OMNIMOVE & CASSITRACK: A Standards-Based MaaS Aggregator and a Low-Cost Real-Time Tracking Prototype

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***Abstract*—**This paper presents OMNIMOVE, a Mobility-as-a-Service (MaaS) aggregator that brings heterogeneous urban mobility offerings — public transit, car sharing, bike sharing, e-scooter rental, taxi, ride-hailing — into a single multimodal interface, letting the urban traveller compare alternatives by cost, travel time and an environmental Green Index. OMNIMOVE is built around standard data formats (GTFS, GTFS Realtime, GBFS, NeTEx, SIRI, TOMP-API), so that any operator exposing its feeds through the relevant interface can be onboarded with only configuration changes. To probe the bottom of the data-source spectrum — small municipal fleets with no real-time presence — we complement OMNIMOVE with CASSITRACK, a deliberately low-cost prototype tracking system based on ESP32 commodity hardware and MQTT/LoRaWAN telemetry that exposes its data exclusively through the same standard interfaces (REST, GTFS Realtime, SIRI). CASSITRACK is therefore not the focus of the project but an exemplar showing that even the MAGNI urban buses of Cassino can become first-class OMNIMOVE-compliant providers at minimal cost. The work also includes a survey of the European regulatory framework (ITS Directive, MMTIS, GDPR, PSD2, NIS2, Open Data Directive, MaaS4Italy) addressing the research question of whether an open, multi-source MaaS aggregator is presently realisable under EU law. The prototype is being developed at the University of Cassino and Southern Lazio across three milestones (June, July and September 2026) with MoSCoW-based requirement scoping.

Keywords*—Mobility as a Service, MaaS aggregator, multimodal journey planning, GTFS Realtime, SIRI, GBFS, TOMP-API, regulatory feasibility, low-cost real-time tracking, ESP32, smart cities.*

I. INTRODUCTION

Mobility as a Service (MaaS) refers to the integration of multiple transport services into a single digital interface that allows the traveller to plan, book, and pay for a multimodal journey [1], [2]. Beyond a user-experience proposition, MaaS rests on a technical assumption: that heterogeneous mobility operators (public transit, car/bike/e-scooter sharing, taxi, ride-hailing) make their static and dynamic data available through standardised, machine-readable interfaces. In Europe this assumption has been progressively turned into a legal obligation by Directive 2010/40/EU on Intelligent Transport Systems and, in particular, by Commission Delegated Regulation (EU) 2017/1926 (MMTIS), recently strengthened by Regulation (EU) 2024/490, which extends the obligation of National Access Points (NAPs) to publish dynamic and static transport data in standard formats such as NeTEx, SIRI, GTFS, and GBFS [5]. On the Italian side, the MaaS4Italy programme funded by the National Recovery and Resilience Plan (NRRP) has financed pilot deployments providing a substantial body of lessons learned for diffusion in mid-sized urban contexts [6].

This work focuses on *OMNIMOVE*, a MaaS aggregator that consumes mobility data from multiple operators and exposes a single multimodal interface — positioned at Level 3 (integration of the service offer) in the topology of Sochor *et al.* [3], with a Green Index aiming at Level 4 (societal goals). Its design centres on standards-based ingestion: any operator publishing its data through GTFS, GTFS Realtime, GBFS, SIRI, NeTEx or TOMP-API can be onboarded with only configuration changes. To probe the bottom of the data-source spectrum — small municipal fleets with no real-time presence — we complement OMNIMOVE with *CASSITRACK*, a low-cost prototype tracking system for the MAGNI urban bus fleet of Cassino, treated as a replaceable data source coupled to OMNIMOVE only via the standard interfaces [4].

The contributions of this work are threefold: *(i)* evidence that standards-based ingestion, taken as the *sole* coupling mechanism, suffices to build an operational MaaS aggregator for a mid-sized city, obviating bespoke per-operator integrations that today dominate the sector [7]; *(ii)* empirical evidence that an MMTIS-compliant real-time provider can be built on commodity hardware at a marginal cost of a few tens of euros per vehicle, extending the population of viable MaaS data sources to otherwise-silent municipal fleets; and *(iii)* a preliminary regulatory-feasibility assessment at European level, developed as a companion paper [9]. The project is developed by undergraduate students with extensive use of AI-assisted development (LLM-based coding assistants) [8].

