State of the art of electric Mobility as a Service (eMaaS)

An overview of ecosystems and system architectures

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Electric Mobility Europe

eMAAS

UNIVERSITY OF TWENTE.

European Commission

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- **Introduction**
- **Presentation structure** (as in paper)
  - Mobility as a Service (MaaS)
    - Definition
    - Ecosystem
    - Architecture
  - electric Mobility as a Service (eMaaS)
    - Definition
    - Ecosystem
    - Architecture
- **Takeaways**

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From literature review

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Authors proposition

Focus of this presentation

INTRODUCTION – About us

University of Twente – Department of Design, Production and Management
Systems Engineering and Multidisciplinary Design (SEMD) Group || Electric Mobility Team

	**Associate Professor**	Dr. Ir. Maarten Bonnema	Chair of SEMD and Project Supervisor
	**PostDoc Researcher**	Dr. Ir. Steven Haveman	Lead Researcher - Systems Engineering and Systems Modeling Research
	**Junior Researcher**	J. Roberto Reyes García	Research on Data Driven Architectures and Knowledge Sources for Electric Mobility Systems

Urban Software Institute GmbH

	**Technologist – IoT specialist**	Dr. Gadi Lenz	IoT centric solutions, platforms and architectures for Smart Cities with a focus on mobility and EVs

INTRODUCTION – The eMaaS project

European Commission

The eMaaS project has received funding from the ERA NET COFUND Electric Mobility Europe (EMEurope)

Electric Mobility Europe

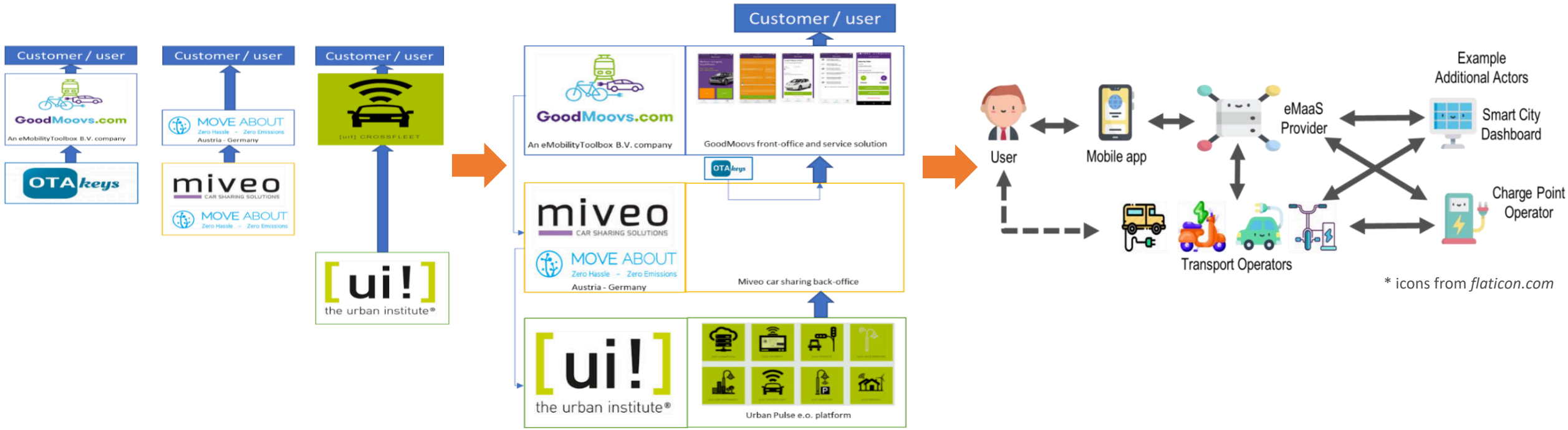
Project consortium

eMaaS

UNIVERSITY OF TWENTE. / GoodMoovs.com	The Netherlands
[ui!] the urban institute®	Germany & Hungary
MOVE ABOUT Zero Hassle - Zero Emissions	Austria & Sweden

INTRODUCTION – The eMaaS project

From isolated solutions → To integrated solutions → To a stand-alone eMaaS solution



