Digital Twins of Natural Resources in the Loire Valley

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Abstract

The Loire Valley is **one of the most emblematic natural environments in central Europe**. We present the design of a Digital Twin for the management of its natural resources. A conceptual approach to the data architecture and component integration is shown by describing represented resources, data sources, use cases and functions. Such a holistic approach enables easier study, management, understanding and prediction of natural resources and their relationship with human activity, crucial aspects for societal and industrial planning, Our work constitutes a precedent for the development of regional Digital Twins consistent with environmental research standards.
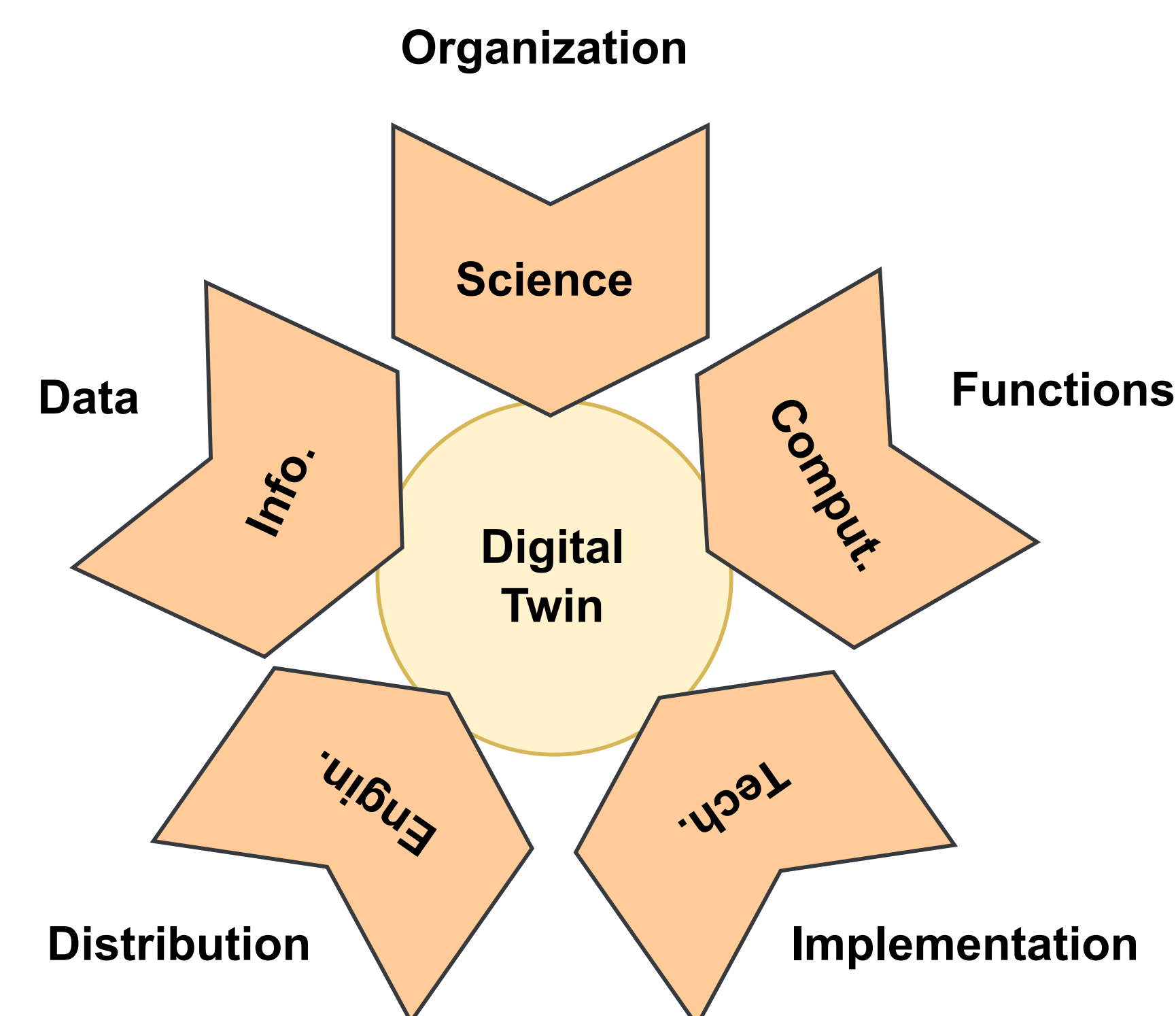
The Loire Valley

The Loire Valley region encompasses natural landscapes, with rivers, farmland and forests, which dominate more than half of the French territory. The Beauce water table is the largest in Europe, and the Beauce plain is the **first cereal-growing region in France and Europe**.

The ENVRI Reference Model

Alignment with the Environmental Research Infrastructures Reference Model [1] facilitates **interoperability** between infrastructures, future reuse, resource sharing and **field standardization**.


