position information of the runners to anyone interested. This real-time information must be presented to the end-user in such a way that the user is able to form a mental image of the proceedings during the race.

The number of objects being tracked by the system must be easily expandable, so the procedure of adding and removing tracked objects must take place according to a plug-and-play idea. Each of these tracked objects is an autonomous entity, which uses a push mechanism to transmit their position information to the system. In order to provide a real-time overview of these tracked objects, the system must somehow synchronize among the unsynchronized information provided by the tracked objects. To be able to do this, the system must implement a time-window as discussed in [2].

The system itself must also be easily adaptable and deployable, able to use existing networks and infra structure. In this way, it can be easily used in any area, without the need to setup extra infrastructure for the system.

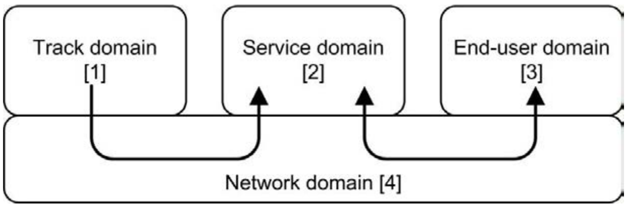

Fig.1: The four different domains of the Bata Positioning System

2.2 Building blocks

Four different domains can be distinguished in the BPS. These are the *(object) track domain* (1), *network domain* (4), *service domain* (2) and *end-user domain* (3). The way in which these domains are ordered is depicted in figure 1. The (object) *track domain* is located near the *tracked object* and provides positioning information. It is connected with the *service domain* through the network domain.

The *network domain* provides the network connectivity for the data communication between the *track domain*, *service domain* and the *end-user domain*. The *service domain* is the central part, which processes the information it receives from the *track domain*. The last domain is the *end-user domain* which represents the interface to the end-user. The information requested by the user is retrieved from the *service domain*.

Figure 2 shows a refinement of the four domains, revealing the basic building blocks of the system. As mentioned above, the track domain provides information about the object's position. It consists of a position receiver, which is used by the execution environment to obtain the position information. Since GPS is the only widely available and operational satellite navigation technique, this is what we rely on in our system. After the position has been retrieved and some metadata has been added to the position data, the execution environment sends the data to the service domain using a *mobile network client*. Since all objects in the track domain must have plug-and-play properties (section 1.1), the position data is pushed to the service domain, utilizing the chosen *mobile network client.* In our case, this is a regular GSM handset. To transfer the data either WAP, SMS or GPRS can be utilized. Since the existing GSM network infrastructure can be considered standardized throughout Europe, this method for transferring data is generally applicable, adhering to the "plug-and-play" property of the system.

Within the service domain the information is being received at the (mobile) network client, which parses the received data for use by the *service logic*, which is implemented in Java [1].

The end-user can access the system through its *HTTP client,* which in turn retrieves the information from the *HTTP server* located in the service domain. The end-user's HTTP client can be connected by either a *fixed cable network* (dial-in modem, cable-modem, LAN) or by *mobile networks* (WAP, GPRS, UMTS, WIFI).

2.3 Architecture

The *service domain* from figure 2 is refined another step in figure 3, showing an abstract view of the architecture used in the first version of the BPS system, which was used in April 2003 as a pilot project. The system uses SMS to transfer the position data from the *BPS-box* (tracking device) to the service domain. Besides position data, the BPS-box also provides us with the speed and course of the tracked object. Together with this data, some time and identification data is send to the *service domain* where it is received by the *data-receiver.* This is a program which receives, translates and stores the position data in the *position database*. The position database is the central part of the service domain and is connected to three entities.