Mobility as a Service (MaaS) – Literature Review

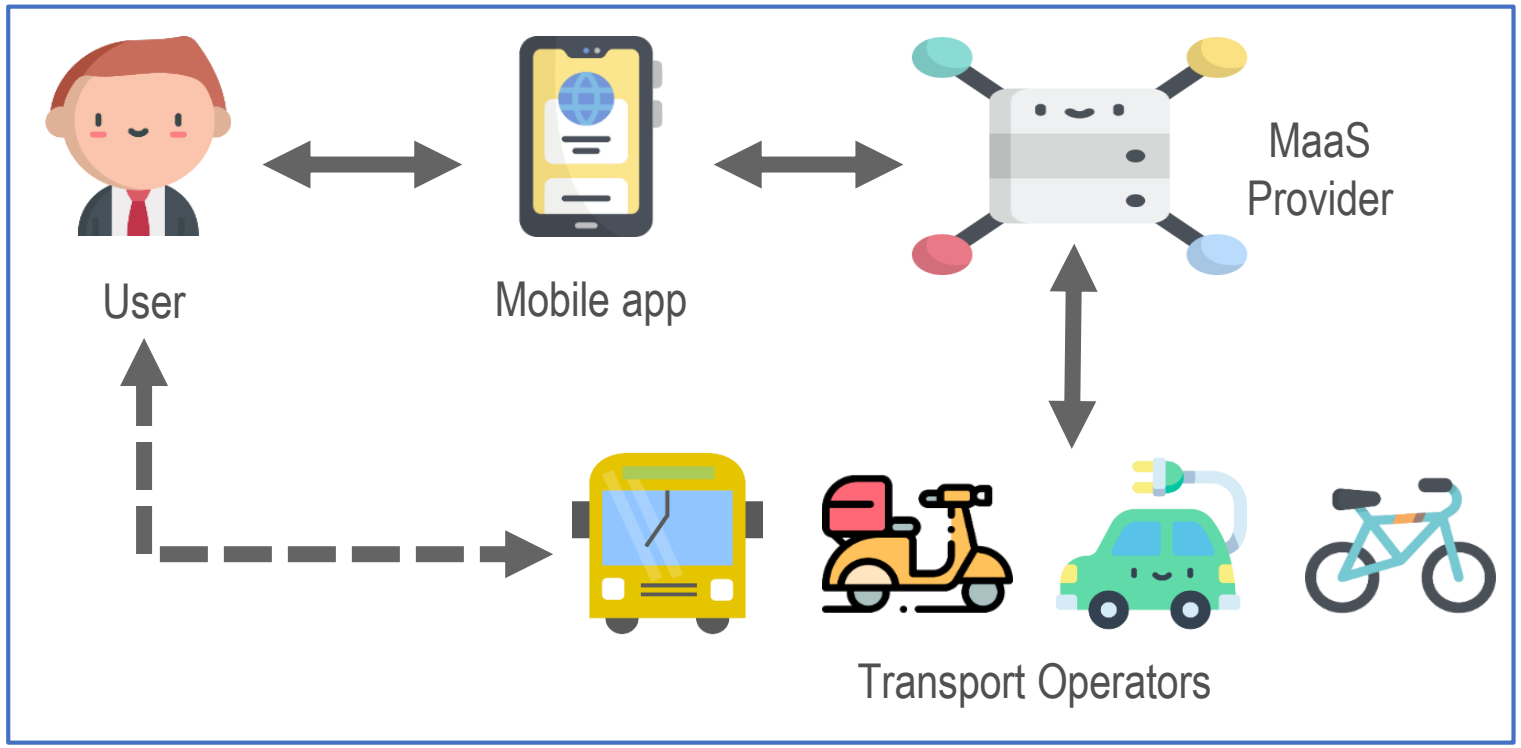
MaaS Definitions

- **Hietanen, S. (2014):** *"Mobility* as a Service (Maas) is a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider. Typically, services are bundled in to a package - similar to mobile phone price-plan *packages"*
- **Burrows et. al. (2015):** *"The* provision of transport as a flexible, personalised on-demand service that integrates all types of mobility opportunities and presents them to the user in a completely integrated manner to enable them to get from A to B as easily as possible*"*
- **MaaS-alliance (2017):** *"the* integration of various forms of transport services into a single mobility service accessible on demand […] through use of a single application to provide access to mobility, with a single payment channel […] to meet all *users'* mobility needs*"*
- **Herrlin (2018):** *"MaaS* is the idea that *we're* moving away from privately owned modes of transportation and towards consuming transportation solutions as a service*"*

