MOVE21 TECHNOLOGY FRAMEWORK

Project Deliverable D5.2

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MOVE21 – Multimodal and interconnected hubs for freight and passenger transport contributing to a zero emission 21st century

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Legal Disclaimer

Project Executive Summary

The main objective of MOVE21 is to transform European cities and functional urban areas into climate neutral, connected multimodal urban nodes for smart and clean mobility and logistics. MOVE21 will do this through an integrated approach in which all urban systems are connected, and which addresses both goods and passenger transport together. As a result, MOVE21 will improve efficiency, capacity utilisation, accessibility and innovation capacity in urban nodes and functional urban areas.

The integrated approach in MOVE21 ensures that potential negative effects from applying zero emission solutions in one domain are not transferred to other domains but are instead mitigated. It also ensures that European transport systems will become more resilient. Central to the integrated approach of MOVE21 are three Living Labs in Oslo, Gothenburg, and Hamburg and three replicator cities Munich, Bologna and Rome. In these, different types of mobility hubs and associated innovations are tested and means to overcome barriers for clean and smart mobility are deployed. The Living Labs are based on an open innovation model with quadruple helix partners. The co creation processes are supported by coherent policy measures and by increasing innovation capacity in city governments and local ecosystems. The proposed solutions deliver new, close to market ready solutions that have been proven to work in different regulatory and governance settings. The Living Labs are designed to outlast MOVE21 by applying a self-sustaining partnership model.

MOVE21 Partners

The MOVE21 consortium consists of 24 partners from seven different European countries, representing local city authorities, regional authorities, technology and service providers, public transport companies, SMEs, research institutions, universities and network organisations.

- **Norway**: City of Oslo, Akershus County, Ruter, Urban Sharing, MIXMOVE, Institute of Transport Economics, IKT-Norge
- **Sweden**: City of Gothenburg, Rise Research Institutes of Sweden, Business Region Gothenburg, Volvo Technology, Renova, Parkering Göteborg
- **Germany**: City of Hamburg, City of Munich, Hafencity University Hamburg, Deutsche Bahn Station & Service
- **Italy**: Metropolitan City of Bologna, Roma Servizi per la Mobilità, Roma Tre University
- **Belgium**: Eurocities, Polis
- **The Netherlands**: TNO
- **Greece**: Hellas Centre for Technology and Research

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Deliverable Executive Summary

Keywords

Seamless transport, public transport and micro-mobility, combining passengers and freight.

Executive Summary

Two MOVE21 pilots tested the integration of micro-mobility with other mobility services. In Gothenburg, micro-mobility was to be connected to parking. In Oslo, public transport and micro-mobility was integrated. In Gothenburg, the technology used in the parking management application was not suitable for proper integration. In Oslo, a new API supporting the de facto micro-mobility standard, General Bikeshare Specification, was developed, and the integration of the two services was successful. Now, seamless services combine public transport and shared city bikes. The new API is free to use for all those attempting similar integrations.

A third pilot (also in Oslo) offers combined passenger and freight transport, enabling spare capacity in vehicles normally transporting people to be used for freight transport. The aim is to reduce traffic in cities. The passenger transport service used in the pilot is a mobility-on-demand service offered to seniors. Shopping centres are popular destinations for these services, and the combined offering involves home transport of goods purchased at the shopping centre.

Integration between the information system managing logistics and the system used to manage the mobility-on-demand service was straightforward since the logistics system selected to accept the special terms used when transporting people, like the term “rider” rather than “cargo item” for the objects to be transported.

The latter pilot indicates that combining people and freight transport is technically quite feasible. Interoperability in the freight transport sector has been addressed in many EU-funded projects. The Digital Transport and Logistics Forum appointed by the European Commission has proposed new approaches for this through the use of interoperability models, also used in the European Interoperability Framework, with a strong focus on semantic interoperability.

Combined with the use of the eDelivery infrastructure and the Connecting Europe Facility Building Blocks (also operated and supported by the European Commission), the DTLF approach to interoperability, the use of Digital Twins representing the objects to be transported, an affordable interoperability framework for freight transport is fast approaching.

For passenger transport, the use of the Transmodel and its companions dominate the interoperability initiatives. However, inspired by the DTLF semantic models are now developed also for the mobility of people, combining public transport and micro-mobility.

It is strongly recommended that the communities for passenger and freight transport join developments and agree on a common approach to the development of semantic models. This will simplify the establishment of combined transport of people and freight, but it may also speed up the process of facilitating seamless end-to-end passenger transport across EU Member States.

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1 List of Abbreviations and Acronyms

Acronym	Meaning
ASAP	As Soon As Possible
B2B	Business-to-business
B2C	Business-to-Consumer
CEF	Connecting Europe Facility
CEN	European Committee for Standardization
DTLF	Digital Transport and Logistics Forum
EC	European Commission
EIF	European Interoperability Framework
GA	Grant Agreement
GBFS	General Bikeshare Specification
KoM	Kick-off Meeting
KPI	Key Performance Indicator
WP	Work Package
OCB	Oslo City Bikes
PII	Personal Identifiable Information
API	Application Programming Interface
GDPR	General Data Protection Regulation
PGMA	Gothenburg Parking company mobile app
LSC	Logistics service client
LSP	Logistics service provider
NeTEx	Network Timetable Exchange

2 Purpose of the Deliverable

One of the specific objectives of MOVE21, as stated in D5.1, is to "*test, deploy, replicate, and upscale zero emission solutions through co-creation in* ***urban nodes*** *and functional urban areas on the TEN-T Scan-Med corridor. MOVE21 does this by co-creating new mobility solutions with quadruple helix partners (public authorities, researchers, businesses, citizens) in a dynamic, open innovation process resulting in:*

- *Different types of zero-emission mobility* ***hubs*** *employing neutral business services, including integrated energy storage and recharging opportunities*
- ***Integrated transport services*** *(includes all surface modes) and technological integration for combining services from public and private transport service providers*".

Smooth mobility across modes (for people, freight, and combinations thereof) requires the possibility of booking end-to-end transport services in a single operation. To facilitate this, the information systems used to manage the different mobility services need to be integrated or interconnected. Different transport and mobility services use different technologies and standards for exchanging information about services. There are also different standards for booking and status reporting.

This demonstrator-type deliverable documents the technology frameworks and interoperability efforts deployed in three chosen MOVE21 pilots and measures. It provides supporting documentation for the demonstrated measures for chosen technologies as well as associated challenges. The following three MOVE21 pilots and measures are described:

- Mobility-on-demand for people and freight, offering home transport of goods from a shopping centre using on-demand services currently transporting only people. Location: Oslo
- Integration of public transport and micro-mobility services. Location: Oslo
- Integration of parking and micro-mobility services. Location: Gothenburg

2.1 Attainment of the Objectives and Explanation of Deviations

This deliverable outlines the project's technology framework (based on the principles of interoperability, connectivity, and open standards). This includes message definitions and Application Program Interfaces (APIs) and supports the execution of solutions across transport modes and types of transport.

The attainment of the objectives has been met. The deliverable has been delayed by approx. 6 months (original due date in October 2023) due to delayed piloting across several sites and time-consuming awareness-raising activities towards cities for what interoperability and connectivity mean in practice when deploying new mobility solutions in an urban context.

2.2 Intended Audience

This deliverable is public, and as such is open to everyone seeking to replicate MOVE21 measures and to understand how the project has gone about solving interoperability and connectivity issues in urban mobility.

2.3 Structure of the Deliverable and Links with Other Work Packages/Deliverables

This deliverable describes the chosen technological solutions for the three pilots in MOVE21 that currently involve the use of information technology where interoperability is in focus. It describes key initiatives for interoperability for freight and passenger transport. It also details the API developed for facilitating integration between public transport of micro-mobility and contributions to the framework for passenger transport interoperability. Finally, it offers some reflections on the experiences related to combining the movement of people and freight.

The framework and technical contributions of this deliverable are directly relevant to work package (WP) 6 and its associated deliverables since the pilots described here are implemented as part of the Living Lab activities in this work package.

The interests of WP 4 (governance) also partly overlap with the content of this deliverable. Having passengers and freight using the same transport service is not legal in all countries in the EU. WP 4 investigates what it would take to make such combined transport possible in all countries in Europe.

Furthermore, the results of WP 5 will be relevant for WP 7 (Replication & take-up), WP 9 (Exploitation management), and WP 10 (Outreach and dissemination).

3 Mobility On-Demand for People and Freight

3.1 Introduction

This MOVE21 pilot seeks to maximise the use of existing resources. In short, this means combining people and goods in the same on-demand vehicles used in public transport offers.

In the new EU Urban Mobility Framework, the term “passengers and freight” is repeated several times. In this pilot, MOVE21 has taken as a starting point that a holistic approach is necessary when designing physical and information infrastructures even though traditionally, authorities have been focusing on passenger (public) transport and have left freight to the industry and private sector. Although passenger and freight transport in cities are considered two separate domains, the need to reduce traffic and the use of energy demand an investigation into how best to apply all transport resources in cities for separate and combined transport of people and freight, see Figure 1.

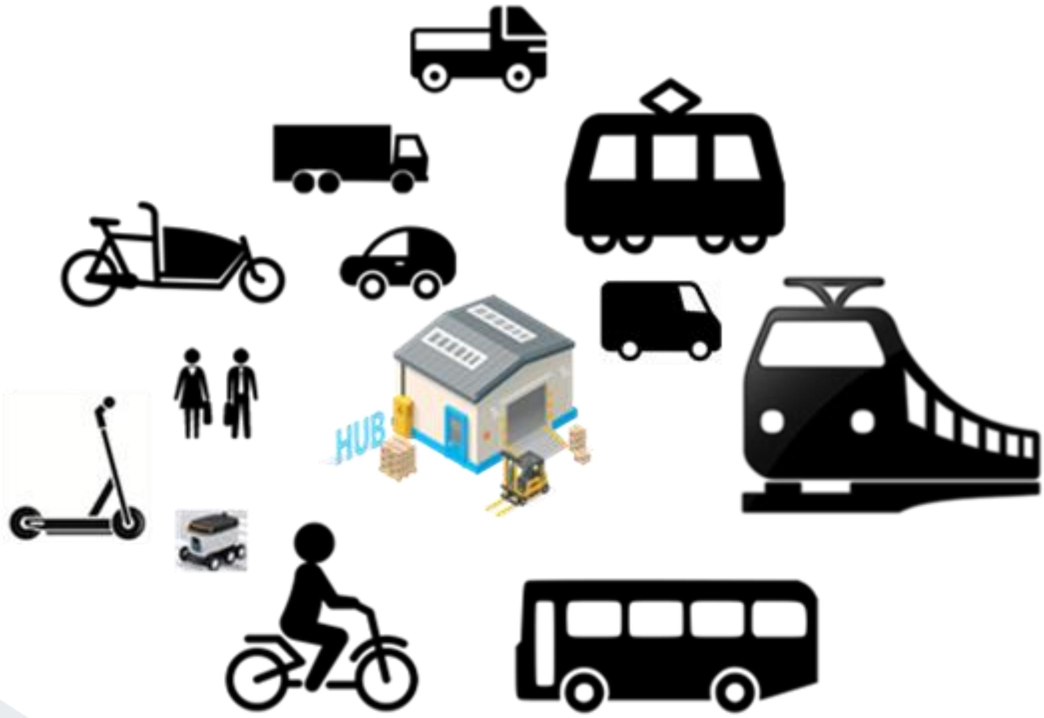

Figure 1 Available transport resources (own illustration)

When considering combining passenger and freight transport, i.e. utilising vehicles normally used for transporting passengers to also transport goods, we faced the challenge that passenger and freight transport are very different domains in the area of information technology and interoperability. In the Oslo Living Lab and the mobility-on-demand for people and freight pilot, we made an effort to investigate the possibility of breaking the barriers between these two domains in the area of interoperability.

3.2 The Technology Framework in the Pilot

This pilot has been presented in detail in earlier deliverables (D5.1, D6.2) from Work Packages 5 and 6. The following will concentrate on providing information on the technological solution. Shopping centres are popular destinations for this service, and this MOVE21 pilot is allowing stores in the shopping centre CC Vest to offer home transport of goods purchased in their stores. The process is illustrated in Figure 2.