JUNON (Organization)

The JUNON program aims to establish a **digital research center** of the Loire Valley including agriculture, urban development, forestry, and river ecosystems. JUNON involves multiples research organizations: BRGM, CNRS, Centre INRAE Val de Loire, Univ. of Orléans, Univ. of Tours, the DREAM water and environment competitiveness cluster, the Agreen Tech Valley cluster, Orléans-Val de Loire Technopôle, and LE STUDIUM IAS.
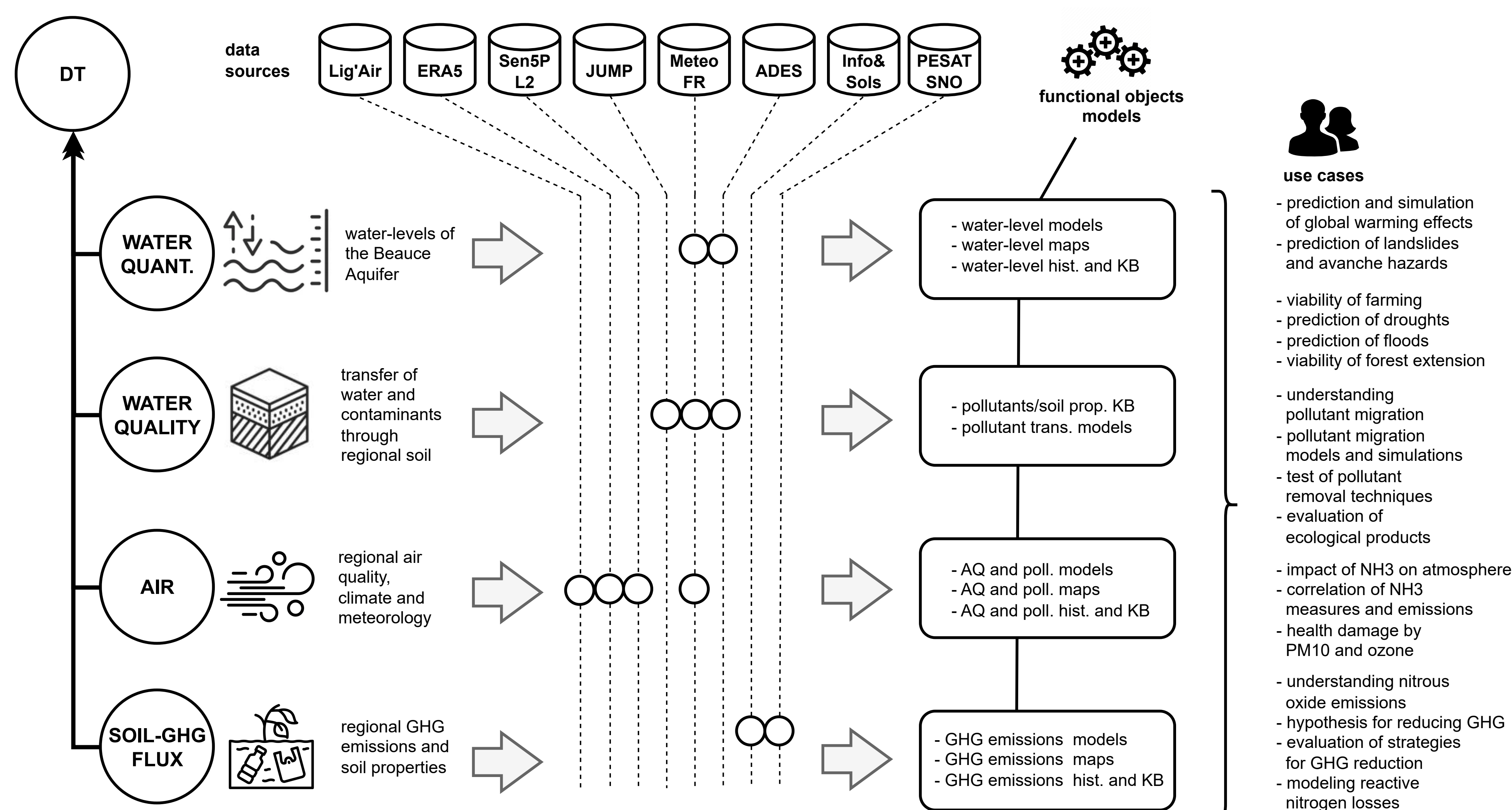
https://www.brgm.fr/en/programme/junon-digital-twins-working-natural-resources