Mobility as a Service (MaaS) – Definition

MaaS Definition elements

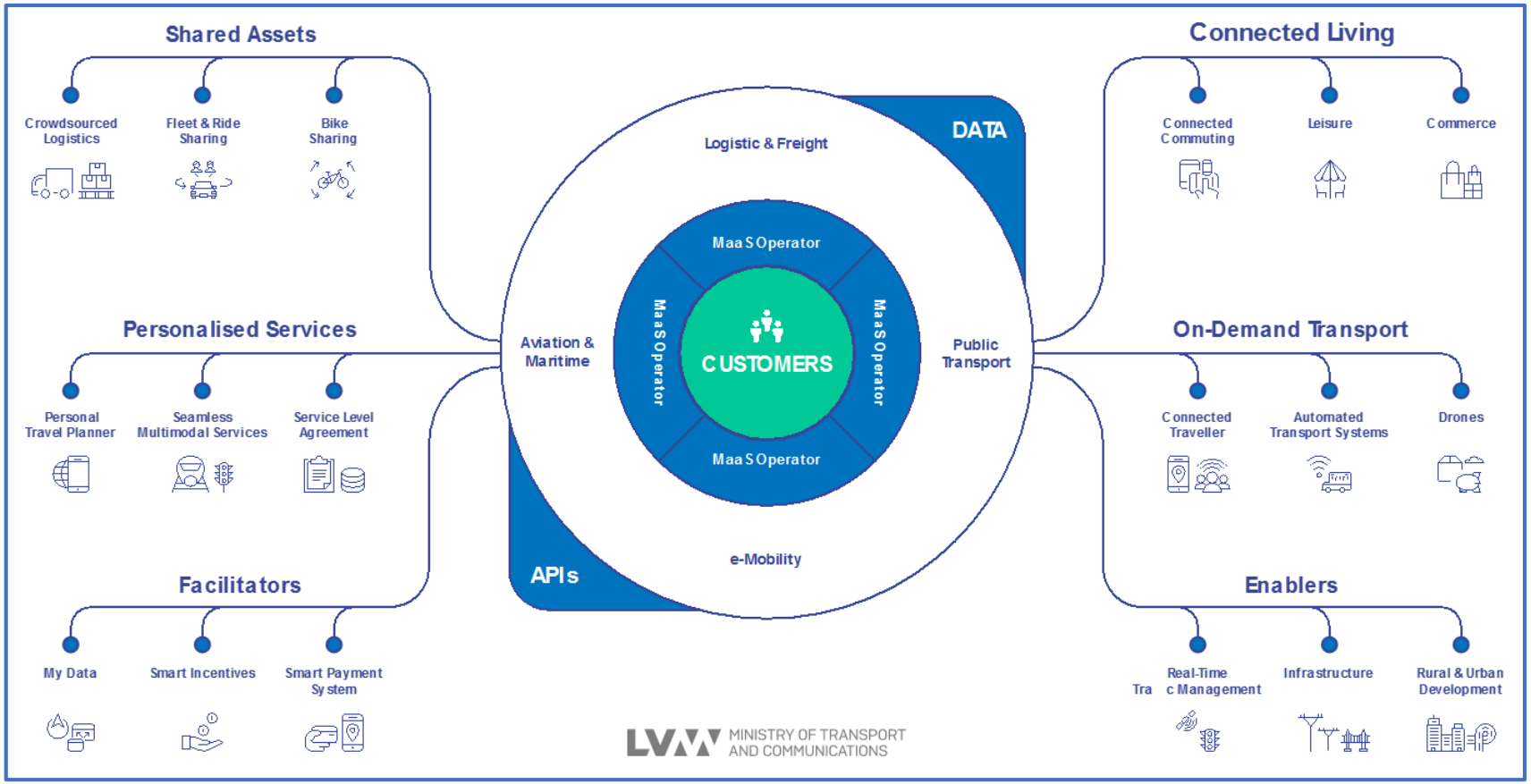
- ✓ Multimodal
- ✓ Seamless
- ✓ Personalized
- ✓ Single interface
- ✓ Data-driven
- ✓ On-demand
- ✓ Easy-to-use
- ✓ User-centred
- ✓ Payment integration