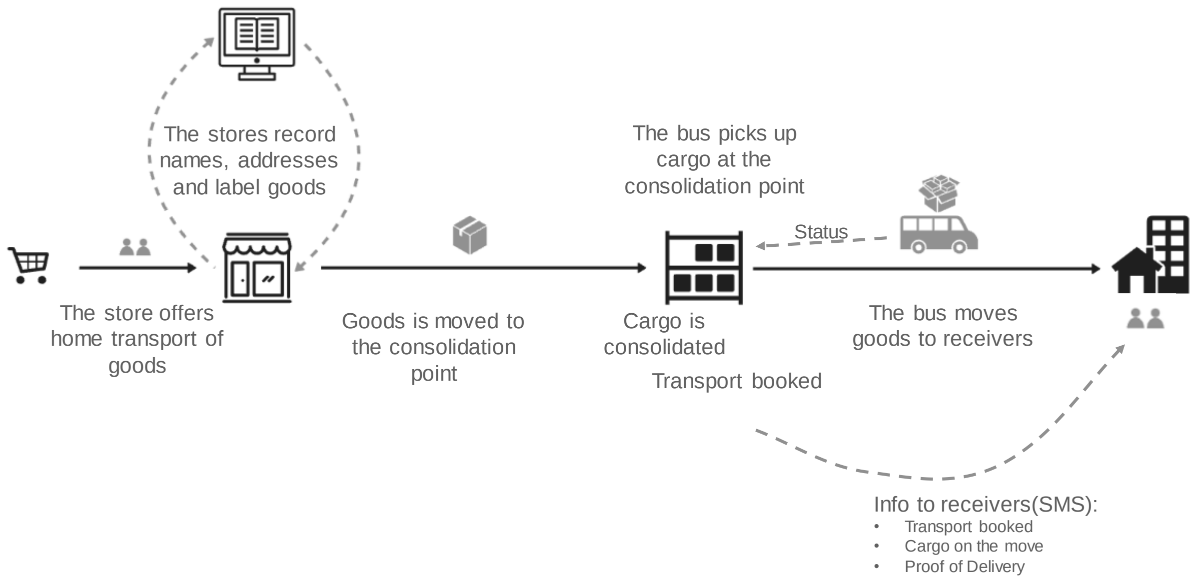

Figure 2 The process for offering home transport of cargo from the shopping centre CC Vest (Own figure)

3.3 The Information Systems Involved

The information systems involved in the pilot are illustrated in Figure 3.

In-store application:
This is the system used by the store staff to record information about the receiver and the goods to be sent. In the pilot, this is an application ("Ship") delivered by the MOVE21 partner MIXMOVE. "Ship" is a generic application for booking transport and was not developed specifically for this pilot. The "Ship" application informs the Hub and cargo management that transport is required and transfers receiver and cargo information.

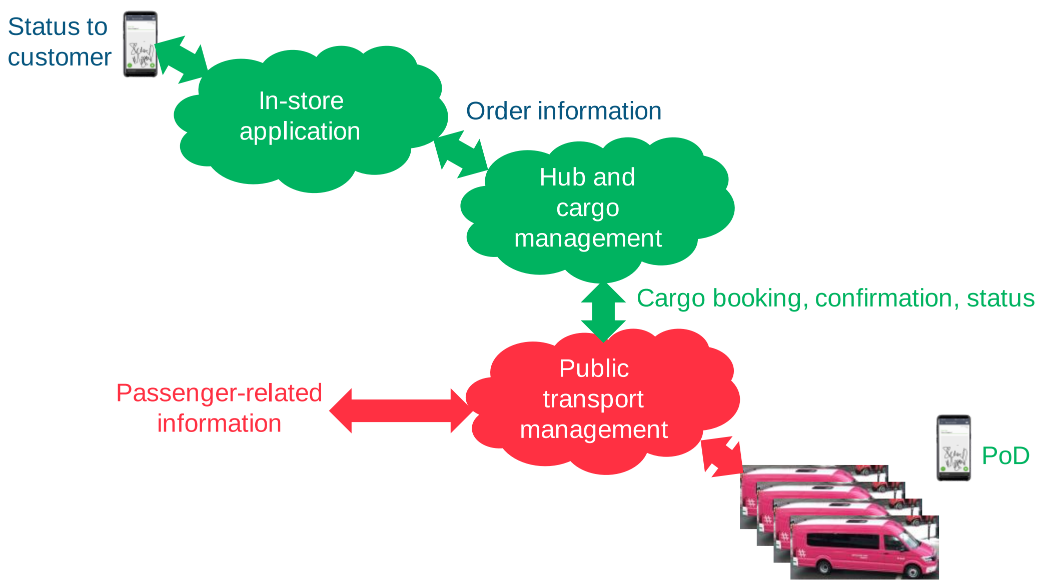

Figure 3 Information systems involved in the pilot moving people and freight (Own figure)

Hub and cargo management:
This application is used at the consolidation point in the shopping centre to consolidate cargo. One example is cargo purchased by the same receiver in several stores. Such cargo will be consolidated for joint delivery. Once the cargo is properly consolidated, the information system used in the consolidation point will book transport for cargo on the bus. The information system used in the pilot is the MIXMOVE solution X-Dock.

Public transport management:
This (TRIPVIA) is the system used by the service operator (Ruter) to manage the operation of the buses. Passengers (or the person responsible for booking freight transport) book transport service from a given origin to a given destination at a preferred time. The system checks the availability of the buses and accepts the booking if space is available.

Before the bus starts its service, the driver is given instructions (run sheet) describing which addresses the bus is to serve and in which sequence (the route plan). These instructions are provided on a mobile device. During transport, information from the mobile device is used to derive the status of the transport, which is communicated back to the X-Dock system at the consolidation point in the shopping centre.

Figure 3 also indicates that the customer buying goods in stores will be given status information about the transport. In the pilot, the information is provided by “Ship” and is sent as an SMS to the mobile phone number that the customer provided during the visit to the store. This means that the customer will be informed about the bus's planned departure and arrival of the goods. Information about planned departure will be received after the booking from the consolidation point has been confirmed. The customer will also receive status information as the bus is moving.

3.4 The Implementation

The integration between MIXMOVE and TRIPVIA allows the transport services requested by the CC Vest stores to be automatically booked with Ruter and ensures that the status updates of those trips in TRIPVIA are reflected as tracking events in MIXMOVE in real-time. The sequence of interactions is illustrated in Figure 4.

MIXMOVE X-Track is part of “Visibility and Analytics” in Figure 29. MIXMOVE X-Dock is part of “Hub Execution and Yard Management”.

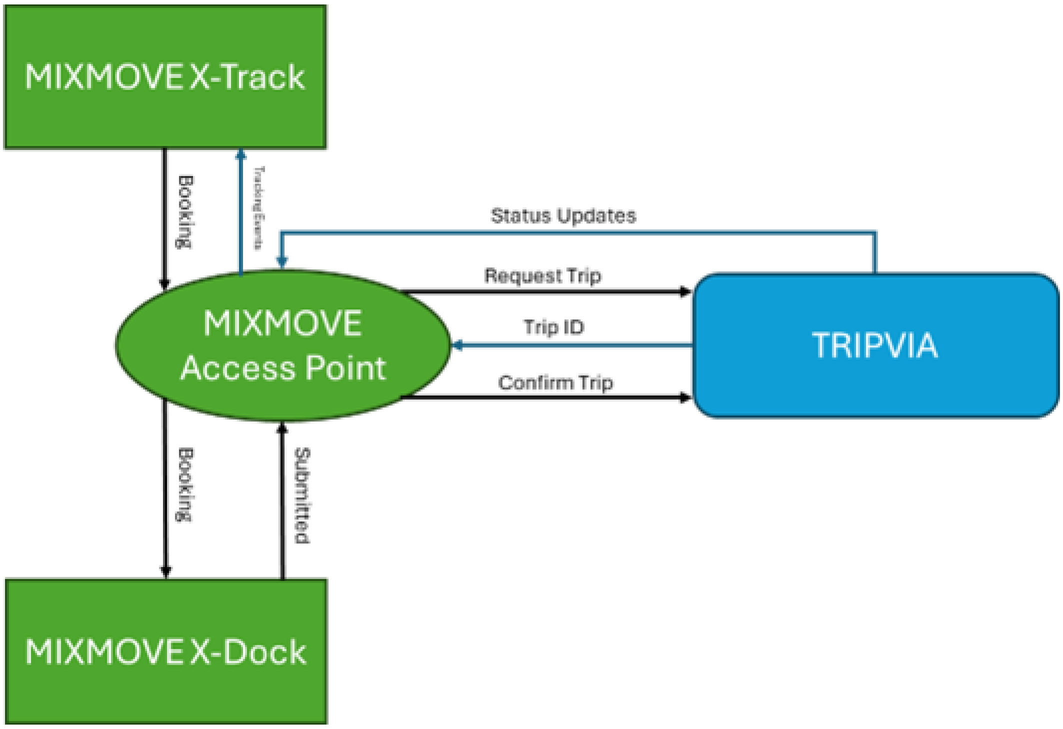

Figure 4 Sequence of interactions (Own figure).

MIXMOVE X-Track is the portal available for the stores in CC Vest to book the transport services with Ruter. Once a service is booked in MIXMOVE X-Track, it is automatically transferred to the MIXMOVE X-Dock platform, which the consolidation centre uses. MIXMOVE X-Track and X-Dock integration is done internally in the MIXMOVE solution, but the access point is still used for communication. This integration is not relevant to this document, since that is an internal integration within the MIXMOVE software platform.

At the consolidation centre, the bags and/or boxes might be consolidated into a bigger bag or a bigger box, resulting in fewer loading units to be transported. The consolidation centre confirms that the consolidation is completed using the handled devices, a label is printed, and it triggers a message that is transmitted via REST API to TRIPVIA requesting a trip available to be booked.

TRIPVIA suggests an available Trip – identified by a unique ID – and MIXMOVE confirms it. Every time a status change occurs in TRIPVIA a message is sent to MIXMOVE, which then requests the information of that update and associates it with the corresponding Trip by producing the corresponding Tracking Event in MIXMOVE.

ViaAPI is fully documented here: https://developer.ridewithvia.com/docs/via-api/6aevhz363ut6i-first-things-first

Both the ViaAPI and the MIXMOVE APIs use Open Authorization (OAuth2) for authentication, which gives secure access without requiring a personal username and password. The API authentication has two layers of security. The first layer is an access token that must be generated every hour, and the second layer is the request header that includes the API credentials. The authentication procedure in

Via API is described in full detail here: https://developer.ridewithvia.com/docs/via-api/qd9vfctukccv3-authentication-with-via-api.

3.5 Step-by-Step Interaction

Request a Trip:
To request a Trip, MIXMOVE does a POST call using the `/trips/request/` endpoint (see Figure 5).


```json
{
    "origin": {
        "lat": 59.917551,
        "lng": 10.635229,
        "notes": null,
        "description": null,
        "address": "Lilleakerveien 16|0283 - Oslo, NO"
    },
    "destination": {
        "lat": 59.932318,
        "lng": 10.640504,
        "notes": null,
        "description": null,
        "address": "Skogfaret 22|0382 - Oslo, NO"
    },
    "rider_id": null,
    "passenger_info": {
        "first_name": "Diogo",
        "last_name": "Alves",
        "phone_number": "+4721420480",
        "email": null
    },
    "trip_properties": null,
    "passenger_count": 1,
    "additional_passengers": null,
    "depart_at": 1709807579,
    "arrive_at": null,
    "return_trip_depart_at": null,
    "return_trip_arrive_at": null,
    "recurring_days_of_week": null,
    "recurring_end_date": null,
    "sub_service": null,
    "ride_groups": null
}
```


Figure 5 Trip Request (Own figure)

The Trip request must include origin and destination details, passenger info and count, and a departure time. In this case the passenger count is being used for the number of bags or boxes that need to be transported. The Trip request response from the ViaAPI is shown in Figure 6.

```json
{
    "trips": [
        {
            "trip_id": "6eef59d7-e5ed-424d-8913-d92291f6a0bd",
            "recurring_id": null,
            "trip_type": "SHARED",
            "pickup": {
                "lat": 59.9175265387592,
                "lng": 10.6351017873367,
                "notes": null,
                "description": "Lilleakerveien 16|0283 - Oslo, NO",
                "address": null
            },
            "pickup_eta": 1709807579,
            "earliest_pickup_eta": 1709807100,
            "latest_pickup_eta": 1709808000,
            "dropoff": {
                "lat": 59.9322745276844,
                "lng": 10.6408904778157,
                "notes": null,
                "description": "Skogfaret 22|0382 - Oslo, NO",
                "address": null
            },
            "dropoff_eta": 1709808146,
            "earliest_dropoff_eta": 1709807559,
            "latest_dropoff_eta": 1709809224,
            "pickup_distance": 7,
            "pickup_walking_time_sec": 7,
            "dropoff_distance": 22,
            "dropoff_walking_time_sec": 22,
            "cost": 0,
            "currency": "USD",
            "trip_properties": null,
            "proposal_uuid": null,
            "sub_service": null,
            "ride_groups": null
        }
    ],
    "uuid": "b3f5db4c-edd2-44da-98e8-9b3e8b2777c7",
    "message": null
}
```


Figure 6 - Trip Request response from ViaAPI (Own figure)

In case of a positive response from ViaAPI, the MIXMOVE X-Dock receives a trip ID which will be used to book the trip. The "Request a new ride" procedure is described in full detail here: https://developer.ridewithvia.com/docs/via-api/xpu6w7aneezuq-request-a-new-ride

Book a Trip:

After receiving the Trip information from ViaAPI, MIXMOVE X-Dock is able to book the Trip by using the trip id provided in the response of the "Request a trip". To book a Trip, MIXMOVE X-Dock does a POST call using the `/trips/book` endpoint (see Figure 7).


```json
{
    "trip_id": "6eef59d7-e5ed-424d-8913-d92291f6a0bd",
    "webhook": "https://move21tracking.mixmove.io/TripUpdate"
}
```


Figure 7 - Book a Trip request from MIXMOVE to ViaAPI (Own figure)

In case of a positive response from ViaAPI, a message will be returned to MIXMOVE X-Dock that includes the 1st status of the trip "PICKUP_DETERMINED" (Figure 8).


```json
{
    "trip_id": "6eef59d7-e5ed-424d-8913-d92291f6a0bd",
    "trip_status": "PICKUP_DETERMINED",
    "pickup": null,
    "pickup_eta": null,
    "dropoff": null,
    "prescheduled_recurring_series_id": 0,
    "info": null,
    "dropoff_eta": 0,
    "uuid": "5573edb4-8688-4d2c-bc6a-ae9a73f50820",
    "ErrorMessage": null
}
```


Figure 8 - Book a Trip response from ViaAPI (Own figure)

The “Book new ride” procedure is described in full detail here: [https://developer.ridewithvia.com/docs/via-api/ktfadr1rdfif9-book-new-rides.](https://developer.ridewithvia.com/docs/via-api/ktfadr1rdfif9-book-new-rides)

Updates:
Once a trip is booked in ViaAPI it can change status until the trip is finally finished. To send a Trip status change, ViaAPI does a POST call using the `/tripupdate` endpoint (Figure 9).

