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USING MICROSERVICE ARCHITECTURE IN INTELLIGENT PUBLIC TRANSPORT TRAFFIC MANAGEMENT SYSTEMS

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Rapid urbanisation and the saturation of transport infrastructure create a need for cities to adopt flexible digital solutions capable of handling large-scale data streams in near real time. Traditional monolithic approaches do not provide the necessary scalability, fault tolerance, or speed of deployment, making them unsuitable for dynamic urban environments that require continuous updates and rapid adaptation to changing mobility conditions.

By contrast, a microservice architecture, combined with web technologies and contemporary analytics, enables the development of manageable, transparent, and reproducible systems for traffic flow management at the urban scale. Decomposing the platform into independently deployable services supports horizontal scaling, increases system resilience, and simplifies the integration of heterogeneous data sources. Such an architectural configuration offers a coherent basis for aligning data acquisition and integration with their analytical interpretation and visual representation, creating a robust foundation for modern, city-level traffic flow management.

The development of the conceptual model was carried out as a sequential architectural design process with the recording of key artefacts [1]. The architectural solution followed a “context → containers → components” approach: microservices were delineated for integration with municipal APIs (data ingestion and dissemination), data processing and aggregation (validation, normalisation, and consolidation of indicators), an analytics module (calculation of indicators and support for forecasting algorithms), a visualisation module (maps and charts for presenting results), and a service for access and configuration management (centralised settings and access rights). For each microservice, public interfaces and message exchanges were specified, thereby ensuring the independent evolution of components and their scalability.

Data processing was organised in two logical modes essential for system operation: an operational mode (ingestion and basic aggregation to produce current traffic indicators) and a periodic mode (reconciliation and summarisation of data for analytical computations and the construction of aggregate metrics). Consistency of indicators was ensured through unified metric definitions and deterministic calculation functions, enabling the results to be reproduced given comparable sources of municipal data.

Visual analytics was implemented as the presentation of processing results through cartographic representations and time-series graphs, enabling the interpretation of spatio-temporal patterns in traffic flows and the outcomes of analytical computations.

To provide a coherent representation of structure and information flows, a domain ER diagram (Figure 1) was created (routes, stops, vehicles, traffic events, indicators/forecasts, users/roles, configurations) and Level-0 to Level-2 DFDs (Figure 2) (the principal channels for data ingestion, processing, and delivery). Taken together with interface specifications and data format descriptions, these diagrams ensure that the proposed model can be reproduced by other researchers under comparable conditions.