* Icons from *flaticon.com*

Mobility as a Service (MaaS) – Literature Review

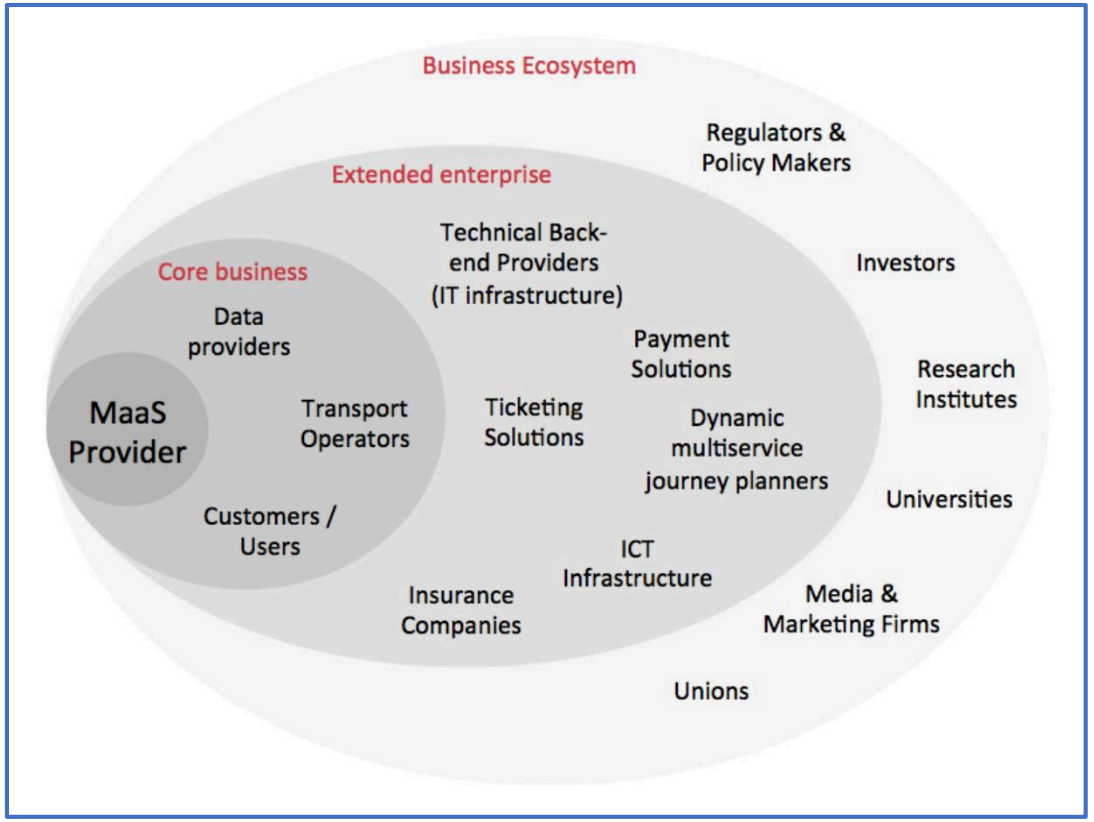
MaaS Ecosystem



Source: Huhtala-Jenks, K. (2017)