II. METHODS

A. Technology stack

OMNIMOVE and CASSITRACK share a *Spring Boot 3 / Java 17* backend exposing OpenAPI 3.0 REST endpoints, secured by JWT, with polyglot persistence — *PostgreSQL/PostGIS* for relational and geospatial data, *InfluxDB* for time-series telemetry, *Redis* for caching and session state. The OMNIMOVE client is a

React/TypeScript PWA over OpenStreetMap; multimodal journey planning builds on well-established route-planning techniques for transportation networks [7]. CASSITRACK on-board units are ESP32 microcontrollers publishing JSON telemetry over MQTT (cellular) or LoRaWAN, buffered locally during connectivity loss. Requirements were scoped with MoSCoW into 19 MUST, 14 SHOULD and 6 COULD items over fifteen user stories.

B. Standards and integration

OMNIMOVE's ingestion layer treats every data source uniformly through the same adapter pattern, with no source-specific code paths. Reciprocally, CASSITRACK exposes its real-time data through a proprietary REST/WebSocket API and a *GTFS Realtime* feed (with a SIRI Vehicle Monitoring interface foreseen for September), so that it can be registered with the Lazio Regional Access Point and ultimately federated into the Italian NAP — exactly as a commercial transport operator would do.

III. RESULTS — PRELIMINARY ARCHITECTURE

Fig. 1 sketches the five-tier architecture: (i) *Presentation* — traveller PWA, fleet dashboard, driver mobile app, admin dashboard; (ii) *Application* — two independent Spring Boot backends; (iii) *Integration* — REST/GTFS-RT/SIRI contract; (iv) *Data* — PostgreSQL+PostGIS, InfluxDB, Redis; and (v) *External / Edge* — GTFS/GBFS feeds, weather API, optional LLM, ESP32 fleet, LoRa gateway, NAP.

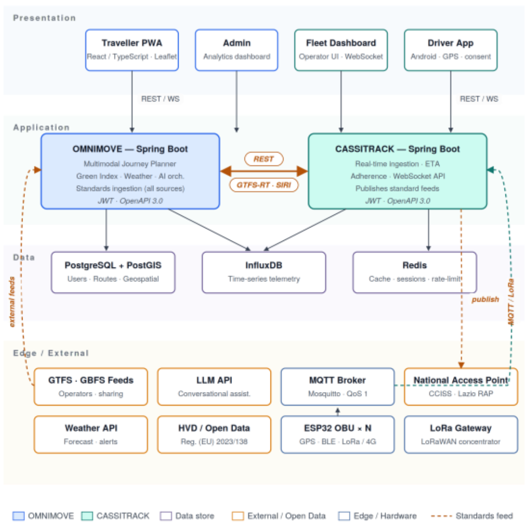

Fig. 1. Five-tier architecture of the OMNIMOVE aggregator. CASSITRACK is one of several standards-based real-time data sources consumed by OMNIMOVE — alongside GTFS, GBFS and weather feeds — and is bound only by the standard integration contract (REST · GTFS-RT · SIRI), which any third-party operator could satisfy.

The June 2026 MVP targets a working multimodal journey planner consuming GTFS and at least one GBFS feed, a fleet dashboard fed by simulated ESP32 telemetry, and the Green Index calculator. SHOULD features (weather, multilingual UI, accessibility, BLE crowd estimation, GTFS Realtime) target the July challenge-ready release; COULD features (LLM assistant, ticketing, SIRI VM, ML ETA prediction) target September.

IV. CONCLUSION AND DISCUSSION

OMNIMOVE shows that an open, multi-source MaaS aggregator can be assembled by composing established open standards (GTFS, GTFS Realtime, SIRI, NeTEx, GBFS, TOMP-API), modern application frameworks (Spring Boot, React PWA), and — when an operator does not yet expose its data — a low-cost data source like CASSITRACK. Our preliminary answer to the regulatory-feasibility question is *positive but conditional*: the EU framework, far from precluding such systems, increasingly mandates the data-sharing layer they rely on (MMTIS, Open Data Directive, HVD); the genuine constraints are GDPR-compliant handling of user geolocation [10], PSD2/SCA when ticketing is added, and the residual dependence on gatekeeper ecosystems, partially mitigated by the Digital Markets Act.

Open issues, to be discussed during the i-Cities session, include: (i) the trade-off between LoRaWAN and 4G/5G cellular for low-cost telemetry in non-dense urban areas; (ii) the legal framing of voluntary GPS tracking of bus drivers in light of Article 4 of the Italian Statuto dei Lavoratori and trade-union consultation duties; (iii) the calibration of BLE-based crowd estimation against ground truth; and (iv) the cost-effective federation of municipal feeds into the regional and national NAPs. Future work will focus on a real deployment on at least five MAGNI buses, on the integration of an LLM-based conversational front-end for OMNIMOVE, and on the publication of the resulting datasets as High-Value Datasets under Implementing Regulation (EU) 2023/138.

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