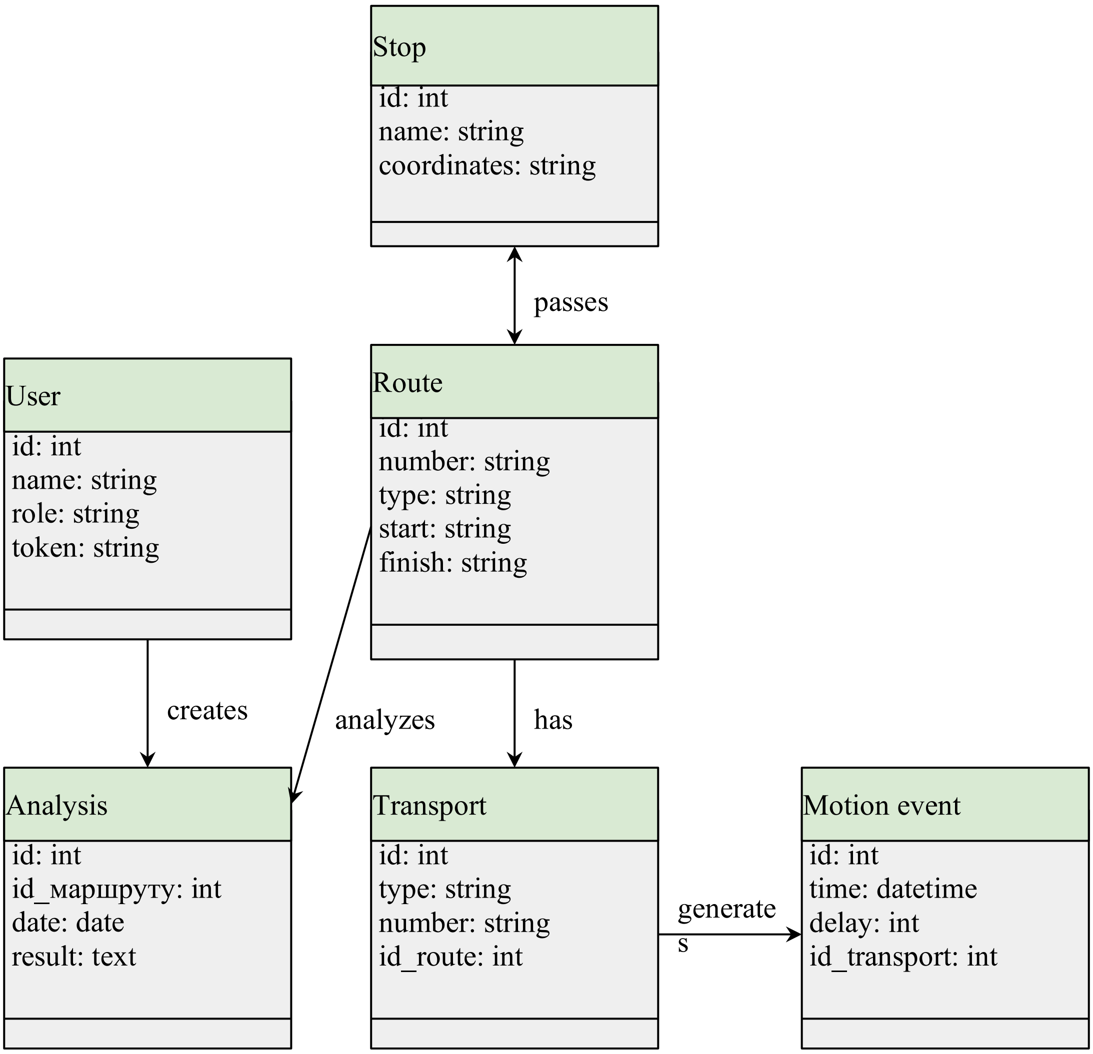

Figure 1. ER diagrams of the databases

The ER diagram depicts the structure of the database that stores information on transport routes, vehicles, stops, traffic events, and analytical results. Each route is linked to a set of vehicles and stops; each vehicle is associated with movement events; and each analytical record may be generated by a system user. This model efficiently encodes relationships between real-world objects and supports rapid access to the required information.

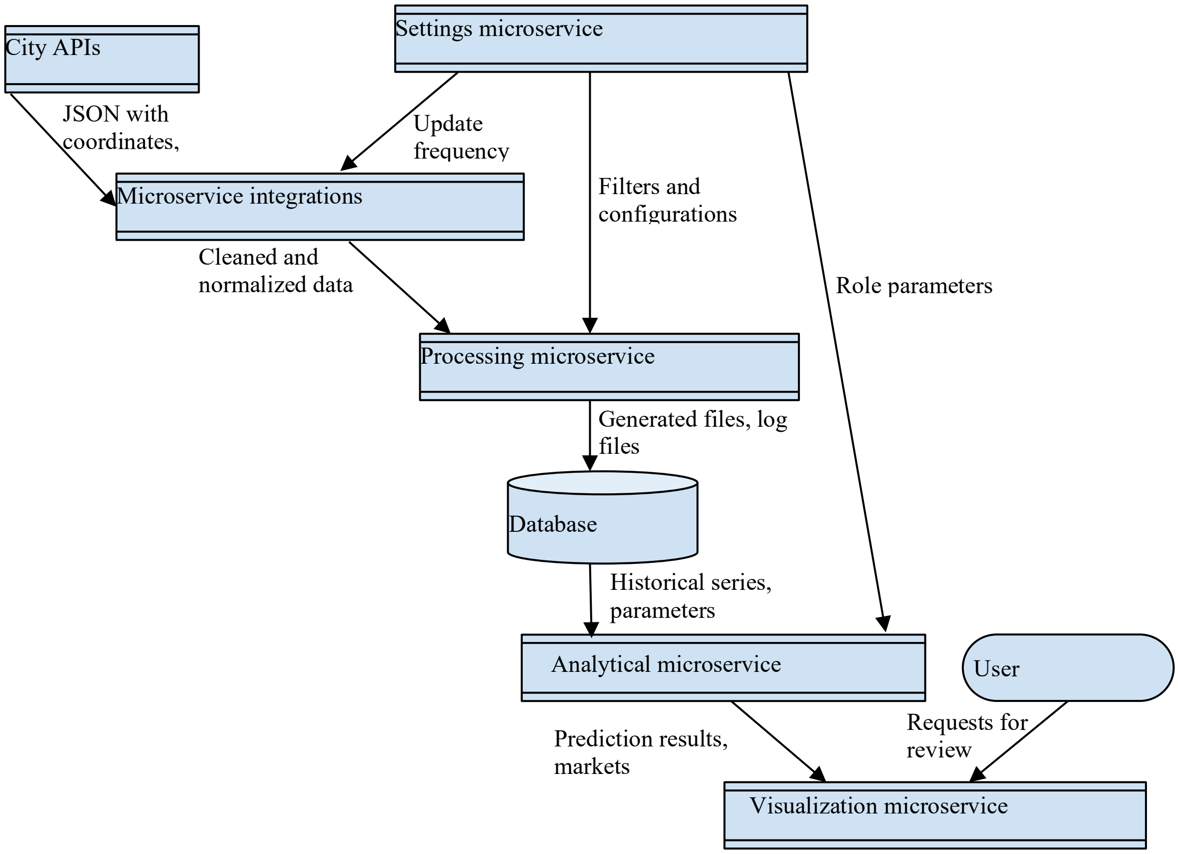

Figure 2. Service DFD diagram

The data-flow diagram depicts the key information transformations within the system. Data arrive from external sources (municipal APIs), are processed by the integration and aggregation microservices, stored in the database, subjected to analytical processing, and ultimately presented to the user. All processes are configured via a dedicated configuration microservice, which ensures flexibility, centralised parameter control, and efficient data movement.

