Snap4city Platform: Semantic to Improve Location Based Services

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Abstract. Location-based Services are becoming crucial in the most recent smart city scenarios, when, according to scholars and urban planners, one of the main objectives is to improve the living conditions of citizens who act and move within an urban or regional area. This work-in-progress paper aims to present the Snap4city platform, an infrastructure capable of collecting large geographical and statistical data from different sources, to integrate them into a semantic and is compliant with the Km4City multi-ontology and finally provide LBSs for multiple users. The Snap4City platform is currently running in many geographical contexts (such as Antwerp, Helsinki, Santiago de Compostela, etc. Italian cities such as Florence, Cagliari, Pisa, Livorno, Modena, Bologna, etc. and entire geophysical zones: Finland, Belgium, Tuscany, Sardinia, Garda Lake, etc.). This allows the authors to present preliminary results for system validation.

Keywords. Smart City, Big Data; Geospatial Ontology, Geospatial APIs

1. Introduction

The amount of information available today is such that issues relating to the quality and significance of it must be addressed already in the designing of an architecture supporting the smart city. Reference scenarios must be well defined to analyse the specific needs of citizens and their behaviour and the actions that contribute to achieving them. Within these scenarios the georeferenced information is crucial in order to get context-sensitive description and analysis of emergent local practices. Add to this that each city is to solve their specific problems, due to its geographical position, its geomorphology or history and culture that make it a *unicum*. For these reasons,

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even though digital and technology-driven approaches are often considered in literature as a universal solution, when it is intended to replicate a model in different cities, individual specificities must be taken into account and therefore develop strategies that may get inspiration from other contexts but are as unique and specific as the city itself. In this logic, the experimentation conducted in different urban and regional areas through Snap4City architecture highlights the paradigm shift, since it does not adopt a simply technology-driven but more specifically data-driven approach. Big Data, open data, sensors, IoT/IoE for monitoring, controlling and managing urban developments, resources, urban infrastructures, energy consumption, traffic congestion, waste, pollution, risks and people, are the tools for a governance inspired by a data-driven urbanism, according to which the expected changes are a consequence of a decision-making process. (Acuto et al., 2019). The nowadays availability of geospatial knowledge and the worldwide generation of geospatial data allow to design services that can support decision making and help to find solutions to daily life problems. However, “the lack of explicit semantics inhibits the dynamic selection of those data, services, and geoprocessing workflows needed for processing geospatial information and discovering knowledge in a data-rich distributed environment” (Yue et al. 2011). An ontology-based approach allows the representation and semantic interoperability of geospatial data and related processes. The integration of semantic information makes LBSs intelligent and able to enhance a smart city. In order to cover all these aspects and manage the large amount of data coming from different sources, from the Smart Cities Open Data Portals to the IoT/IoE connected devices (sensors, actuators and various agents rapidly increasing in number in a smart city context), a Big Data approach is necessary. One of the most innovative tools, is to flank to a Big Data Platform, the possibility of aggregating data at a semantic level allowing data to communicate among themselves. Thus, the aggregated data, can be used to extract new knowledge and develop services for citizens increasingly performing and focused on their needs. In such a context a Big Data Platform must be compliant with: i) Data Precision in terms of Geospatial representation and timing; ii) Semantic Data Aggregation; ii) Scalability in terms of data stored/managed and services provided; iv) Guarantee of different Privacy Levels.

2. Snap4city Architecture

The Snap4City infrastructure respects all the requirements above described. Snap4City is a Big Data Platform compliant with the KM4City multi-ontology, managing and aggregating data from EU cities and regions.

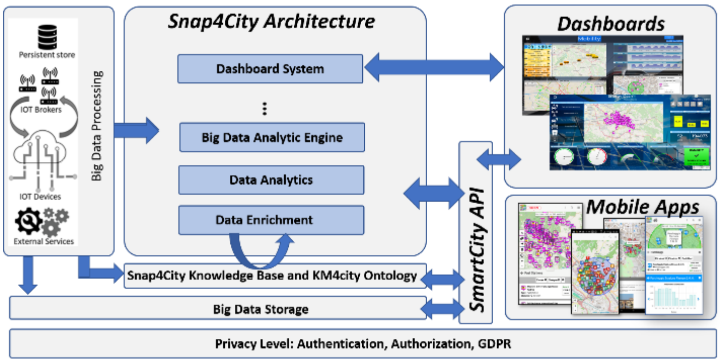

Figure 1. Snap4City Architecture.

In Fig. 1, the Snap4City Architecture is depicted. The starting point is the Big Data Processing (harvesting, formalization, geo-localization enrichment, storage, etc.), all the ingested data are aggregated and collected in the Snap4City Knowledge Base, in compliance with the Km4City multi-ontology (Bellini et al., 2014), and indexed in order to speed up and facilitate data retrieval. A such semantic aggregation of data poses the basis to provide LBSs to the final users, always at the forefront both in terms of functionalities offered and of performance achieved. These activities are included in many European (Snap4City, TRAFAIR, Replicate, etc.) and national (Sii-Mobility, Ghost, MOSAIC, etc.) research projects. Thus, the aggregated data can be Analysed and used to produce Smart LBSs by generating predictions and suggestions for final users. The Snap4City solution allows to ingest and manage Big Data coming from different providers, External Services, OD Portals, ArcGIS Enterprise Servers, IoT/IoE devices, applications and services, and finally provides LBSs, available to the final users thanks to the set of visual tools developed. A Dashboard System allows all registered users to easily create a set of different thematic dashboards (weather, mobility, energy, etc.), respecting user authorizations and privacy level on the data (Snap4City is GDPR compliant). These interactive dashboards support decision-making processes for: Public Administrations, tourists, citizens, developers, etc. Moreover, Snap4City allows the creation of data-driven applications: based on Microservices, exploiting mobile and web apps, flows of processing data and IoT data (Bellini et al., 2018; 2019).