.


```json
{
    "event_type": "STATUS_CHANGED",
    "event_details": {
        "trip_id": "c34918bb-7d78-477c-b4df-fafd06ab2dbe",
        "trip_details": {
            "trip_status": "FINISHED",
            "pickup": {
                "lat": 59.917551,
                "lng": 10.635229,
                "description": "Lilleakerveien 16|0283 - Oslo, NO, in front of Lilleakerveien 16|0283 - Oslo, NO."
            },
            "pickup_eta": 1709725528,
            "earliest_pickup_eta": 1709726355,
            "latest_pickup_eta": 1709726445,
            "dropoff": {
                "lat": 59.932318,
                "lng": 10.640504,
                "description": "Skogfaret 22|0382 - Oslo, NO, in front of Skogfaret 22|0382 - Oslo, NO."
            },
            "dropoff_eta": 1709726962,
            "earliest_dropoff_eta": 1709726917,
            "latest_dropoff_eta": 1709727007,
            "driver_arrival_timestamp": 1709725527,
            "last_status_change_timestamp": 1709725740,
            "prescheduled_ride_id": 869799,
            "rider_id": 8934,
            "passenger_count": 1
        }
    }
}
```


Figure 9 – Status update message from ViaAPI to MIXMOVE (Own figure)

MIXMOVE X-Dock receives the message via one of its API’s and generates a tracking event. These tracking events inform the users about the status of the trip and not only are visible in MIXMOVE Tracking page (Figure 10), but can also generate an email or SMS messages to the users. In the MOVE21 pilot, the following SMS messages are sent to the receivers of the goods:

Event Code	Description
CONFIRMED	The space availability is guaranteed.
BOARDED	The cargo was picked up.
FINISHED	The cargo was delivered.

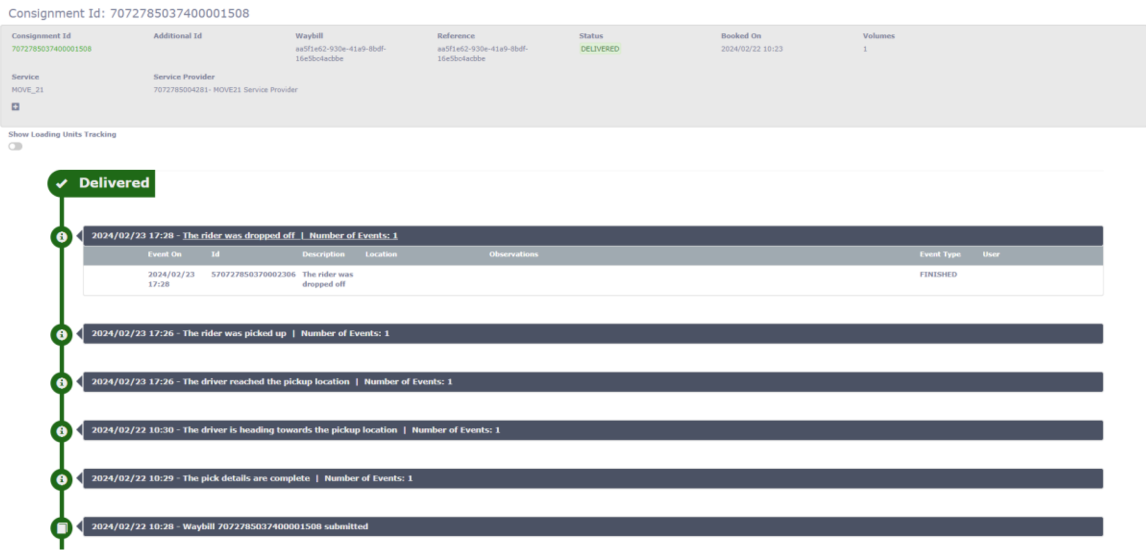

Figure 10 – Tracking events in MIXMOVE that result from the status updates provided by ViaAPI (Own figure)

4 Integration of Micro-Mobility with Public Transport

4.1 Introduction

When integrating micro-mobility and scheduled public transport services, there are (at least) two challenges that need to be considered:

- Public transport normally charges per trip. The rate is fixed between different start and end points within zones or between zones).

  Micro-mobility has a very different way of charging users, either per the time of use, the distance travelled, or similar.

  In order to provide seamless end-to-end services in this context, the ticketing (payments) models need to be combined so that the rider (traveller) pays for the single end-to-end trip and the service providers are properly compensated.

- The integration of the information systems enables information about the combined services to be visible coherently to travellers and that the appropriate information is exchanged between the information systems that are used to manage the different mobility services.

Significant efforts were made to harmonise the former in the pilot. However, this document only describes the latter.

4.2 The Service

This pilot has been presented in detail in deliverables D5.1 and D6.2 from Work Package 5 and 6. The following will concentrate on providing information on the technological solution.

Ruter, the public transport authority in Oslo owned by the City of Oslo and the Akershus County, aims to offer mobility services that are competitive compared to private cars. One ambition is to increase the use of bicycles and public transport.

Oslo City Bikes (OCB) is a city bike scheme in Oslo and a collaboration between the City of Oslo and Clear Channel Norway AS. OCB provides 1.3 million rides annually. Improved collaboration between public transport and OCB should make the combination more attractive to travellers.

Among the facilities supported in the collaboration between the two operations were:

- Distribution/rebalancing of bicycles.
- Travel proposals and/or reservations of bicycles.
- Smart ticketing.

Ruter has an app for planning public transport and for ticketing, and in this pilot OCB services were integrated into the Ruter app. The combination of capabilities enables users to:

- Plan a trip from origin to destination combining the use of public transport and OCB services.
- Rent a bike at the appropriate location.
- Pay for the whole multimodal trip.

Figure 11 shows how the OCB offerings are visible in the Ruter app.

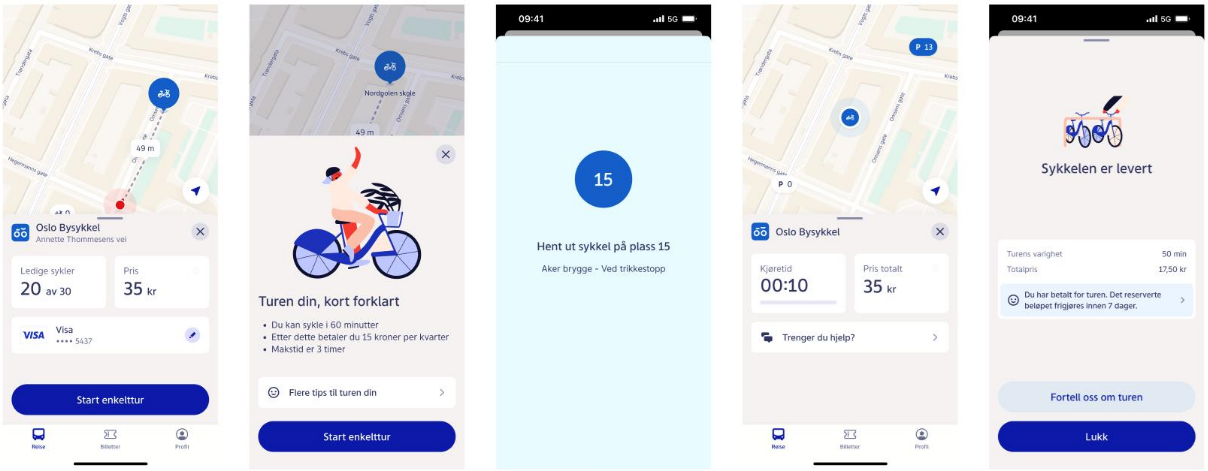

Figure 11 Images from the Ruter App illustrating the integration of OCB services (Source: Ruter)

An overall description of the integration is as follows:

- The Ruter app collects information about available bicycles and unlocks them using the REST API provided by Urban Sharing (see below).
- All events related to the bicycle renting period are communicated asynchronously to the Ruter app using an API provided by Ruter.
- All incoming events cause updating of information about the bicycle rental in the Ruter app.
- When a bicycle is parked, the rental is automatically ended, and the rental is paid automatically without any actions from the user.

4.3 The New API

MOVE21 partner Urban Sharing used the integration activity as an opportunity to develop an innovative API. The API integrates micro-mobility offerings into Mobility as a Service (MaaS) applications seamlessly, thereby enhancing the accessibility and efficiency of urban transport systems.

The key API project objectives were to:

- Develop an API that leverages the General Bikeshare Specification (GBFS) Feed to integrate micromobility offerings into existing MaaS platforms.
- Enable OCB and Ruter to collaborate effectively in providing comprehensive transport offers.
- Establish a user feedback loop managed by the micromobility authority to enhance service quality and user experience within MaaS applications.
- Ensure data privacy and security by implementing a bespoke ID system that maintains user data confidentiality across systems.

The key features of the API are:

1. GBFS Integration: The API utilises the GBFS Feed to gather real-time data on micro-mobility services, ensuring accurate and up-to-date information for users.
2. Seamless Integration: Enables easy integration of micromobility options into MaaS applications, promoting multimodal transport solutions.

3. Consistent User Experience: The micromobility provider maintains control of the user experience ensuring timely customer query handling and consistent branding.
4. Data Privacy: Implements a bespoke ID system to protect user privacy while facilitating data exchange between systems.
5. Operator Agnostic: Any micromobility operator that supports the GBFS feed can be easily integrated into a local or regional MaaS application.

The benefits of the API are:

1. Enhanced Mobility: Integrating micromobility options expands users' transport choices, promoting sustainable and efficient urban mobility.
2. Improved User Experience: Real-time data and user feedback facilitate informed decision-making and enhance overall user satisfaction.
3. Efficient Operations: The API streamlines the integration process for MaaS providers, reducing development time and costs.

Urban Sharing's collaboration with OCB and Ruter represents a significant milestone in advancing shared mobility and MaaS integration. The novelty is the innovative API that offers seamless access to diverse transport options without sacrificing data privacy and data quality.

The API provides access to the following services:

- Initiating vehicle trips using a vehicle ID, QR code or station ID.
- Trip status event stream: each time the status of a trip changes an event will be sent to your webhook.
- Trip state information
- Updating of an ongoing trip state: pause, resume, cancel, end.
- Vehicle damage reporting.

The Micromobility Maas API does not provide the following features. These features need to be managed by the client (Public Transport or MaaS application):

- User Management
- Product Management
- Payment
- Apps

The API provides several endpoints to facilitate the integration of micro-mobility offerings in MaaS applications. These include:

- Get vehicle data based on its QR code.
- Get vehicle data based on its GBFS ID.
- Start dock group trip.
- Start a vehicle trip.
- Reserve a specific vehicle.
- Get a vehicle reservation based on its ID.
- Cancel an existing vehicle reservation.
- Get a damage type for a vehicle.
- Create a damage report for a vehicle.

- Update a trip status (pause, resume, cancel or end).
- Find a trip based on an ID.
- Find the products provided by the micro-mobility operator.
- Find the user penalties accrued by the user.
- Add penalties to a user.
- Resolve user penalties.

To receive events you can implement a number of webhooks.

- /trips/events - Posts the status of a trip when it changes
- /reservations - Posts the status of a reservation changes when it changes
- /users/invoices - Posts an invoice when a trip with a product ID ends
- /users/penalties - Posts an update when a user incurs penalty points. Only applicable to trips started with a product ID
- /users/messages - Posts messages destined for a user

The micromobility operator must manage the authentication of both APIs. It is suggested that the MaaS provider request API credentials from the micromobility operator, which can then be used to generate a JSON Web Token (JWT) that can be passed in the authentication header when accessing the API resources.

The micromobility operator will also manage webhook authentication.

To ensure GDPR compliance and restrict the need to pass Personal Identifiable Information (PII) between the MaaS provider and the micromobility operator, a unique user ID must be provided when a trip is started. This is the ID used to identify the user in your system. Each micromobility operator may use their own user ID linked to the MaaS provider's user ID. If a user with the ID you provided by the MaaS provider does not exist in the micro-mobility operators' system, it should be created.

The micro-mobility provider should never expose their internal user IDs, only the IDs provided by the MaaS provider. The micro-mobility company should comply with GDPR and not store any PII data about the MaaS provider's users. The only information stored should be the user ID and the user position if provided. The user position is only used for validation during trip state changes.

For more information follow this link to the API documentation: https://maas.api.urbansharing.com/.