For the storage, processing, and subsequent analysis of transport data, the web system employs a centralised relational database. Its structure is modelled using an Entity–Relationship (ER) diagram, which visualises the core entities, their attributes, and the relationships between them. Relational data models oriented towards domain-specific entities (routes, traffic events, stops, etc.) continue to demonstrate effectiveness in urban transport information systems – particularly with respect to scalability, access to historical data, and integration with analytical modules [2]. At the same time, a well-designed schema with robust key relationships enables the handling of large volumes of GPS data and route events under urban loads [3]. The list of database entities is presented in Table 1.

Table 1. Principal Database Entities

Entity	Description
Routes	Route number, mode of transport, origin and terminus stops.
Vehicles	Identifier, type, associated route number, GPS coordinates.
Stops	Stop name, coordinates, list of routes serving the stop.
Traffic Events	Timestamp, location, delay, vehicle ID, distance to the nearest stop.
Analytics/Forecast	Model type, route ID, date, forecast output.
Users	Name, role (analyst, administrator), access token.

Figure 1 presents a visual representation of the database in the form of an ER diagram.

The study has enabled the formulation of a coherent conceptual model of a web-based system for managing urban traffic flows grounded in a microservice architecture. It was found that delineating the system's functional zones at the microservice level ensures a clear separation of responsibilities and facilitates scaling without disrupting the overall data-processing logic. The analysis showed that the chosen sequence of modelling artefacts – an ER diagram for the domain and a multi-level DFD to trace information flows. It was demonstrated that integrating these artefacts within a single methodological framework minimises ambiguities in data interpretation and conflicts between components, which is particularly important in urban scenarios characterised by heterogeneous data sources.

It was found that the asynchronous interaction of the integration module with municipal application programming interfaces ensures stable message intake and simplifies the unification of data formats. The analysis showed that deploying a dedicated processing and aggregation module makes it possible to standardise core traffic metrics and prepare aligned temporal slices for subsequent interpretation. It was substantiated that the analytics module should be constructed as a superstructure over aggregated indicator sets, focusing on the computation of indicators and baseline forecasts, whereas the visualisation microservice provides cartographic and time-series renderings of results for the prompt interpretation of situations across the urban space.

References

1. Abramova, L., Ptytsia, H., Kapinus, S., & Shyrin, V. (2025). Conceptual Approach to Hybrid Traffic Management in Cities. Intelligent Transport Systems: Ecology, Safety, Quality, Comfort (LNNS, Vol. 1336), pp. 81–89. Springer, Cham. https://link.springer.com/chapter/10.1007/978-3-031-87379-9_8

2. Batita S. Makni A., & Amous I. Intelligent Transportation Systems: A Survey on Data Engineering (2024). DATA 2024 Proceedings of the 13th International Conference on Data Science, Technology and Applications (DATA 2024), 169-179 https://www.scitepress.org/Papers/2024/128573/128573.pdf
3. Mansurova, A., Mussina, A., Aubakirov, S., Nugumanova, A., & Yedilkhan, D. (2025). From Raw GPS to GTFS: A Real-World Open Dataset for Bus Travel Time Prediction. Data, 10(8), 119. https://doi.org/10.3390/data10080119

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ЗАПОБІГАННЯ ПОЖЕЖАМ В ЕЛЕКТРОМОБІЛЯХ ШЛЯХОМ ВИКОРИСТАННЯ ШАХТОВОГО З'ЄДНАННЯ З'ЄМНИХ АКУМУЛЯТОРНИХ МОДУЛІВ

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Проблема пожеж в електромобілях залишається однією з найактуальніших у сфері транспортної безпеки. Це зумовлено високою енергетичною щільністю літій-іонних батарей та потенціалом розвитку явища термічного розгону, яке може призвести до вибуху й займання [1]. Традиційні заходи: пасивне охолодження, використання вогнестійких бар'єрів і систем раннього виявлення - лише частково знижують ризики, проте не усувають можливості повторного займання та масштабних руйнувань конструкції автомобіля [5].

Рис.1 Конструктивне розміщення акумуляторів електромобілів (стандартне інженерне рішення, коли батарейний блок розташований у нижній частині кузова між осями для рівномірного розподілу ваги й захисту елементів)