Mobility as a Service (MaaS) – Literature Review

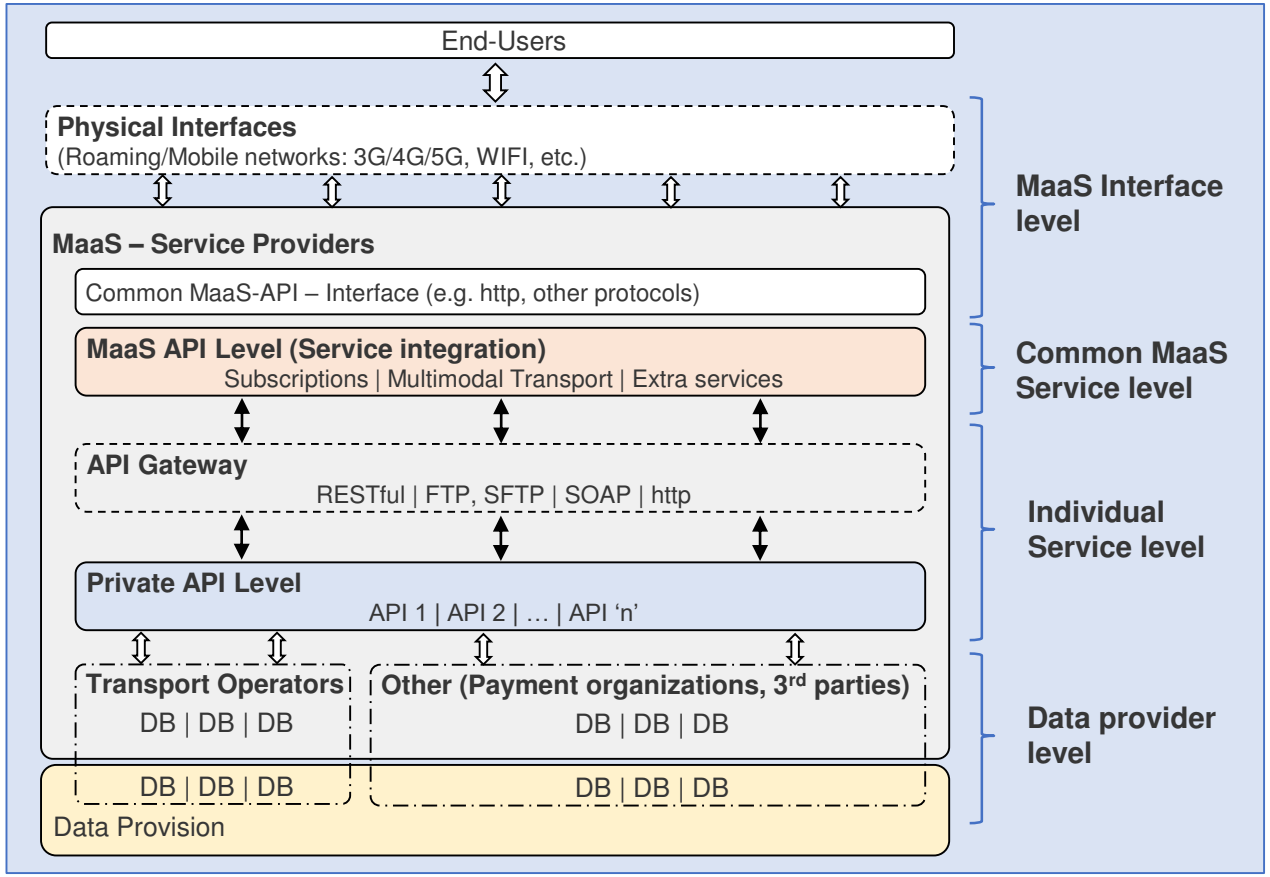
MaaS Business Ecosystem



Source: Kamargianni, M. and Matyas, M. (2017)

Mobility as a Service (MaaS) – Literature Review

MaaS System Architecture



Source: Adapted from König, D. et al. (2017)

electric Mobility as a Service (eMaaS) – Definition

eMaaS = MaaS + EVs ?

electric Mobility as a Service (eMaaS) – Definition

eMaaS = MaaS + EVs ? ✗

The complementary goal of eMaaS, when compared to MaaS, is to provide users the possibility to go from A to B in an **eco-friendly** way. Therefore, **eMaaS** is meant to be **electric** and **shared**.