5 Integrating Parking and Bike-Sharing at test site Klippan

5.1 Introduction

Traffic in central parts of Gothenburg is getting denser. One way of contributing to reducing traffic and emissions is to move car parking from the city centre to more peripheral locations. The aims are:

1. Fewer parking spaces in the city centre make the use of cars less attractive.
2. Parking the car in the outskirts and then utilising public transport, bikes, or other micro-mobility services will reduce total emissions from travel.

The test site chosen for park and ride/park and bike is Klippan, located about 2 km from the city centre of Gothenburg (see Figure 12).

Figure 12 Location of test site Klippan Source: City of Gothenburg)

5.2 The Service

To provide access to the combination of parking, public transport and/or micromobility, the transaction for travellers, the Gothenburg Parking company and the City of Gothenburg investigated how the Parking Gothenburg mobile app (PGMA) could be used to also provide access to mobility services. The first step was to assess technical abilities of the PGMA. The development team at Ruter, responsible for the integration of bikes and public transport in Oslo (see Section 4), were consulted, some research was made and discussions with electric scooter suppliers were conducted.

At the start of the pilot the PGMA provided payment for electrical charging and tickets for public transport (Västtrafik).

The initial analysis concluded that the current design and implementation of the PGMA is not suited for fully integrating free-floating transport services, like shared bikes and e-scooters. Within the MOVE21

project, it was not realistic to undertake a complete redevelopment of the PGMA. Hence, an alternative was needed and found in integrating with another mobility provider.
The one selected was Styr & Ställ, providing 1750 bikes all over the city. They have designated parking areas (fixed "hubs") for the bikes, and journeys start and stop at a hub. To start you scan a QR-code with a mobile app and enter the four-digit verification code you get in return. You stop your ride by pressing a button on the bike's computer.

With this as a starting point, the solution under discussion has been to show the designated parking areas for the bikes on the map in the Gothenburg Parking company mobile app PGMA. A simple solution with starting (and stopping) the bike rental with payment transactions included can most likely be implemented in the PGMA but needs more detailed investigation at the time of writing.

It would be beneficial if a more general integration solution could be developed so that it could be used for integrating with other micro mobility alternatives. In light of the technical and operational limitations the PGMA has today, the way of reworking it to be a full MaaS solution is not possible.

5.3 The Implementation

Figure 13 illustrates the user interface in the PGMA, which shows links to parking (Köp av parkeringstilstånd), public transport (Västtrafik), and biking (Styr & Ställ).

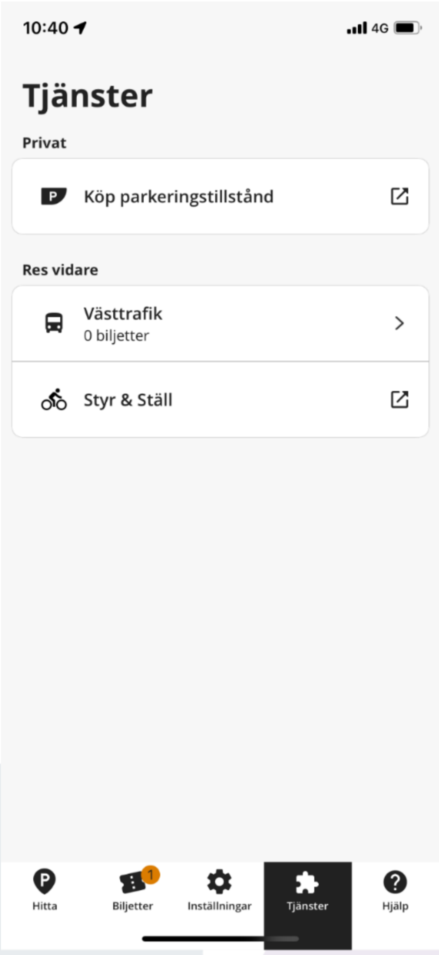

Figure 13 Simple integration of parking, public transport, and bike rental (Source PGMA).

Underneath this user interface, there are links directly to the various apps where these individual services may be procured. At this stage, a seamless link between these services in the app is not possible. This integration should be seen as a first step in marketing/nudging the solution for bike sharing towards car users rather than integration with the hopes of selling lots of rentals. Even this simple integration proved more costly and time-consuming than originally estimated by those involved.

6 Achieving Interoperability in European Transport Systems – A Bigger Picture

Since the 1990s, the main author of this document has been following and participating in transport and logistics projects in the EU framework programmes. Many of them have involved providing interoperability between road, rail, and maritime transport services, aiming to achieve smooth multimodal end-to-end transport.

When working on projects early in this period, each project was focused on itself, and there were few synergies between these projects, up to a point.

Now, we experience a similar situation among those working on freight transport and those engaged in passenger transport. If we want to "close the gap" between these two transport domains, we can learn lessons from other initiatives. Some of these are described below.

The need for interoperability between information and communication systems is not limited to transport and logistics. The Peppol project (Peppol, 2008) was tased to facilitate an open European market for public procurement. Different standards for describing products and other information were used across Europe. Hence, before Peppol, it was not possible for public authorities to procure products outside their own country without having to pass many barriers. Peppol should provide infrastructure and capabilities such that all providers in Europe should be equally accessible to all authorities in all EU member states during procurement processes, despite the use of different standards. The project's results have been widely adopted. The eDelivery Infrastructure and the CEF Building Blocks are the most visible elements, presented below.

The EU Member States are modernising their public administrations by introducing digital public services in countries other than their own. For this reason, efforts to digitise the public sector should be well coordinated at European and national levels to avoid digital fragmentation of services and data and help the EU's digital single market work smoothly. The European Interoperability Framework (EIF) was developed to promote seamless services and data flows for European public administrations.

When describing the technology framework (to support interoperability), it is important to note that interoperability for freight and passenger transport has developed differently.

However, when trying to look at the combined transport of people and freight, the Norwegian initiative ARKTRANS (Natvig et.al, 2009), which published version 6 of its "Multimodal ITS Framework Architecture" combining freight and passenger transport in 2009, made some interesting observations. ARKTRANS argued that there are quite several similarities between managing the movement of people and goods, to the point that when talking about the physical objects that are to be transported, the term "Load Item" was used to include both passengers and cargo.

According to the Multimodal ITS Framework of ARKTRANS, a "Load Item" may be:

- Passengers that have actually boarded the Transport Means. May include the following information for each passenger:
  - Passenger ID
  - Passenger category (man, woman, child, baby)
  - Agreement (business class, tourist class, etc.)

  - Resource allocation (seat, cabin, compartment, etc.)
  - Handling instructions. May include requirements for special treatment and special terms of agreement, e.g. for handicapped travellers, unaccompanied children, diseases/allergy.
- Cargo Load Items on-board the Transport Means. May contain the following information for each item:
  - ID (Load unit ID or Waybill id)
  - Consignor and consignee (with respect to this trip)
  - Size and weight
  - Information about certificates
  - Information about special load (Dangerous Goods Information, food, etc.)
  - Position on board."

Recent developments for achieving interoperability have developed differently for freight and passenger transport.

Freight activities are global. Efforts to enable door-to-door freight transport using multiple transport modes and services using a single "ticket" have been around for many years. Since various standards for expressing transport and logistics-orientated information are being used, the European Commission has funded many projects on interoperability in the transport and logistics sector. These, however, have not led to the introduction of one single standard, but like in Peppol, providing a framework where many standards can be combined in seamless operations.

In 2015, the EU Commission formed the Digital Transport and Logistics Forum (DTLF) to provide a platform for structural dialogue, provision of technical expertise, cooperation and coordination between the Commission, Member States and the transport and logistic sector as part of an effort to (finally) achieve interoperability in the industry. DTLF has inspired several projects, most notably FEDeRATED (FEDeRATED, 2019-2024) (Digital cooperation in logistics, "developing the foundation for a secure, open, and neutral data sharing infrastructure") and FENIX (FENIX, 2019) (supporting the development, validation, and deployment of the digital information systems along the EU transport Core Network).

Learning from these and similar projects, new technologies, such as targeted digital twins and semantic technologies, are increasingly used to achieve interoperability in the freight transport sector.

Developments have been different for passenger transport. It seems that the development of standards and interoperability in passenger transport, the Transmodel standard (CEN, 2024), was developed for this purpose and has a local (or regional) rather than global focus (CEN is the European Committee for Standardization). The European Commission provided the Commission Delegated Regulation (EU) 2017/1926 (EU, 2017) to try to ensure interoperability in public passenger transport and facilitate the use of the same standard in all European member states.

The Transmodel and its companions describe public transport activities, while new standards have been introduced for micro-mobility, where the GBFS (GBFS, 2024) has emerged as the industry standard. GBFS is part of the Transmodel community. However, initiatives like the project ReiseNavet (ReiseNavet, 2022) aim to extend Transmodel to also include micromobility. In MOVE21, part of the challenge was to connect services in the Transmodel community with micro-mobility services while complying with the GBFS.

6.1 Common Standards Across Europe

6.1.1 Freight

As presented in MOVE21 D5.1, there are numerous standards for information exchange in the freight transport and logistics domain, see Figure 14.

Figure 14 Standards for information exchange in transport and logistics (Own figure).

Over the last twenty years, the EU Commission has tried to provide interoperability by finding one common framework for information exchange, which eventually led to the ISO 19845 standard.

Despite this effort, having people and organisations change from what they have invested significant effort and money into (users of the standards in Figure 14) to the new standard proved difficult. Hence, the efforts of the DTLF and projects like FENIX and FEDeRATED worked on describing the semantics of the various standards (using ontologies) so that information exchange would be possible and affordable.

6.1.2 Passengers

Mobility-as-a-Service (MaaS) is illustrated in Figure 15.

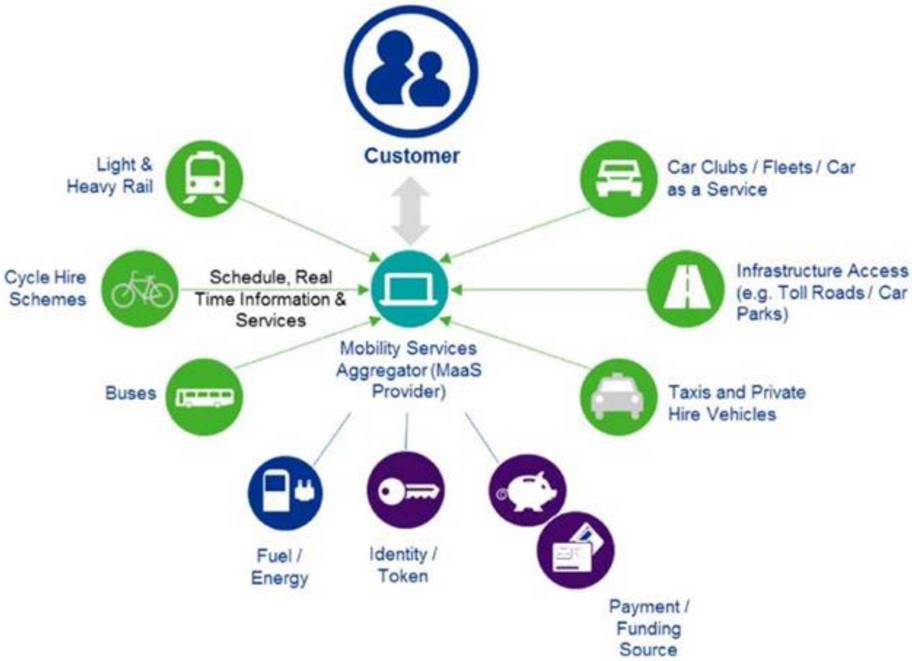

Figure 15 Mobility-as-a-Service for people (Martinelli, 2020)

For MaaS, we need to relate to (at least) three standards:

- Public transport. Commission Delegated Regulation (EU) 2017/1926 (EU, 2017) provides the governance basis interoperability in this domain. Transmodel (CEN, 2022) is the reference data model providing an abstract model of common public transport concepts and data structures that can be used to build many kinds of public transport information systems, including timetabling, fares, operational management, real-time data, journey planning etc.

  As a reference model, Transmodel is supplemented by NeTEx (NeTEx, 2021), which is a CEN Technical Standard for exchanging public transport schedules and related data, and SIRI (Service Interface for Real-Time Information), which specifies a European interface standard for exchanging information about the planned, current, or projected performance of real-time public transport operations between different computer systems.

The Transmodel "community" is illustrated in Figure 16.