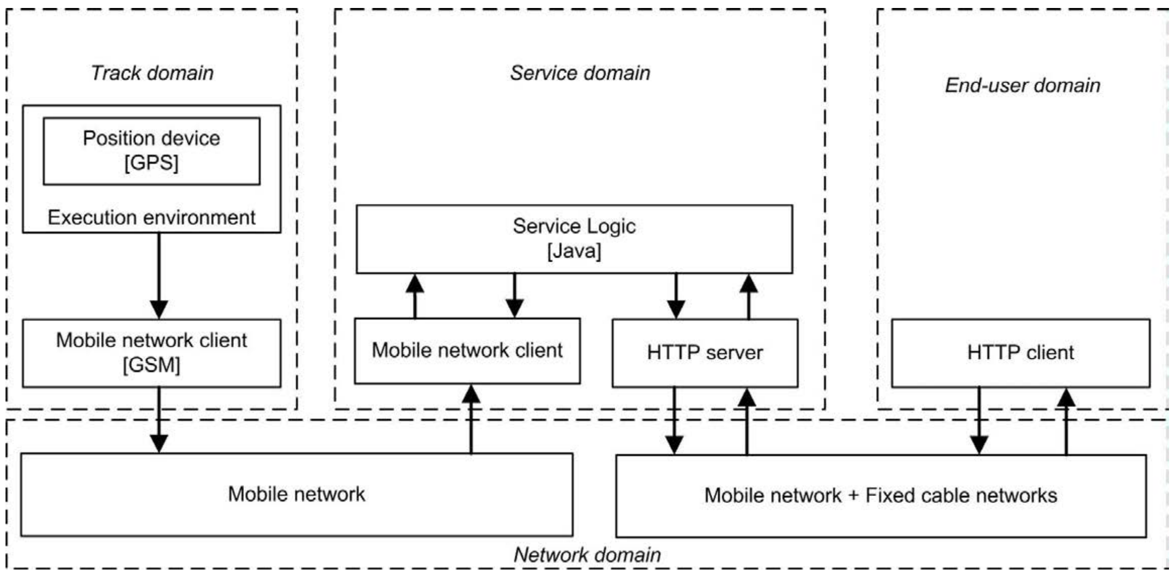

Fig.2: A refinement of the system domains

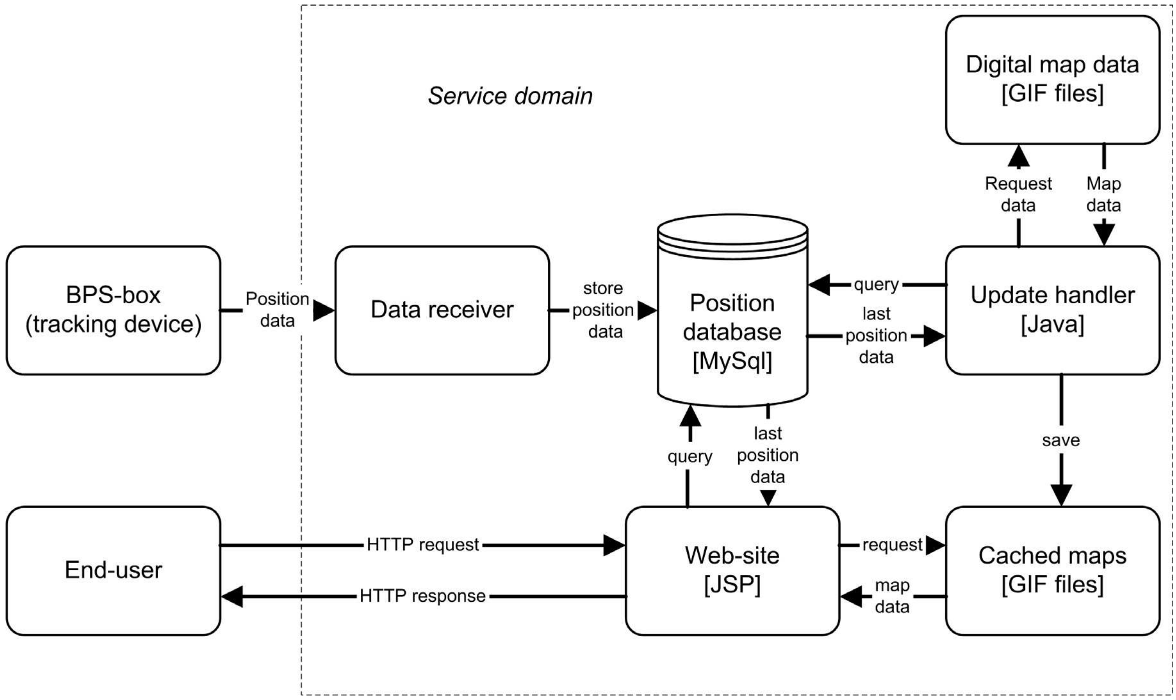

Fig.3: Depicts the architecture of BPS 1.0 system.

The *update handler* is an entity which continuously queries the position database for new (real-time) data. When new data has been found, the update handler retrieves this data and calculates which map files should be used when displaying the new positions. The digital data which belongs to this map (stored as raster data, using the gif format [3]) is then retrieved from the file system. This map data is processed in such a way that the new position will be shown centered on a map. Finally, this manipulated map data is stored back onto the file system in the cached maps entity.

This caching is performed to improve the performance of the data since it saves a lot of processing power, making the system more scalable as the map data is constructed only once instead of reconstructing the data at every request. Besides map data, the update handler is also used to calculate data like the current stage and town.

