Data-Driven Waste Management

Degree programme: BSc in Computer Science
Specialisation: Digital Business Systems, Data Engineering, Data Engineering
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Municipal public waste collection must balance service quality and cost efficiency. Building on a previous pilot for structured data collection, this thesis develops a Business Intelligence platform to examine the analytical value of operational waste collection data for decision support in the City of Biel, using synthetic data in the absence of historical records.

Context

Public waste bin collection in Biel relies heavily on the experience of the Street Inspectorate's staff. This works in practice, but provides only a limited basis for data-driven analysis. A preliminary proof of concept validated a mobile app for structured data collection during regular collection work. However, before a rollout to all bins, the practical value of the collected data must be examined. This thesis investigates how the recorded observations can be translated into decision-relevant information for the City of Biel.

Implementation

As no historical operational data were available, a synthetic data generation component was developed. It generates realistic operational events such as bin visits and fill-level observations. The data is processed in a PostgreSQL database landscape through an ETL pipeline, which ensures data quality through validation and plausibility checks, performs calculations and enriches the records with contextual information such as weather and municipal events. The BI platform was implemented as a web application with a Java/Spring Boot backend and an Angular frontend. The overall system architecture is shown in Figure 1.

Result

The result is a functional BI prototype that makes the processed operational data accessible through several analytical views. These include a dashboard with key metrics as well as map and detail views for collection tours and individual bins. Rule-based indicators flag bins for prioritisation, while heatmap-style views visualise spatial patterns and potential inefficiencies in collection. The evaluation with the Street Inspectorate showed that the prototype turns collected data into clear, practically relevant insights.

Outlook

A rollout of the data acquisition approach would provide data to further align decision support with daily operations. The BI application could be extended towards predictive or prescriptive decision support. Potential directions include fill-level prediction and optimisation of collection routes. Further potential lies in connecting additional data sources such as tour information from GPS data and other contextual data such as public holidays and population density.

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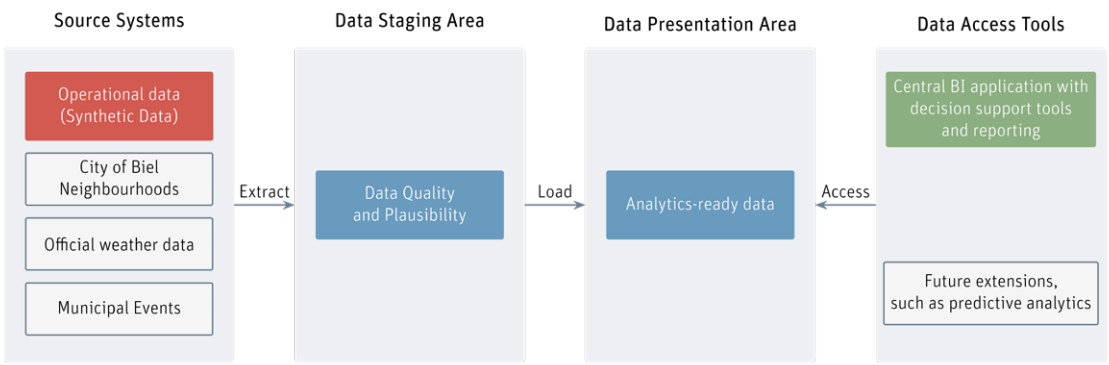

Figure 1: System architecture, based on Ralph Kimball and Margy Ross's «The Data Warehouse Toolkit»