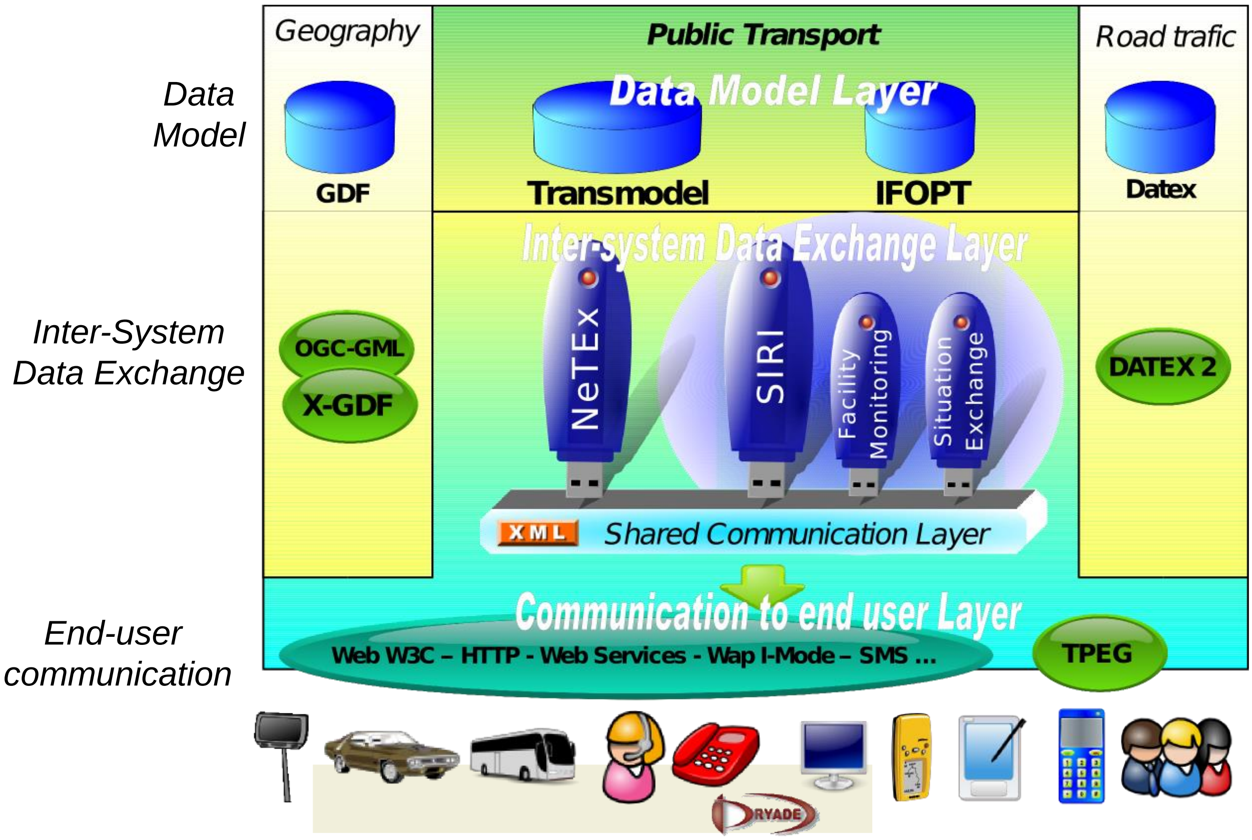

Figure 16 Transmodel "community" (Source CEN).

The Transmodel "community" is adapted to national requirements. Hence its evolvement is driven from the development of national standards, see Figure 17.

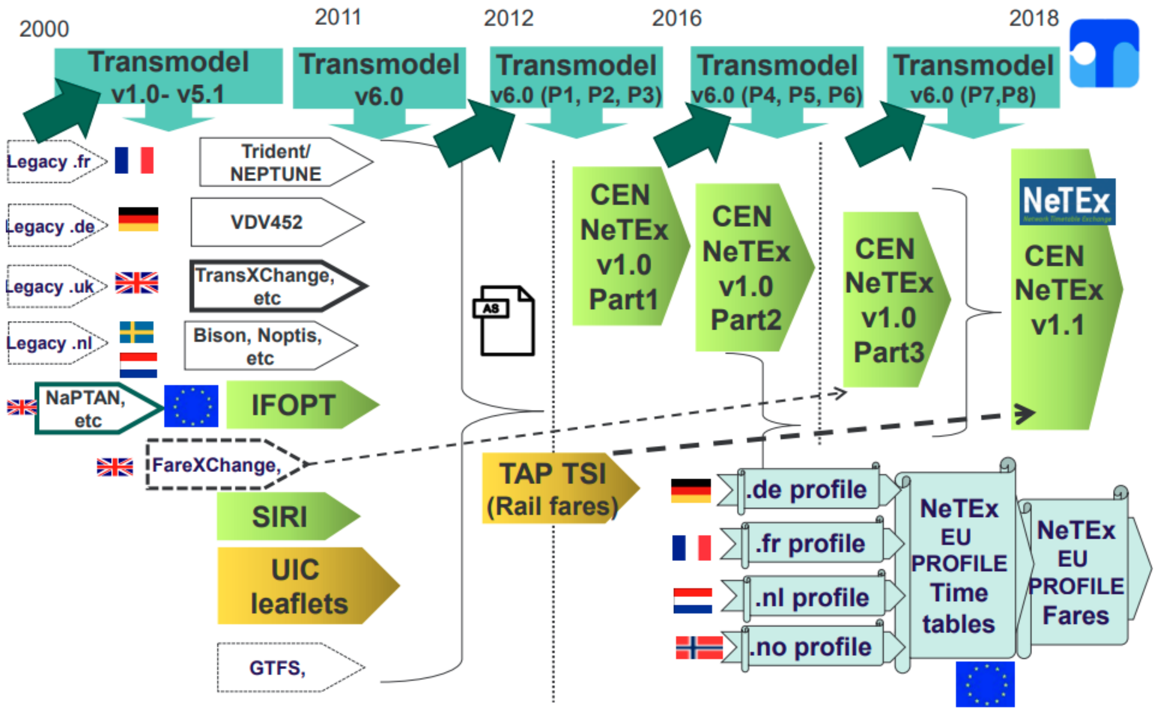

Figure 17 Evolution from National Standards (Source UK Department of Transport)

To get a feel for the information inside the Transmodel community, Figure 18 illustrates:

- The content of NeTEx, which is about places served, routes, stops, schedules, fares, etc., and
- How the profiles of NeTEx are developed individually in countries or regions and how the different national profiles may interact.

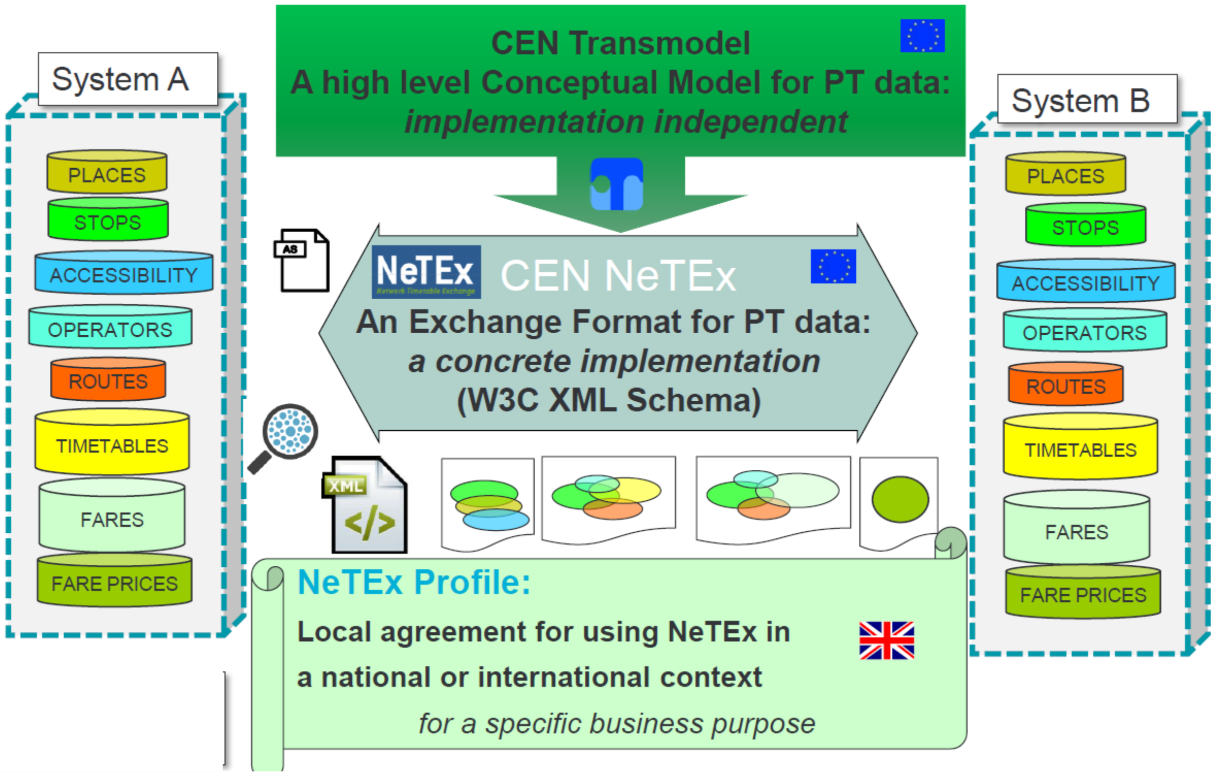

Figure 18 NeTEx Profiles (Source UK Department of Transport)

- Micromobility. Micromobility refers to the use of devices such as bicycles, e-bikes, electric scooters, electric skateboards, and shared bicycle fleets.

  GBFS (General Bikeshare Feed Specification) has manifested itself as the de facto branch standard in this domain. It covers vehicles (form factor, type of power, distance that can be travelled, service pricing and rental terms, and geofenced areas for rules related to speed, parking, and prohibited zones), stations, dock locations, and availability.

- Parking. Passenger car use is included in the mobility mix. Consequently, using the APDS (Alliance for Parkin Data Standards) is also relevant.

In MOVE21, efforts have been made to integrate public (bus) transport and micro-mobility in Oslo and parking and micro-mobility in Gothenburg. Both initiatives are described in this deliverable.

6.2 Interoperability Layers

According to the EIF Brochure (EIF, 2017), the purpose of the EIF is to:

- *Inspire European public administrations* in their efforts to design and deliver seamless European public services to other public administrations, citizens and businesses which are, to the degree possible, digital-by-default (i.e. providing services and data preferably via digital channels), cross-border by-default (i.e. accessible for all citizens in the EU) and open-by-default (i.e. enabling reuse, participation/access and transparency);
- *Provide guidance to public administrations* on the design and update of national interoperability frameworks (NIFs) or national policies, strategies and guidelines promoting interoperability;
- *Contribute to establishing the digital single market* by fostering cross-border and cross-sectoral interoperability for the delivery of European public services.

Even though the EIF is not directly targeted towards mobility and logistics, its principles are worth considering. The DTLF recommends it and the FENIX and FEDeRATED projects mentioned above adopted it.

The EIF distinguishes four layers of interoperability; see Figure 19. In addition, the framework provides for a Governance function. The four levels of interoperability are:

- Legal interoperability is about ensuring that organisations operating under different legal frameworks, policies, and strategies can work together.
- Organisational interoperability is about aligning activities, responsibilities and expectations between parties to achieve their commonly agreed and mutually beneficial goals.
- Semantic interoperability is ensuring that the exact format and meaning of exchanged data and information are preserved and correctly understood by all exchanges between the parties involved.
- Technical interoperability is defined as the ecosystem of applications (applications) and infrastructures through which IT systems and services can be linked.

Figure 19 The EIS 4 layers of interoperability (Source EIS brochure)

For some types of considerations, these levels are vague. Hence, built on the EIF, the DTLF defined six levels of interoperability, as illustrated in Figure 20.

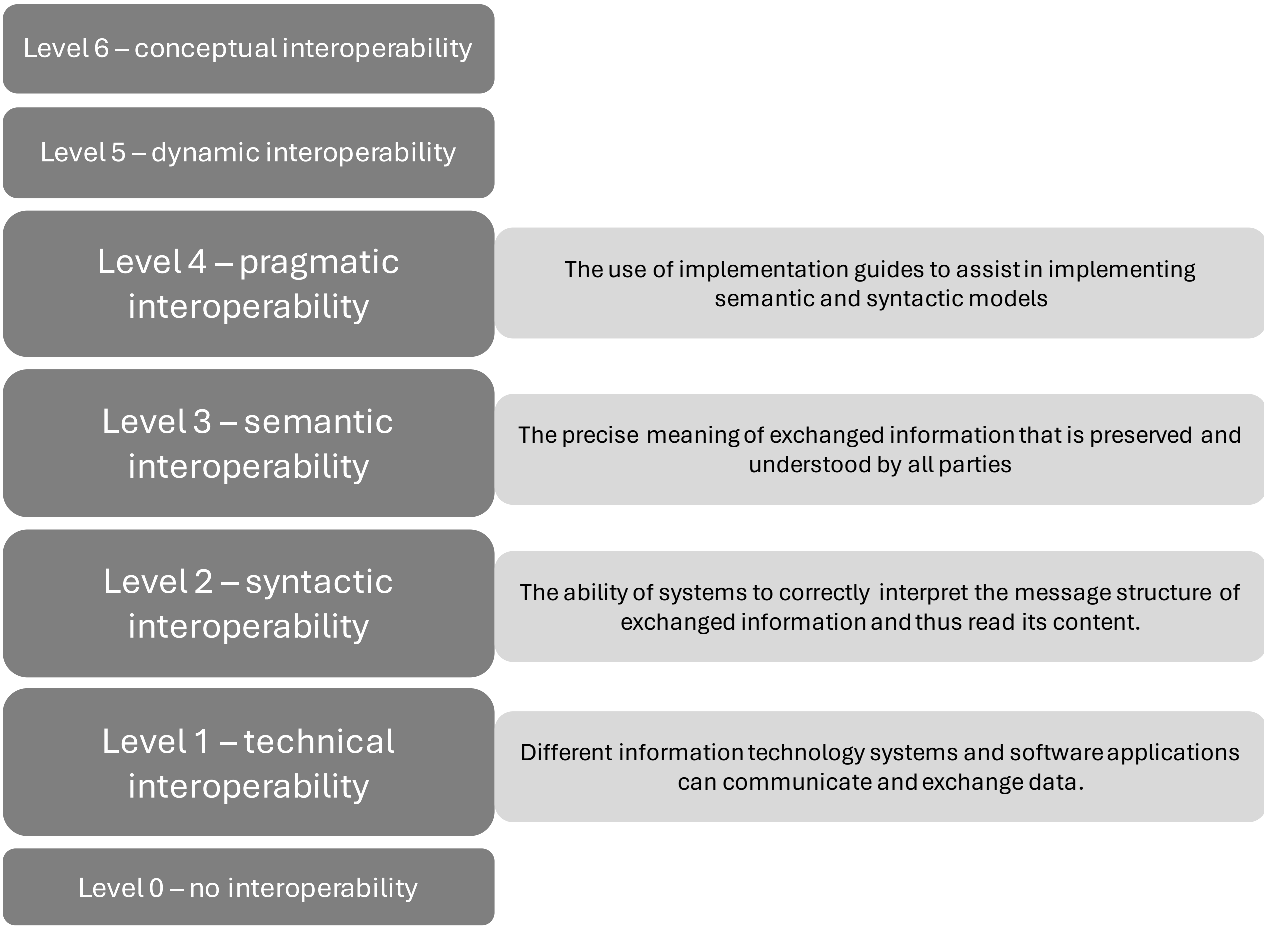

Figure 20 The DTLF levels of interoperability (Source DTLF)

