CitySPIN

Cyber-physical Social Systems for City-Wide Infrastructures

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ICT of the Future (IKT der Zukunft) Program

Cyber-physical systems (CPS), i.e., systems that link physical and virtual objects and processes across information systems, have started to diffuse into many areas, including public transportation and energy services which affect the lives of numerous citizens that rely on them on a daily basis. An emerging development is the growing recognition of the importance of the social dimension of such CPSs and of the need to evolve them into **cyber-physical social systems (CPSS),** in order to better address the needs of the human actors in these systems. Such systems span the physical (e.g., sensing and actuating hardware), cyber (e.g., monitoring and optimization algorithms)

Figure 1: Typical structure of a CPSS.

and social spaces (including users and maintainers of the system) alike (Fig. 1).
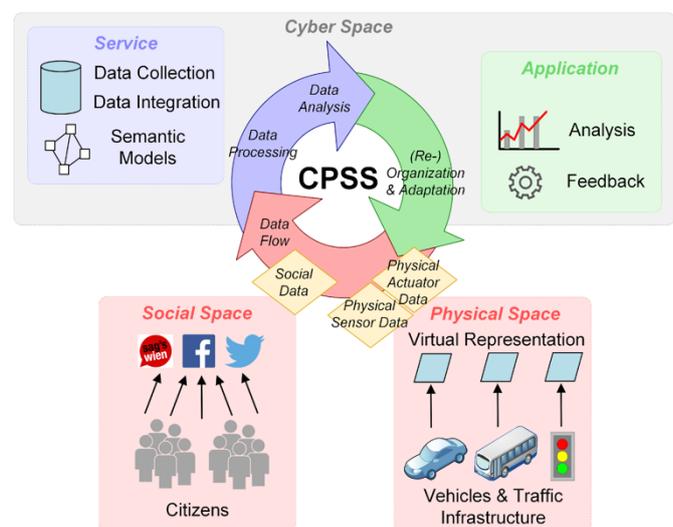
The **CitySPIN** project advanced the **theoretical and practical foundations** for effective CPSSs engineering and validated these findings in **two high-impact use cases** provided by Wiener Stadtwerke, which operates Vienna's energy and public transportation networks. Key highlights include:

- Theoretical **understanding of the CPSS concept** based on extended literature reviews, which led to the elicitation of CPSS types, the description of a CPSS architecture pattern and core design concepts as well as CPSS ontologies.

- **Scalable data integration methods** and architectures based on advancements of Semantic Web and Linked Data technologies

- A **framework for privacy-aware data access** to ensure compliance with the EU General Data Protection Regulation (GDPR) including: (i) policy language syntax and

semantics; (2) methodologies for companies that operate CPSSs to ensure transparency; (iii) representations of encrypted datasets for multiple users with different access rights.

- Advanced **process mining algorithms** and their adaptation to function on semantically represented data in order to identify social dynamics.

Two demonstrators were implemented to address high-impact use cases at Vienna's main utility provider. In the transportation domain (Wiener Linien), we developed a dashboard to support mobility planners in improving the responsiveness of the transportation network schedules during large events (see Fig. 2). A key benefit was achieved by extracting and semantically integrating data from several sources (unstructured documents, internal data, open data, social data) to provide planners an integrated view on all data relevant for planning. In the energy domain (Wien Energie), semantically integrated data was the basis for a number of demonstrators that supported Wien Energie data scientists in investigating which social characteristics have an impact on energy usage.
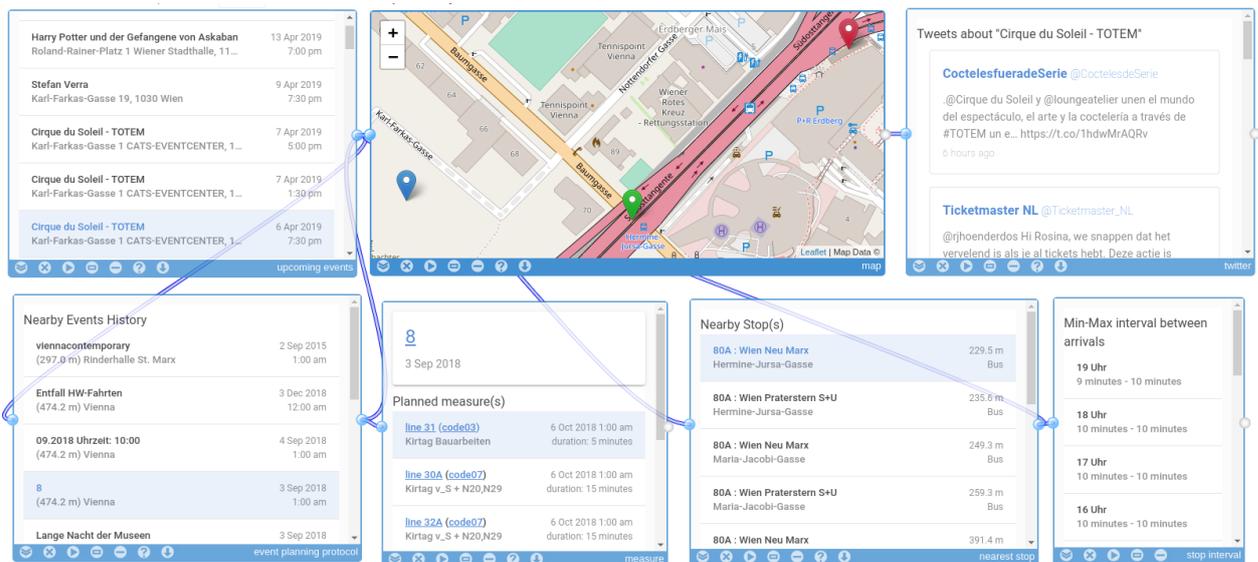

Figure 2: Dashboard for supporting transportation network planners at Wiener Linien.

CitySPIN led to over 25 peer-reviewed papers, numerous international collaborations, intense teaching activities and several follow-up research projects. The participating companies benefited by (i) developing capabilities for addressing new markets; (ii) rethinking internal data infrastructures; (iii) identifying new potential services and innovation directions. The project was also presented in front of the city of Vienna representatives providing lessons learned from the project use cases for further modernizing Vienna's city-wide infrastructures.

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