When an *end-user* requests the current positions on the website (via a HTTP request), the website will retrieve the latest positions and other information from the position database, then calculate which map data belongs to this position data. These are retrieved from the pre-processed map data stored in the cached maps.

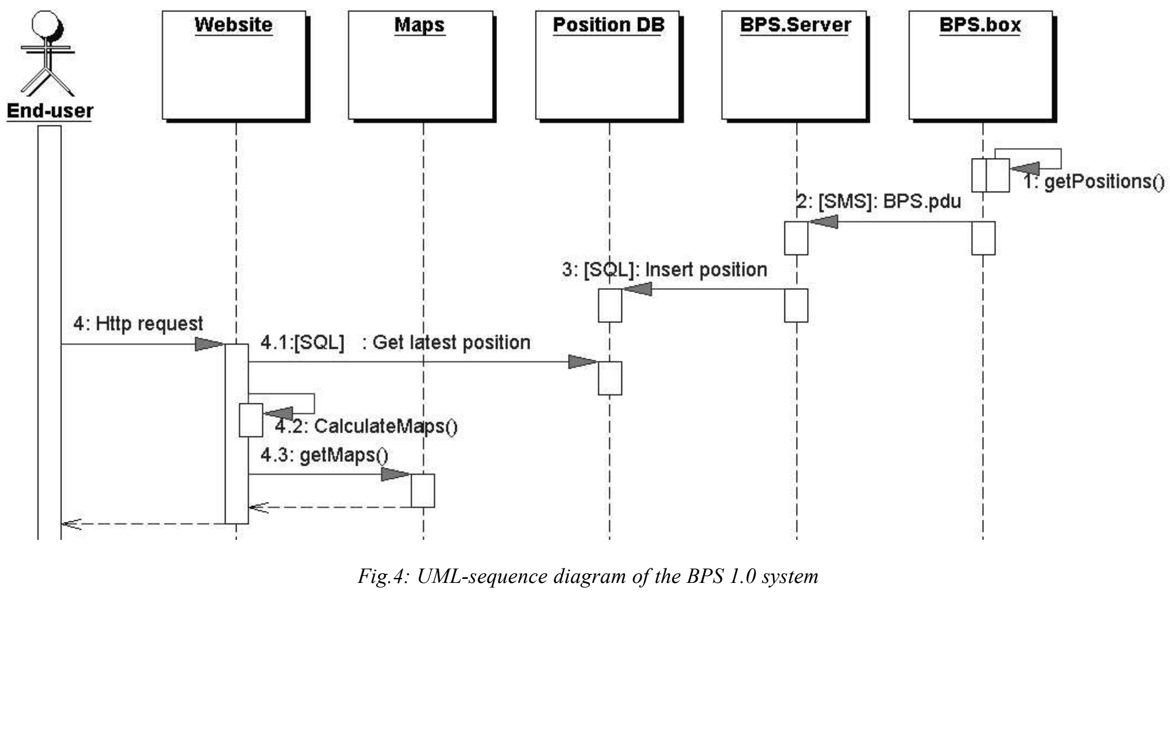

Fig.4: UML-sequence diagram of the BPS 1.0 system

Fig.5: User representation of the BPS 1.0

Figure 4 depicts a sequence in which a position is retrieved at the BPS-box, sent, then processed at the server and finally requested by and shown to the end-user.

2.5 User representation

The goal of our system is to give anyone interested more insight in the progress of the race. This is accomplished by projecting the positions onto a map. We used 2 different maps: an overview map, showing the entire route, and a zoomed map giving a close-up view of the race.

Figure 5 shows a screen shot of the actual user representation. The team selected by the user is centered in the middle of the map, represented by an arrow. The angle of this arrow is defined by the course retrieved from the position data (see section 1.3). Any other team whose position is within the viewed area is shown as a red dot.

Using the box in the bottom of the screen, a user can choose to center the view on another team, or go back to the overview map.

2.6 Pilot-project

During the pilot project, it was possible to follow the progress of three participating teams and our team-bus live on the Internet.

Because some complex database queries required the use of sub-queries, and having only a Windows 2000 server at our demands, we chose to use the MySQL 4.1.0 alpha version [9] for our database. This is a good and fast database for simple queries, but using an alpha version for sub-select functionality would turn out to be a bad choice on our part. This setup held up well during testing. During the race however database usage was much more intensive, and as soon as the number of position entries became more than a couple of thousand, the database locked up completely. Clearing the tables at regular intervals solved this problem.

Another problem we faced during the race was a lack of capacity of the BPS-box power supplies. Although we had tested the BPS-boxes under different circumstances, batteries did run out and subsequently had to be replaced during the race.