The key difference between these two approaches is that in the EIF, syntax and semantics are both included in the semantic interoperability level, while they are separated in the model developed by the DTLF. While syntactic interoperability is defined to deal with data structures and formats, semantic interoperability is about concepts, definitions, and relationships between them.

6.3 Semantics

FEDeRATED is the initiative following the DTLF activities that has spent significant efforts on defining a semantic model for freight transport interoperability.

Figure 21 shows the initial semantic model developed in FEDeRATED.

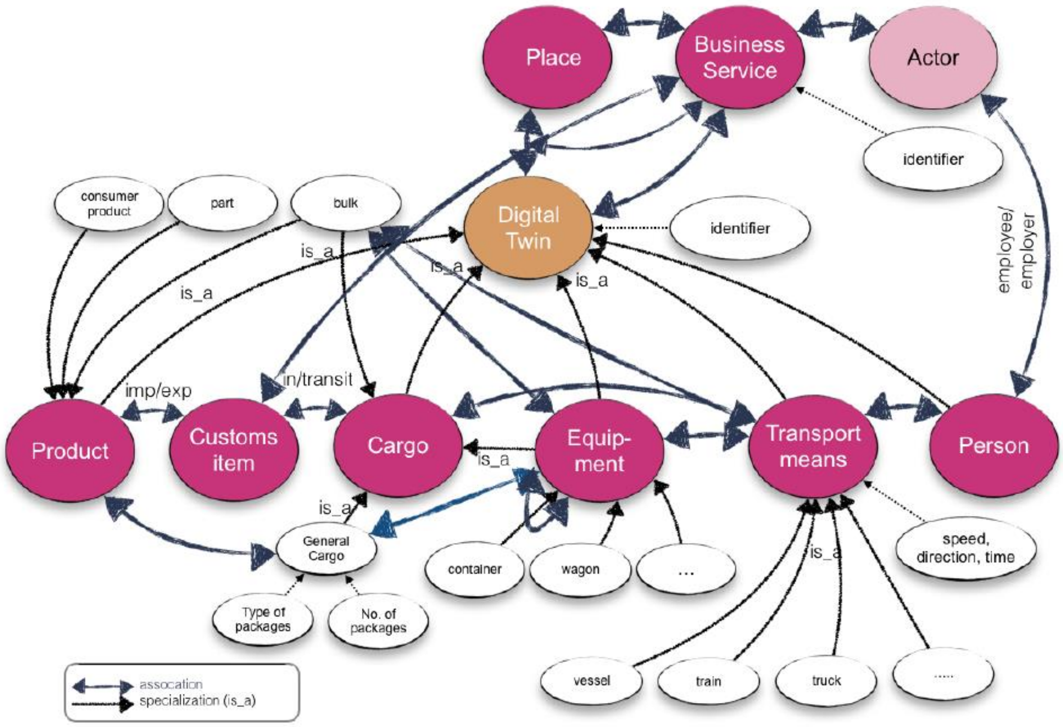

Figure 21 Initial semantic model in FEDeRATED)Source: FEDeRATED web site)

A more detailed visualisation of the FEDeRATED semantic model may be found here (https://www.federatedplatforms.eu/index.php/products/developer-portal/visualization).

An extract of that model is shown in Figure 22.

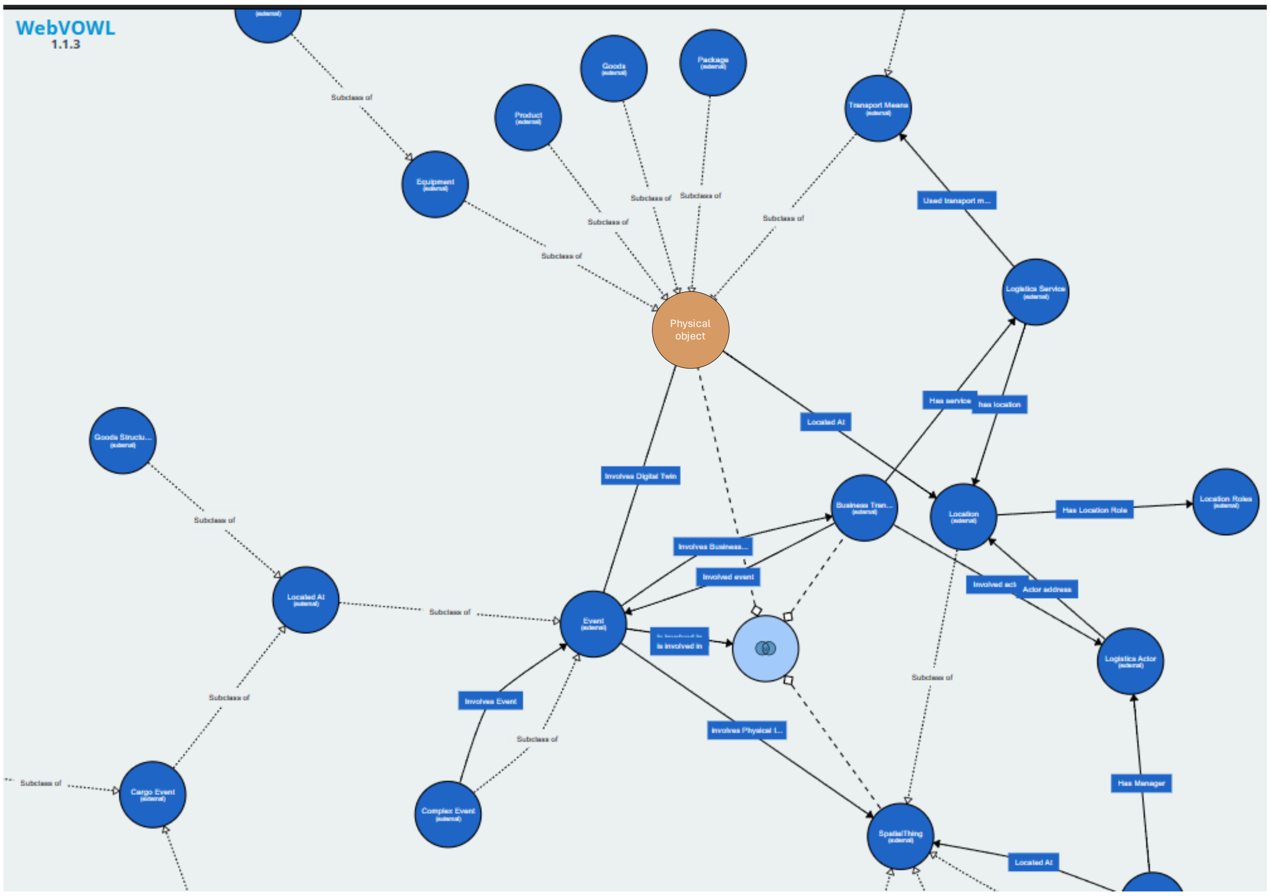

Figure 22 Extract of the FEDeRATED semantic model (Source FEDeRATED website)

The MIXMOVE system used in the pilot combining passenger and freight (see Section 3), has adopted the idea of using semantics as a way of achieving interoperability. The data structure at the core of the systems is using a so-called graph, see Figure 23.

As can be seen by comparing the structures in Figure 22 and Figure 23, the graph structure is especially suited for implementing semantic models, in addition to facilitating very efficient searches through large amounts of data.

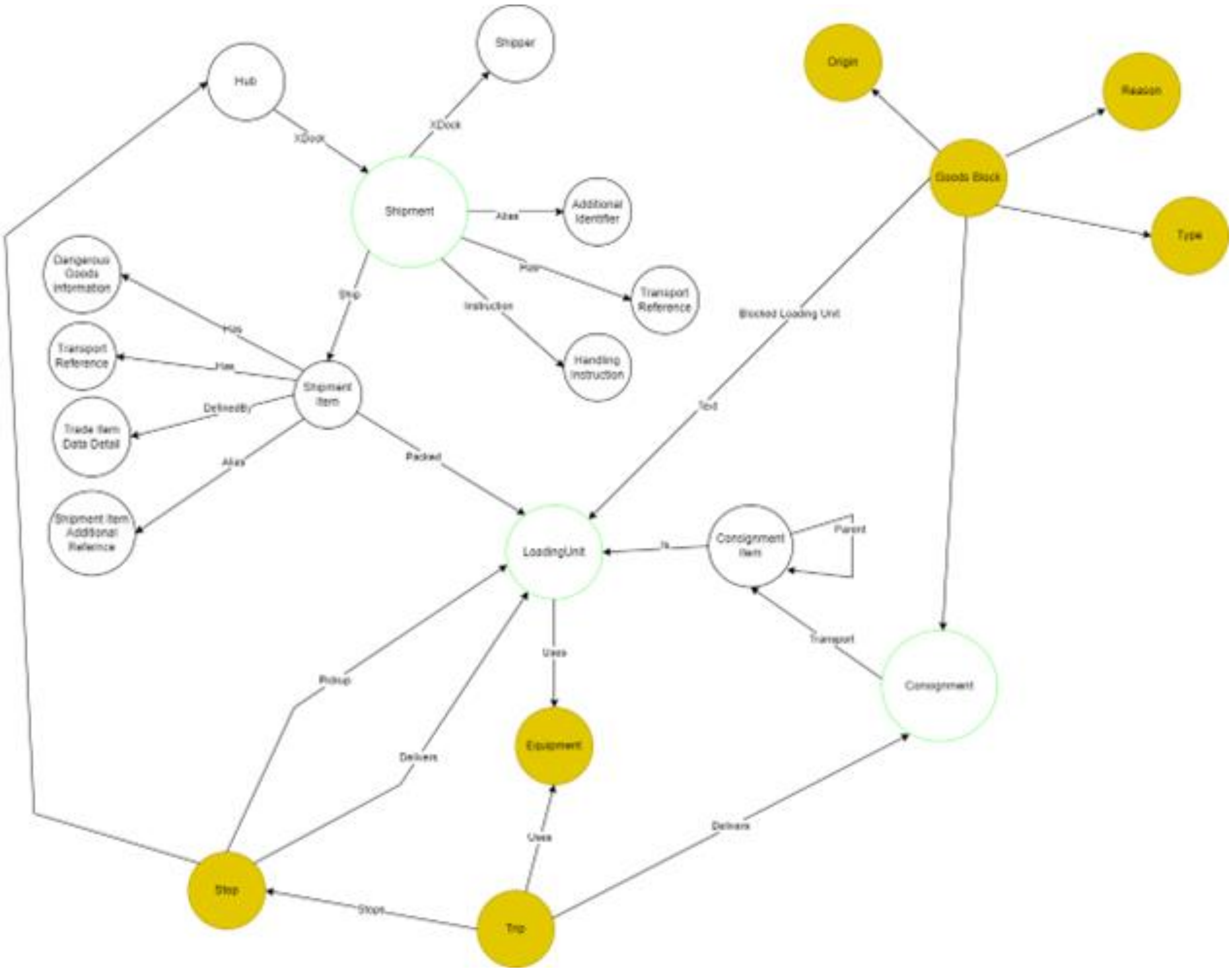

Figure 23 The graph structure of the MIXMOVE event pipeline (Own figure)

6.4 Digital Twins

Looking closely at Figure 21 and Figure 22, one of the elements in each model stands out. In Figure 22, one of the nodes is named “Digital Twin”. In Figure 22 we find a node named “Physical Object”.