electric Mobility as a Service (eMaaS) – Definition

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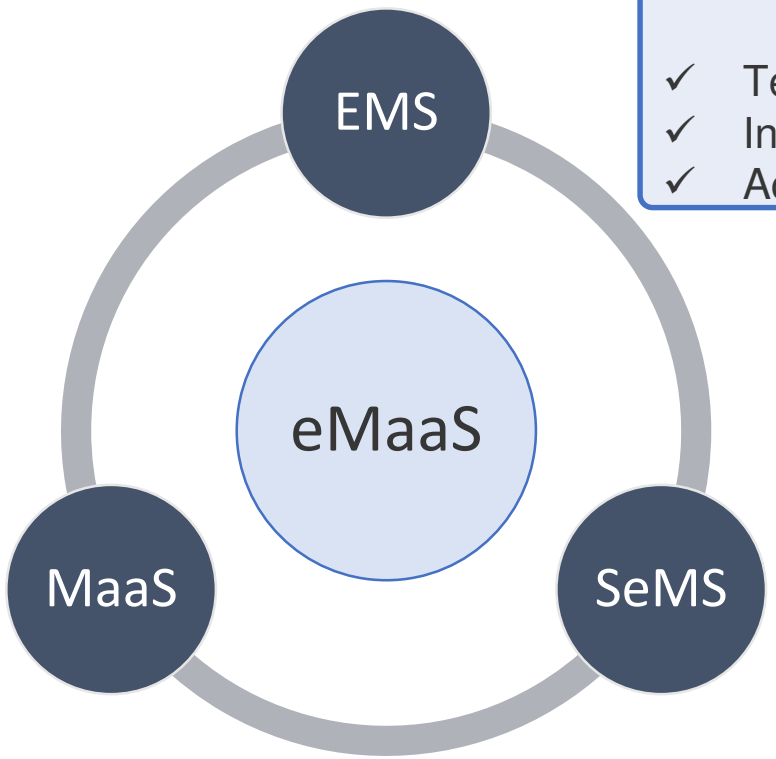
eMaaS = MaaS + EMS + SeMS ✓

EMS = Electric Mobility Systems
SeMS = Shared electric Mobility Services

electric Mobility as a Service (eMaaS) – Ecosystem



EMS

- ✓ Technologies
- ✓ Infrastructure
- ✓ Actors

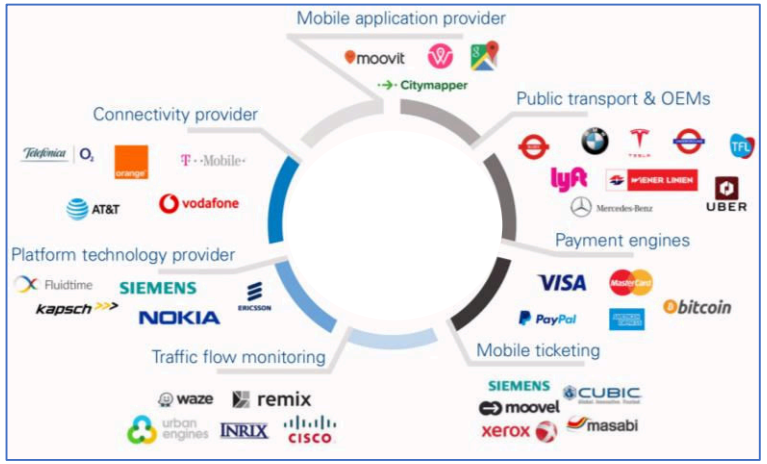
MaaS

- ✓ Multimodal
- ✓ Seamless
- ✓ Personalized
- ✓ Single interface
- ✓ Data-driven
- ✓ On-demand
- ✓ Easy-to-use
- ✓ User-centred
- ✓ Payment integration

SeMS

- ✓ Membership-Based
- ✓ Peer-to-Peer (P2P)
- ✓ Non-Membership
- ✓ For-Hire Service
- ✓ Mass Transit Services