3. Km4City Multi-Ontology

The need to standardize and aggregate data becomes increasingly necessary in a Big Data context, for this reason the Snap4City solution is based on the Km4City multi-ontology. The development of Km4City started in 2013 to interconnect the data provided by the Tuscany Region, the Open Data of the City of Florence (Static and Real Time). Some notable works included are:

(i) the Ontology of Transportation Networks (Lorenz et al., 2005); (ii) the Semantic Sensors Network Ontology (Compton et al., 2012); (iii) the IoT Lite Ontology (Bermudez-Edo et al., 2016); (iv) the Schema.org Ontology (Hernich et al., 2015), that now also includes the GoodRelations project. Km4City enables interconnection, storage and the retrieval of heterogeneous data from many different sources. Its main sections are: (i) *administration*; (ii) *road infrastructure*; (iii) *POIs*; (iv) *public transport*; (v) *Internet of Things (IOT)*. Predictions and early warnings, mobility planning, multimodal routing, resiliency, are just a few of the challenges that can be faced to improve city governance and people behaviours, and therefore citizens' quality of life, tourists' satisfaction, environmental sustainability. On the other hand, IoTApps are required to: (i) collect huge amounts of heterogeneous data at real-time; (ii) be resilient and ensure safety, security and privacy of distributed data and communications; (iii) enable machine learning and data analysis; (iv) enable effective data displaying (Badii et al., 2019). The Km4City Ontology also includes a set of concepts for modelling real-time status and predictions and a flexible modelling of IoT/IoE entities has been achieved, introducing *IoTSensor* and *IoTActuator*, and *IoTBroker* with its specializations *NGSIBroker*, *MQTTBroker*, etc. Types of measurements and managed input signals are modelled as *DeviceAttribute* instances, each having a *value_type* property filled by an SSN *Property* (Compton et al., 2012) that allows to distinguish devices that measure temperatures from those that measure traffic flows and so on.

4. Snap4city Location-Based Services

LBS are largely dependent on the data coming from IoT/IoE and from the mobile user's location: understand where the user is and what are his/her needs, is one of the primary objectives of a service provider system.

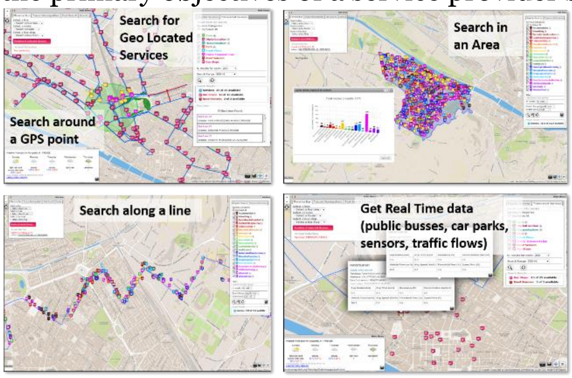

Figure 2. Snap4City Geographical searches.

Some of the most common LBS applications include: POI, local events, multimodal routes, emergency, asset tracking, weather forecast, statistics, previsions, etc. All the services can be requested by the users (pull) or sent to them in form of recommendations (push). The Snap4City most common LBS requested by the users could be services: i) around a user (GPS point); ii) in a specific geographical area described (e.g. a polygon in Well-known text format); ii) among a line; iii) related to the Public transport lines, routes, timetables, etc. (Fig. 2). The Snap4City Recommendation System is capable to establish what are the user needs and sending them suggestions basing on their position in the city (via Mobile Apps, totem, etc.).

5. Conclusion. Snap4city Validation Scenarios in Smart Cities

The Snap4city platform is currently used in many cities and regions. The Snap4city APIs allow accessing all this information from different applications. Some mobile applications have been developed (e.g. Helsinki in a Snap, Antwerp in a Snap and Tuscany in a Snap) to leverage all these geographically annotated information and provide useful services to the citizens or tourists on the move from their mobile phones (find services nearby, time tables, heatmaps of pollution or weather conditions, etc.).

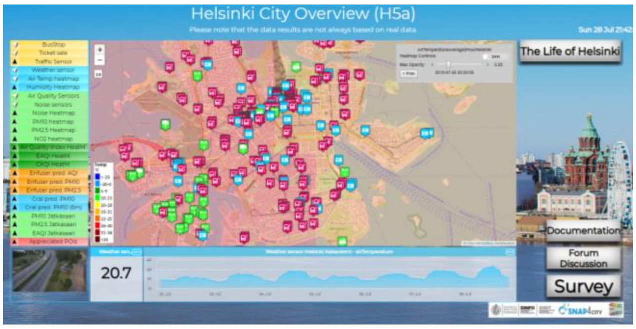

Figure 3. City of Helsinki dashboard

The platform allows building custom dashboards using the data coming from the city. The dashboards can use maps allowing users to locate services and access to data associated to them, such as that developed for the city of Helsinki, Fig. 3. The experimentation of the platform in the context of the Select4Cities project is currently in progress (July-October 2019) testing the Snap4City tools in Helsinki and Antwerp cities. Table 1 reports the Snap4city geographical search APIs use, in different cities in the month of July 2019. Most of the APIs used are related to geographical searches (93%) and performed in a circular shape; while searches in a rectangular area reach the 6.5% of total. The advanced searches inside a complex polygonal area or along a path cover the 0.13% of the requests.

Geo search Type	N. requests	
Coord & radius	445,608	93.32%
Rectangle	31,248	6,54%
Polygonal area/path	655	0,13%
Total	**477,511**	

Table 1. Snap4city geographical search API.

6. Acknowledgement

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