Distribution

The operational schema below shows a DATA network allocating **core elements** of the Digital Twin, i.e., analysis results, aggregated data, summaries, precomputed data, validated models, and high-quality benchmarks.
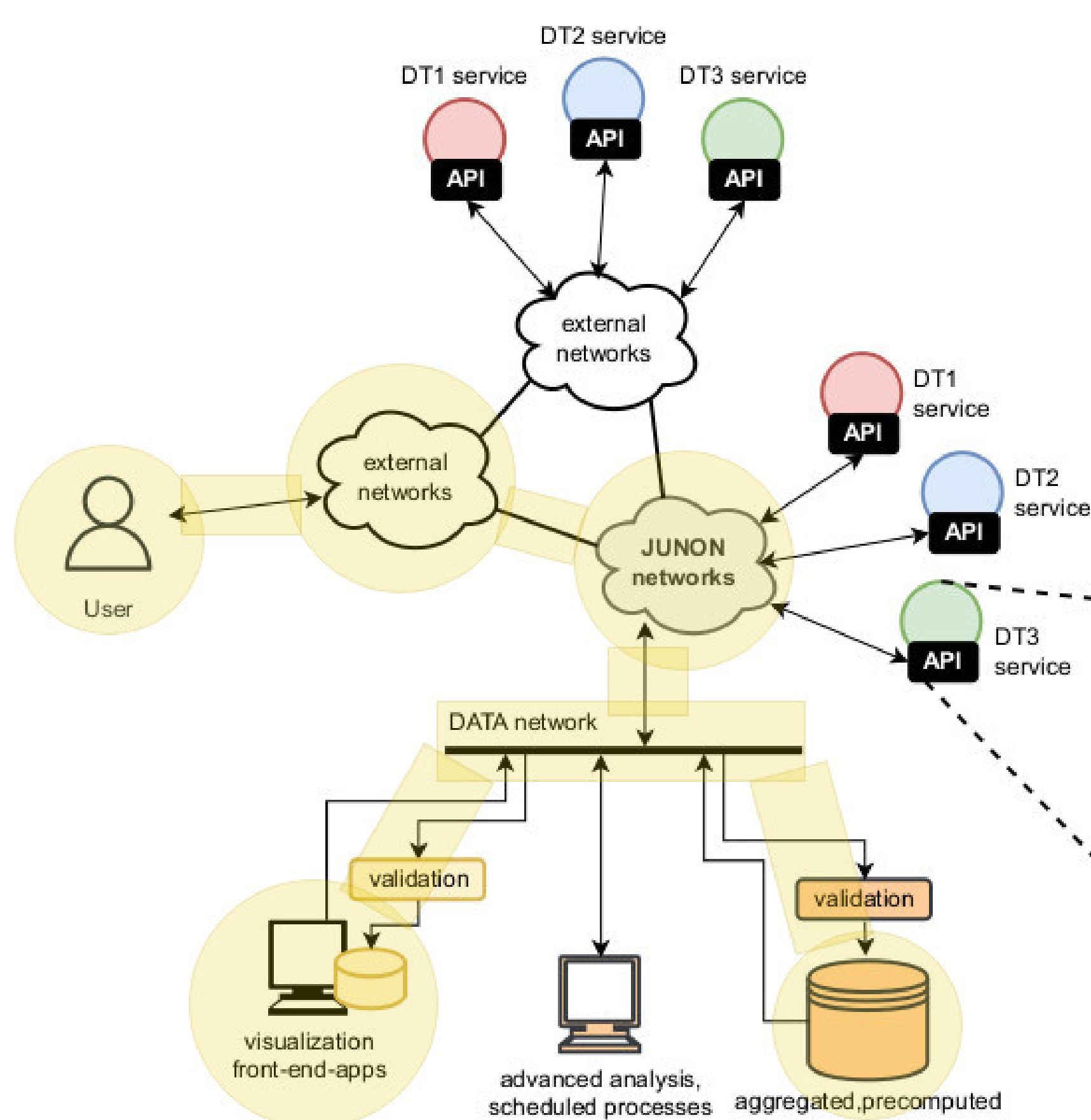
Data & Functions

* KB: Knowldge Base, hist.: historical, poll.: pollutants, prop.: properties, trans.: transportation, AQ: Air Quality, GHG: GreenHouse Gases (N_2O, CO_2, CH_4)

The DATA network also contains components to run scheduled tasks, advanced analysis and resource-costing AI processes (GPUs, clusters, etc.). It connects to specific services and dedicated external and internal networks to JUNON through APIs.

Main underlying technologies are: **FIWARE** (data integ. platform), **MongoDB** (unstructured databases), **NGSI-LD** (info models), **Python** (prog. lang.)

Functions & Implementation

Users access the Digital Twin through a system composed of:

- Three-layer **Front End**: Visualization, Applications & Data,

- Three-layer **Back End**: Face (main operations), Limbs (data retrieval), Back (maintenance, configurations, scheduled tasks).
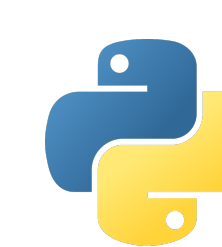
References

[1] Nieva de la Hidalga, A., Hardisty, A., Martin, P., Magagna, B., & Zhao, Z. (2020). The ENVRI Reference Model. In Z. Zhao, & M. Hellström (Eds.), Towards Interoperable Research Infrastructures for Environmental and Earth Sciences: A Reference Model Guided Approach for Common Challenges (pp. 61-81). Lecture Notes in Computer Science; Vol. 12003. Springer.