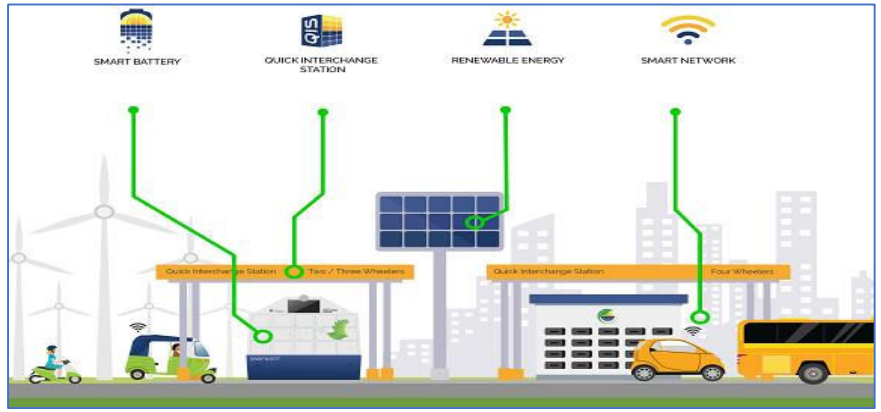
electric Mobility as a Service (eMaaS) – Ecosystem



Actors & Technologies

EMS

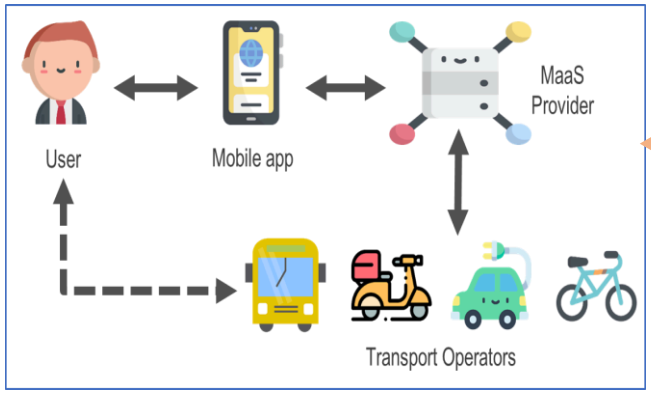
Infrastructure