Despite these problems, our way of tracking runners and offering the collected information on the internet in real-time worked correctly, yielding a very satisfying result for us. Therefore, we have decided to continue development of the Bata Positioning System.

3. BPS 2.0

This section gives an overview of our plans and goals for the second edition of the Bata Positioning System.

3.1 Improvements

During the pilot project, the main piece of information presented to the user was a map with real-time position data along with some additional information.

It is of course possible to present a far wider array of information to the user. This is one of our main goals for the next version of BPS. Some possibilities for additional information:

- Show runner information, current stage information
- Time prediction
- Add real-time and static location based information (e.g. weather info, points of interest)
- Add additional zoom levels
- Let the user roam about the map freely

By adding these features, the level of interactivity with the end-user will also increase quite drastically, allowing more insight in the race.

Another drawback of the current incarnation of the BPS system was the relatively slow update speed of the positions (once a minute). This was mainly due to our choice of communication method: SMS. This choice was initially made on grounds of the following two considerations:

- Because the race route is close to the Dutch/German border (and sometimes across it), the Cellular network along the route does not have full GPRS coverage. Since we wanted to make sure we would not have any problems with the data-transfer, we decided to choose the most reliable way of transferring data using mobile telephony: SMS.
- For the actual implementation of our system, we only had several months available. With our hardware, choosing GPRS for our communication needs implied we would have had to implement PPP, IP and UDP in a microcontroller. This is certainly possible, but also quite time consuming. Time we simply didn't have.

Despite it advantages, simplicity of implementation (using AT-commands [5]) and its availability, there are also some major drawbacks to SMS. Firstly, you have a limited message size (max 160 chars), a limited character set (7-bits default alphabet [4]) and the price per data transfer is very high. Therefore, the BPS 2.0 system will use GPRS as its primary means to transfer data. The price per data unit is dramatically lower, allowing for far more rapid updates, and there are no restrictions on the data representation (you can use your own message format, with any character encoding). In case GPRS coverage should fail, SMS will temporarily be used to transfer data. As soon as GPRS coverage is restored, the system will switch back.

Since we had some problems with the MySql Database during our pilot project, the next version will make use of the PostgreSQL [6] database, which is more robust and has a far larger feature-set. This also allows us to make use of a PostgreSQL specific extension for GIS data, PostGis [7].

There will also be some major improvements in the BPS-box (track domain), but since that is outside the scope of this paper we will not discuss those in this document.

4 Future Improvements

This section describes some future improvements which could be made to the Bata Positioning System.

4.1 Vector based data

In order to give the user larger freedom in choosing what types of information they want to view, make zooming smoother, and minimize data traffic between the user and the service provider, we are also planning to look into using vector based data (in particular, [8]) in our system. A vector based format would also make it considerably easier for us to make changes in the map data. An example would be adjusting the data for a sudden adjustment in the route, or the removal of a checkpoint. There are, however, a couple of drawbacks associated with this technique.

First and foremost, whether or not someone is able to view a page using SVG is dependant on a separately available plug-in. As one of our goals was to create an easily accessible client, which is viewable without any barriers to the vast majority of end-users, this is not our ideal situation. The number of people with a SVG plug in installed seems to be on the rise though. It will, however, probably not become a standard web technology unless it gains the support of Microsoft, currently the market leader on the browser market. We could also opt to use a vector based format just for internal purposes and still present the output of the system as rasterized files. This would require a lot of processing power, however, and would also neglect the advantages SVG has to the end-user.

Secondly, using SVG for our entire map would be very database intensive. Since we have to be able to serve the page to dozens (and potentially hundreds) of people simultaneously, keeping database queries cheap would be one of the major challenges.

A hybrid between using conventional raster data and vector data would seem most likely, but this is something we will have to investigate.

4.2 BPS as a real-time LBS

At the moment, we have a system that provides us with the real-time position of the runners during the race and displays their positions on a map. Using the type of data we accumulate, it is also possible to give valuable feedback to the runner. As an example, the system can let the runner know when he is off the track, or let him know how close his nearest competitor is. When you offer this type of services, the system turns into a LBS (location based service), the definition of an LBS being: *mobility services that exploit the derived location of a user (specified by user, network or handset) to provide services that have a geographic context*. The BPS system is theoretically able to provide these services. In what manner the usage of Location Based Services in the BPS system will be implemented has to be investigated more thoroughly. Part of this will consist of changes in the software, along with the use of hardware like PDA's. In this context one can take a look at the bachelor thesis from Ekkebus [2] where the usage of LBS in a real-time positioning system is discussed.