As stated on the FEDeRATED website, moving cargo is a very physical business. Cargo is physically picked up at a real warehouse, lifted into a vehicle, and transported to another real-world location. What could be more down to earth and real than moving cargo? Paper documents are still used to support logistics and transport processes. However, virtually every part of the logistics and transport business is rapidly pursuing digital transformation and every part of the process is being digitalised, leading to the concept of ‘Digital Twin’, which may be said to be a virtual representation of an object or system designed to reflect a physical object accurately.

When taking a closer look at the paper documents used in transport and logistics, many of these were almost certainly prepared using, for instance, a sophisticated Enterprise Resource Planning (ERP) - or a similar system. Therefore, paper documents have digital origins representing the physical, real world – their Digital Twins, to be precise. Looking even closer, it would be clear that the entire process around these documents, like planning, booking, tracking, invoicing etc., are all supported by similar enterprise systems. Therefore, these real processes also work with Digital Twins of the real world: cargo, trucks, containers, vessels, aeroplanes, etc.

Unlike their physical counterparts, Digital Twins are not subject to the limitations of gravity, space and time. Digital Twins are a data – and process representation of real-world objects, where the data can be accessed from anywhere in the world at any time. When objects themselves are equipped with sensors that determine their geographical position and the condition of the contents, such as the temperature and humidity of flowers or pharma products, such information will enrich the information and the usefulness of the digital twins. We can detect the well-being of animals being transported or the security of valuable shipments. Now we can check exactly how our cargo is doing without the need for a local pair of eyes.

This idea is further extended to the equipment used for transport. Containers are being equipped with sensors. As are the trailers that they are on and the truck or train itself or the airplane or vessel it is transported on. Anything and everything that is used for the movement of cargo is increasingly paired with a Digital Twin, having computational capabilities themselves based on assessing their environment by means of sensors like cameras and other devices. It not only allows assessment and sharing of data about the real world but also supports predictions and prescriptions for behaviour like Estimated Time of Arrival and dynamic planning. Certificates, logs, identity, etc. digitally represent people as the last member in the family of digital twins. The drivers, pilots, safety inspectors and anyone that is part of the process.

It may seem obvious that in a world where our private lives are entwined in a digital world of social networks, online shopping, dating, entertainment, etc., a digital twin of the logistics and transport chain is a real thing. True, but the motivation goes much further.

For the past couple of decades, supply and logistics have been working on digitalising their artefacts and processes. The reason was always the same: accelerate information so that cargo can move seamlessly and be handled more efficiently. This has been shown to work, but it turns out that digital twins can go a lot further than just speed and efficiency.

Imagine that every organisation in supply and logistics has this sort of access to data. Not only will every digital twin of every physical artefact, process or thing be at their fingertips, but they will also be able to create virtual constructs that reflect the way they think about their business. Shippers will see their complete supply chain as a constructed digital twin. Warehouse managers can navigate around their virtual storerooms and see a timeline of its occupancy. Carriers will see their transport equipment on a map or they can see where each vehicle is in the maintenance queue. Customs officers will a flux of goods starting from manufactures long before it reaches their borders.

The GS1 Scan4Transport initiative (also mentioned in MOVE21 Deliverable 5.1) is an example of how digital twins can be used in logistics and how interoperability may be achieved without connecting information systems.

6.5 The eDelivery Infrastructure

Standards are important for integrating information systems and also in the mobility of people and goods. However, standards may not be the only issue of importance. In transport and logistics, many standards have been developed over many years. In the freight transport sector, the EU Commission has been working on improving interoperability between the various modes of transport for many years, but the idea of defining one standard to be used by all was abandoned many years ago.

Public procurement is also an arena where numerous standards exist, some of them local to specific EU countries. Part of the EU vision is open borders. Hence, any public buyer should be able to procure goods from any provider in any country in the same way. To facilitate this, the Peppol project (2008 to 2012) worked to solve "interoperability issues in electronic public procurement by aligning business processes using common standards, addressing common legal issues and developing open-source technologies" (Wikipedia, 2024).

Peppol worked with several issues, one being an infrastructure for information exchange (supporting the use of different standards). Another one was an electronic invoice. The use of the Peppol results were extremely successful. These results have been implemented and developed further, and they have been adopted by the EU Commission as part of what is called the Connect Europe Facility (CEF) Building Blocks (EU, 2020); see Figure 24. The CEF Building Blocks are used in various sectors; see Figure 25. Other sectors are engaged in applying these components, one of them is transport and logistics. What is particularly interesting in MOVE21 is the *eDelivery* infrastructure, see Figure 26.

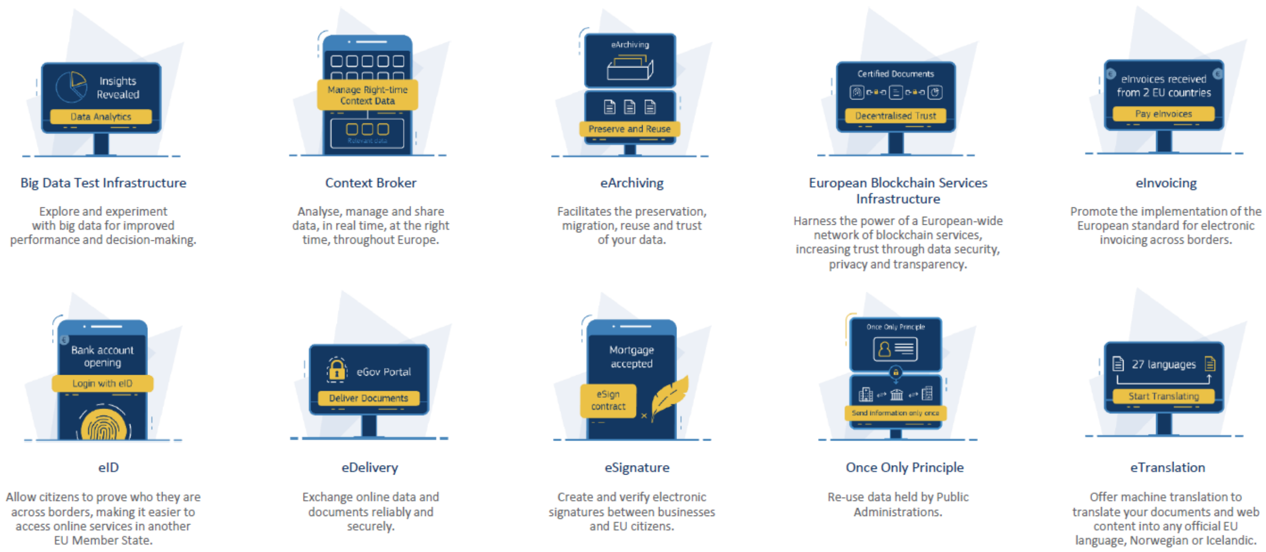

Figure 24 The CEF building blocks (Source: EU CEF documentation)

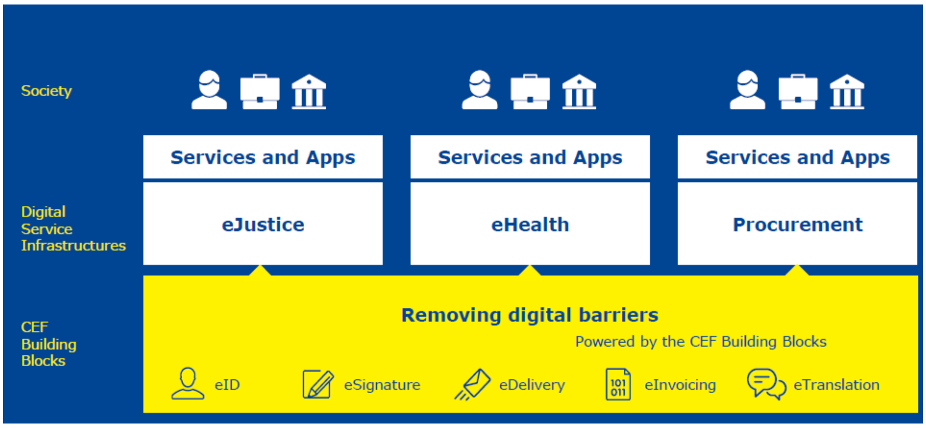

Figure 25 Sectors using the CEF Building Blocks (Source: EU CEF documentation)

When connecting information systems using the eDelivery infrastructure, the connection is not direct. Systems are connected to Access Points in the infrastructure, as illustrated in Figure 26, using freight transport as an example. The process for sending and receiving is presented in Figure 27.

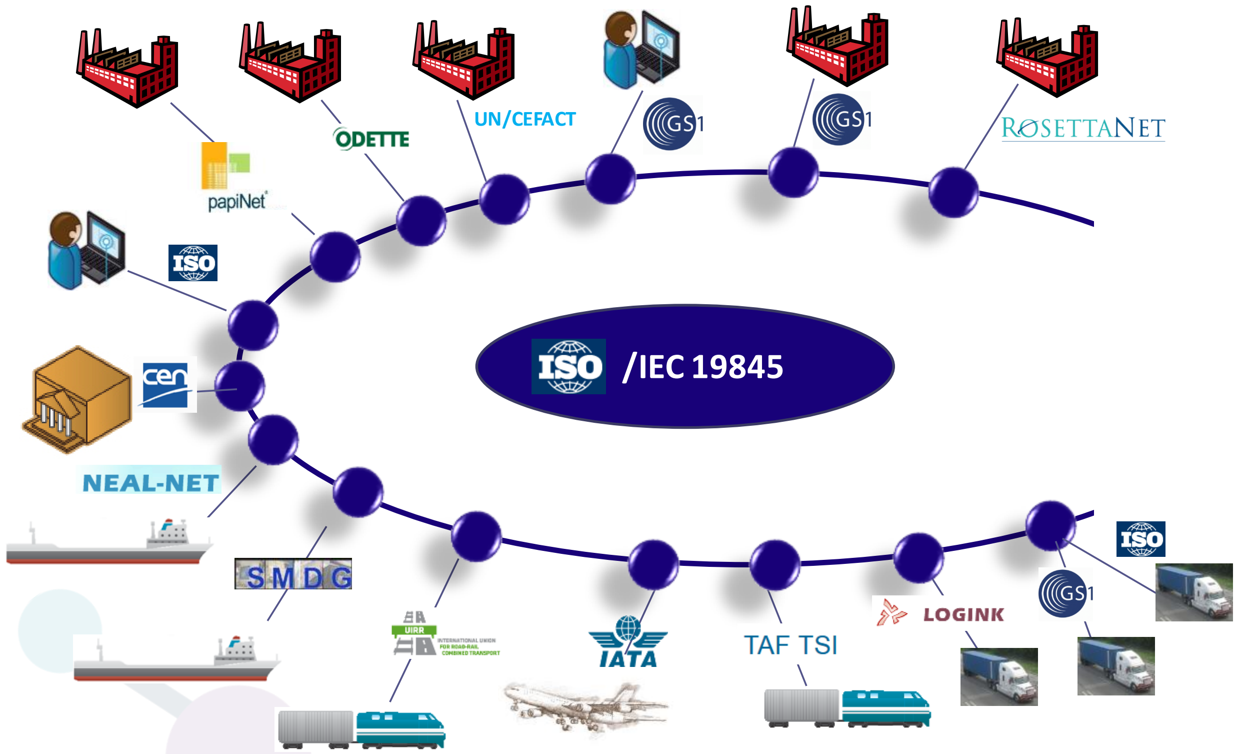

Figure 26 eDelivery - Connecting using Access Points (Own figure)

What is special about the Access Points is that they not only receive but also validate and compress messages. They may also add value-added services, like translating a message from one format to another, enabling the use of various standards. An example of how this may be done is shown in Figure 28.

