Prototype for the Analysis and Visualization of Data for Municipal Parking Management as a Cloud Service

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Problem/Goal

Data is an important resource for future mobility and municipal parking management. Many cities already have broad datasets, however, these are usually insufficiently integrated in analyses. Municipalities are trying to figure out how to utilize their data for parking management and traffic control. But Public administrations often lack the necessary human and infrastructural resources to implement their own data evaluations, forecasts and models.

The organizational structures in municipal administrations often make it difficult to collect and view city-system-mapping data across disciplines. Therefore, on the one hand, municipalities need knowledge about existing data sources within municipal administrations to link information in a meaningful way. On the other hand, there is a need for collaboration tools that promote interagency collaboration in data analysis and that do not require advanced infrastructure, such as data centers with information technology (IT) experts.

For high-performance systems, the simple scaling of resources and to reduce maintenance effort, cloud based offers of hyperscalers such as Amazon Web Services, Microsoft Azure, Google Cloud Project, or SAP Queries and other cloud service providers have become increasingly popular in recent years, also in the public. The solutions of these providers consist of individually bookable modules that fulfill various functions from data collection and storage to analysis and forecasting. In many cases, the first challenge is selecting the right combination from the large number of modules with very similar functions. Furthermore, the analysis tools are often rather generic in order to appeal to a broad mass. Occasionally, there are very special, industry-specific tools that do not respond much to the specific needs of municipal stakeholders. Although custom applications can be developed in addition to the supplied analyses and machine learning (ML) models, many municipalities lack the necessary artificial intelligence (AI) experts to do so. In addition, the solutions offered partly lack the necessary transparency about the methodical traceability of data evaluation and compliance with data protection regulations.

For this reason, Fraunhofer IAO is developing a prototype of a cloud service that provides municipal actors with relevant information on the control and management of parking space based on their supplied data. The service offers functionalities to visualize municipal (mobility) data in an appealing way, enrich the data with publicly available data and offers analysis options, which also allow for integrated investigations and data grading.

The aim is to show municipal actors the added value and potential of their data and to enable them to carry out their own evaluations.

Methodology

In the context of service development, an agile and user-centered approach is chosen. The cloud service is to be developed according to the Scrum method. To meet these requirements, the interdisciplinary development team of Fraunhofer IAO has designed a two-stage procedure: In a first step, personas of departments in the municipal administrations for which the use of such a cloud service will be designed are created based on expert interviews. User needs are identified, and functional and system requirements are derived from them, which are recorded in a product backlog.

The second step consists of the prototype development and testing. According to the agile scrum method, the defined functions of the service are categorized, subdivided into sub-modules and assigned a priority level. In subsequent sprints, developers independently assume responsibility for processing individual elements of the backlog, or sub-modules, in the areas of programming, testing and further development. The innovation process is accompanied by experts from municipal administrations, politics, parking operators, technology providers and data specialists, who give feedback on the modules and can act as test users.

Results

Overall, data analysis skills are generally assessed as low to moderate within the municipal departments. Therefore, it is planned to design the cloud service in such a way that it does not require any programming knowledge and can also be used by beginners. In total three main components were identified, which the prototype shall provide. These are described as building blocks below:

Building block I – data upload and integration of external data sources:

Users shall be able to upload their own municipal data via an upload function, which will be stored in a cloud. By means of checkboxes, users shall be able to manually classify the data before uploading it. In addition, it shall be possible to import external, freely available data sources via interfaces to open data portals (e.g. OpenStreetMap®). Furthermore, users shall receive information on data storage and processing. It shall be possible to delete individual personal data on request without having to remove entire databases.

Building block II – data and user management:

Before using the cloud service for the first time, municipal stakeholders shall have to register, which creates a user profile. The personal area shall provide an overview of already uploaded data as well as own and shared analysis results. Inter-agency communication and collaboration is to be promoted through user management, which can be used to create groups, assign authorizations for individual persons and departments, write notes and assign tasks.

Building block III – data analysis and visualization:

The unique selling point of the prototype developed is to be found primarily in the tailored analysis functions that can be used to answer specific questions in the context of parking management (e.g. Where in the urban area is a particularly high parking pressure at a specific time?). Classical statistical methods (descriptive and explorative methods) as well as AI and ML methods will be used to analyze the data sources. A special focus will be placed on the descriptive visualization of data and analysis results. For example, municipal data often have a spatial reference, which makes the presentation in maps particularly suitable. In addition, users shall be provided with assistance that facilitates the interpretation of the results by highlighting heavily weighted samples in supplied data and offering comprehensible in-depth explanations to applied methods. Furthermore, the interpretation shall enable recommendations to be made to political decision-makers (e.g. Where in the urban area could applications for the designation of new residential parking zones be successful?). The export of the analysis results will be ensured by a reporting function.

Due to the modular design with microservices, further functionalities and analyses can be added. All these microservices are strongly oriented towards municipal needs and can thus be applied in a targeted manner without further adjustments by data scientists, or similar. In the beginning, the use cases are defined from a test in one city, and new needs and requirements are continuously derived in an intended, close collaboration with municipal users.

Following the prototype development, the service must be tested in a city and different departments in a subsequent step. Here the focus lies on the effects on collaboration between departments and the impact of the service on them, while the quality of the analyses is continuously improved in the background.

The importance of a user-centric approach is already becoming apparent. Thanks to many years of cooperation with municipalities in the field of data-supported parking management, as well as the expert interviews in the beginning, the Fraunhofer IAO team is highly familiar with the needs of municipal actors and includes them in the prototype development. This ensures that the prototype meets the requirements of municipal actors and increases their acceptance for the use of the cloud service.