5 Summary

The BPS system combines several off-the-shelf components and combines these into a highly efficient and powerful application. The BPS system is developed with a focus on the service domain (*figure 1*), and will stay focused at that domain since the track domain will always be dominated by electronics-manufacturers.

Altogether the BPS system is a low cost and scalable system, making it possible to track many objects simultaneously and display their positions on the Internet in real-time. Although the system still needs development and fine-tuning and can be improved in many ways, we think we developed a solid basis for a system that certainly possesses growth potential.

6 Acknowledgements

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7 Links

Bata Positioning system project web-site: http://eleanor.student.utwente.nl/bps
International Institute for Geo-Information Science and Earth Observation: http://www.itc.nl
Database group University of Twente http://db.cs.utwente.nl

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Bridging the Gap between LBS, GeoVisualisation, and Decision Support

Gennady Andrienko and Natalia Andrienko, Sankt Augustin

Mobile devices are widely used now in the context of location-based services. People often consult their mobile phones, PDAs or mini-laptops (sub-notebooks) for obtaining navigation information, getting an overview of closer surrounding or information about specific objects, calculating optimal driving route, acquiring trains schedule etc. Another application is field collection (verification, update) of data. Some services for on-line information access are available. For example, one can request a list of nearby restaurants, select one, and book a table. These services are usually based on information about the location of the person.

There is another valuable kind of information that can be made available easily: a history of positions of the person and his actions (requests for information and services). This history can be used for making the mobile services more focused and useful. For example, the routing system can take into account the speed and duration of the movement, moments and locations of stops etc. The system that recommends restaurants can use the information when the user ate last time, at what time he usually eats, and what types of restaurants he used to visit. Of course, privacy concerns should be taken into account.

Another direction of improving mobile services is in use of visualization and interactivity. Currently graphics, mostly in the form of maps, is often used for presentation of results. Usually these maps are bitmap images pre-stored on the device or acquired from a server on request. In some cases the bitmap images are enhanced by SVG or Java vector information: drawing a street route as a line with texture, showing locations of some objects by icons etc.

Numerous restrictions of mobile devices limit possibilities to use graphics in applications. These limitations are:

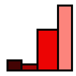
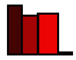
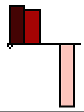
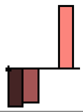
- Slow CPU;
- Small amount of memory;
- Small screen size and low resolution;
- Limited interaction possibilities;
- Low bandwidth of network connection.

However, fast development of hardware and communication technology allows us to expect that in the nearest future mobile devices will have parameters similar to today's desktop computers. This will make possible to use mobile devices for new tasks and problems. In particular, we foresee expanding possible usages from information access to data analysis, problem solving, and decision making.

Therefore we expect that in the nearest future several directions of information visualisation and interactive data analysis will become the important topics in the LBS world. Let's consider a typical task of a mobile device user: selection of a hotel in some city not visited before. Currently this task is supported by a possibility to specify a query to a service provider posing a set of restrictions (location, quality, price etc.) with further selection using a map of locations combined with information screens about each individual hotel. More advanced technology could significantly improve this procedure.

- It is very difficult to formulate a "reasonable" query in an unknown situation, e.g. a typical range pf prices in a particular city or time period. Too strong requirements will result in empty responses, while too relaxed queries could result in thousands of options that is long to receive and difficult to analyse. Therefore it would be very useful to get some information about distribution of values of attributes before formulating a query. Graphical displays like histograms could be used for this purpose. The optimal solution could be the dynamic query engine that provides an immediate feedback after précising or relaxing each element of the query.
- It should be noted that the selection problem involves multiple conflicting criteria. Usually increase of quality results in higher price etc. Therefore an alternative solution seems to be more suitable: the user can specify the desired characteristics of hotels instead of posing restrictions. In response, the system provides him a list of options similar to his request or better. Taking into account tolerance could make the system more efficient (for example, proposing a 5-stars hotel for 100 EUR if the request was for 3-stars not more expensive than 95 EUR).
- Characteristics of the selected subset of options could be presented visually. Thus, instead of putting icons on the map, the system could use utility bars that demonstrate how good each option in respect to all criteria is. Interactive

manipulation (for example, visual comparison of options by clicking to a reference option on the map) can greatly facilitate the selection process and support more effective decision making.

	Option A	Option B
Initial appearance of the symbols (no comparison)		
Comparison to option A		
Comparison to option B		

Tab.1. "Visual comparison" using utility bars.

Of course, there is a need in modification and adaptation of the methods for specific categories of users of mobile devices, their tasks and information needs, computer skills. However, it is clear that transition from information services to decision support has great potential.

Prototypes of the visualisation and decision support services will be demonstrated at the conference.

Appendix

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