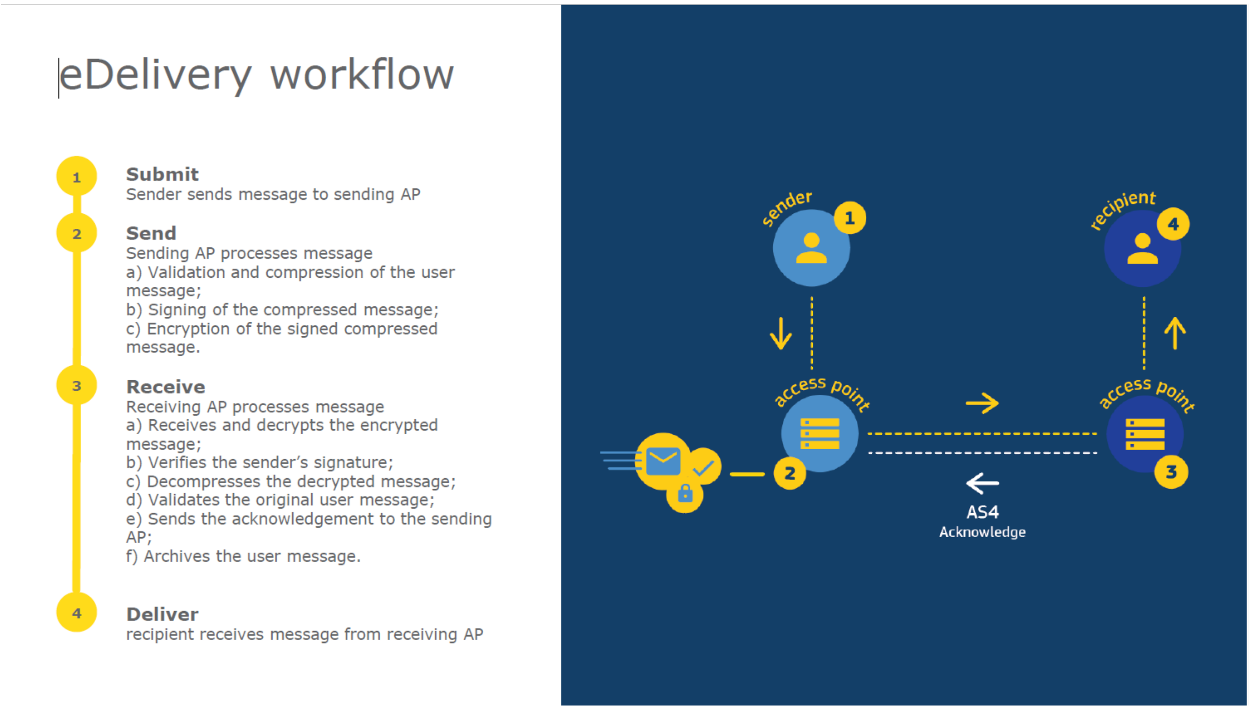

Figure 27 eDelivery workflow (Source eDelivery documentation)

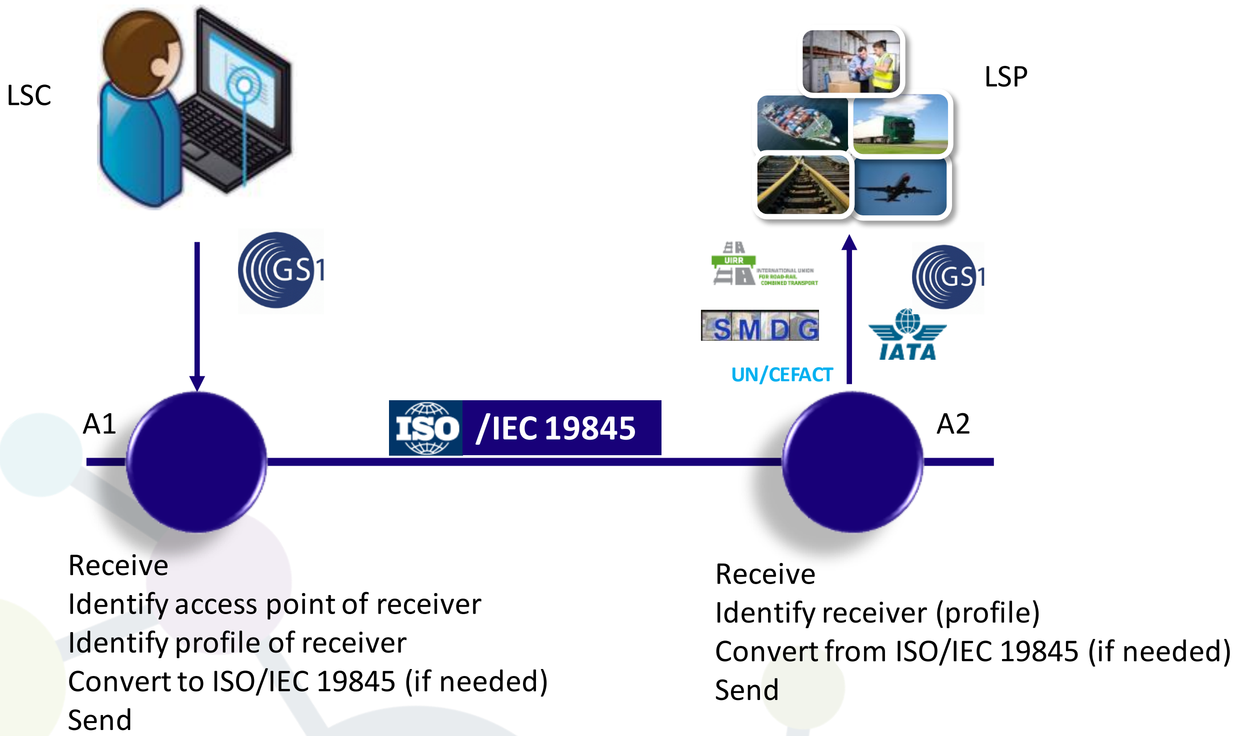

Figure 28 Example using the eDelivery infrastructure (Own figure)

In the example in Figure 28, the logistics Services Client (LSC) connected to access point A1 wants to book transport from a Logistics Services Provider (LSP) connected to access point A2. The LSC's management system applies the GS1 standards (GS1, 2024).

The standard used to transfer information between access points in the example is ISO 19845.
For booking transport, the following process is activated:

- A Transport Instruction (TI-a GS1 message used for booking transport) is sent from the LSC's ICT system to access point A1.
- Here, the TI is translated into the appropriate ISO 19845 message (TEP). A1 also detects that the message receiver is connected to A2 and sends the TEP message there.
- When access point A2 receives the TEP message, the receiver is identified. Access point A2 also knows which standard is used by the information system of the LSP, such as UN/CEFACT. Consequently, the TEP message is translated into the appropriate UN/CEFACT format (IFTMBF) before it is sent to the LSP.

When a confirmation is returned, the process is similar but in reverse. Besides the interoperability models presented in Section 6.2, with the eDelivery infrastructure (CEF Building Blocks) and semantic developments like the ones in FEDeRATED, we have a potential framework to support MOVE21 interoperability.

When adopting the semantics approach suggested in FEDeRATED, the syntactic and semantic translations take place in the Access Points. are where the syntactic and semantic translations take place. This enables each connected party to benefit from investments already made in implementing standards.

6.6 Applying eDelivery Principles

The author of this document was heavily involved in the eFreight project and in developing what became to be the ISO 19845 standard for information exchange in logistics.

The principles in eDelivery (or the Peppol transportation) infrastructure of connecting once and communicating with many using access points were more than attractive. When the MIXMOVE software solutions were developed starting in 2011 (funded by the EU-project iCargo (2011-2015), the principle of applying access points was adopted as an integral part of the product architecture, see Figure 29.

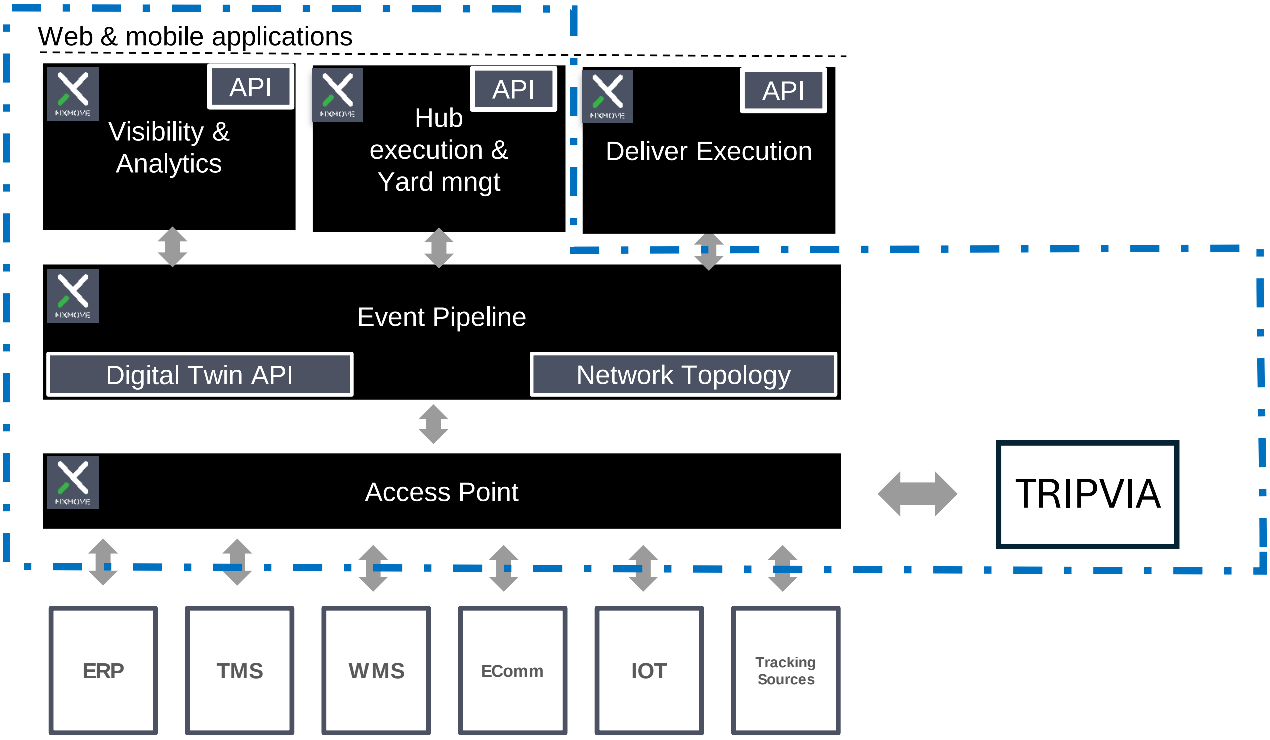

Figure 29 MIXMOVE product architecture overview (Own Figure).

The marked elements of the product architecture are included in the mobility-on-demand for people and freight pilot in MOVE21.

7 Recommendations and Conclusion

The focus in MOVE21 was never on developing new technologies but on enabling technologies to facilitate non-technological innovations. One key element in this was to enable interoperability or connectivity between mobility services that normally are not interconnected.

The three pilots presented here aimed to connect mobility services in innovative ways, and the lessons learned from them in the near term should be valuable for others attempting to make similar integrations.

For those who are doing research and developments with longer horizons, it is suggested that the barriers that exist between passengers and freight transport are being lowered and that the two communities meet and learn from each other. As a minimum, the two communities should agree on a common approach to use semantics as the way to represent or describe mobility information and the objects that are transported.

7.1 Integrating Micro-Mobility in Other Services

As the Living Lab in Gothenburg shows, the architecture and technology used to implement mobile apps are barriers to providing integrated, seamless services. The Oslo example shows that the new API (supporting the GBFS) makes such integrations effective and efficient.

The new API from Urban Sharing is a significant contribution to simplifying such integrations and offers a good basis for enabling attractive combinations of public transport and micro-mobility.

7.2 Integration Freight and Passenger Transport

One observation to be made here is that the status information for freight in Figure 10 specifies the status of “riders” even though the objects being transported are goods (packages, bags, etc.). This reflects the fact that, at the moment, such integration needs to use APIs and other mechanisms that exist in the various domains.

Reverting to the FEDeRATED semantic model and reflecting on the approach taken in the ARKTRANS initiative, the following observations are made.

In the FEDeRATED semantic models, the physical object (or its Digital Twin) is part of the model. The attributes of the physical objects are typically weights and dimensions, material, etc. In ARKTRANS, the aim was to find a common reference architecture for transport of passengers and freight. Given this background, it may be fair to ask the following question: Would the FEDeRATED semantic model have any effect if the physical object to be transported is a person and not a cargo item?

One immediate answer is that the model would be simpler. Common between the passenger and freight transport domains are:

- Scheduled and non-scheduled services. Liner shipping services, like trains and buses, have regular schedules and multiple stops. Most truck transport operations are on-demand.
- There are various transport means in use. These are typically defined by carrying capacity, what types of objects they can carry, energy use, cost of use per time unit, etc. The transport means may look different, but their attributes can be described in the same way.
- Business services are offered in both domains.

- Locations in the form of origins, destinations, networks, stops routes, etc., are also common.

However, there are specificities about freight transport that are not relevant to passenger transport. From Figure 21, entities like products, customs items, and cargo are not relevant to passenger transport. Semantic models that describe information related to passenger transport should be simpler than the ones used in the freight transport domain. Therefore, it should be possible to also use semantic modelling to describe passenger transport-related information.

If the freight and passenger transport communities could agree on a common representation of these semantic models, we would at least achieve the following:

- The communities could learn from each other.
- Combining freight and passenger transport could be significantly simplified from an information system point of view.
- New gains from combined transport in terms of resource utilisation and efficiency.

The effect of such an approach would be that it would be simple to convert the information that is “rider” in the system, planning the mobility-on-demand services in Oslo, to a cargo item object in the systems managing the logistics in the same pilot. As previously mentioned, the Norwegian project ReiseNavet has already developed an ontology representing the Transmodel and its elements, also including micro-mobility.

7.3 eDelivery

The eDelivery infrastructure was originally developed in the Peppol project for public procurement, enabling providers from all over Europe to openly compete, even though product information and formats for ordering and invoicing, etc., were different in many European countries. The EU initiatives for providing interoperability in logistics goes back many years and is currently culminated through the establishment and execution of the DTLF activities. Both the FEDeRATED and FENIX are direct results of initiatives from the DTLF.

The link between ordering and delivering products is tight. Hence, in the eDelivery community, initiatives to use this infrastructure for information exchange in logistics were taken in projects like eFreight (2010-1013). These experiments were promising, even though the initial eDelivery infrastructure was not designed to handle real-time information exchange. Since then, this weakness in the infrastructure has been removed, and there is now an interest group in the eDelivery (Open Peppol) community dealing with logistics.

The so-called four-corner model illustrated in Figure 28 has been adopted in applications beyond procurement and should also be considered in the area of passenger (people transport).

8 References

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