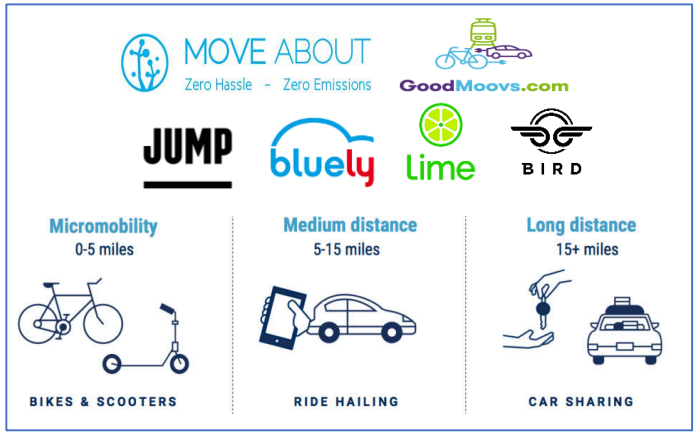


eMaaS

MaaS

SeMS





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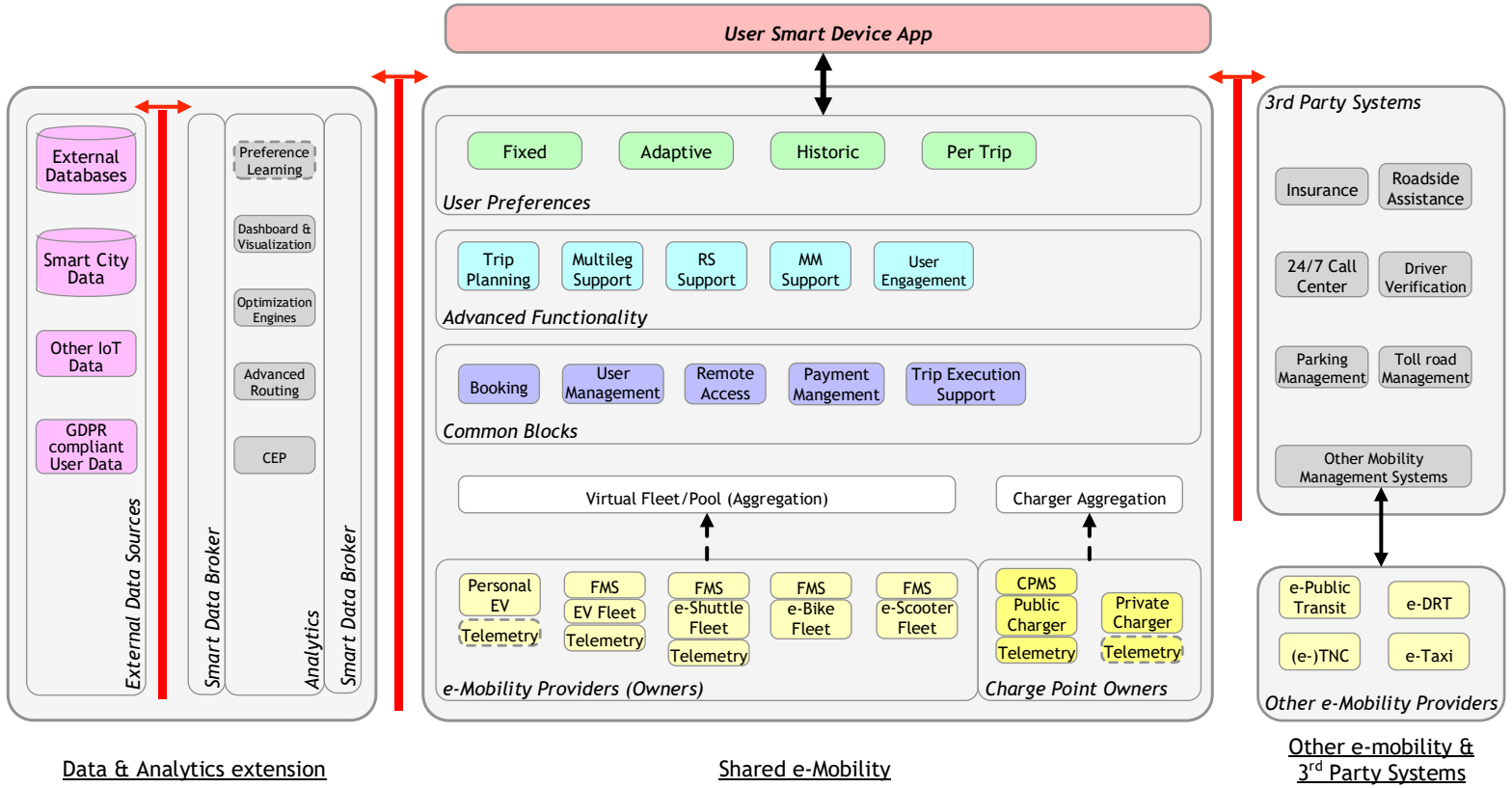
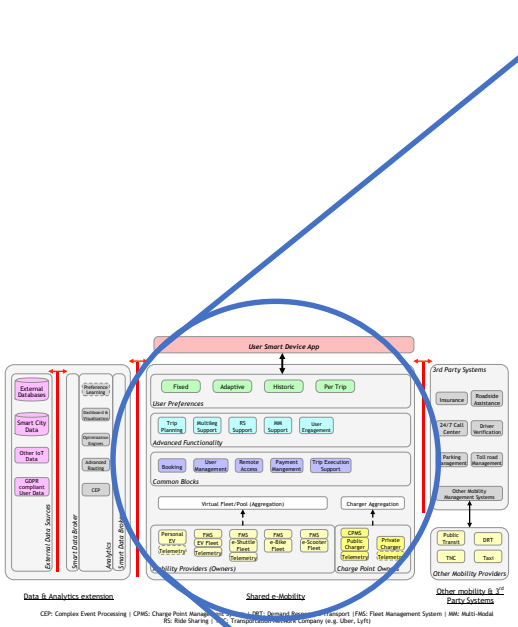
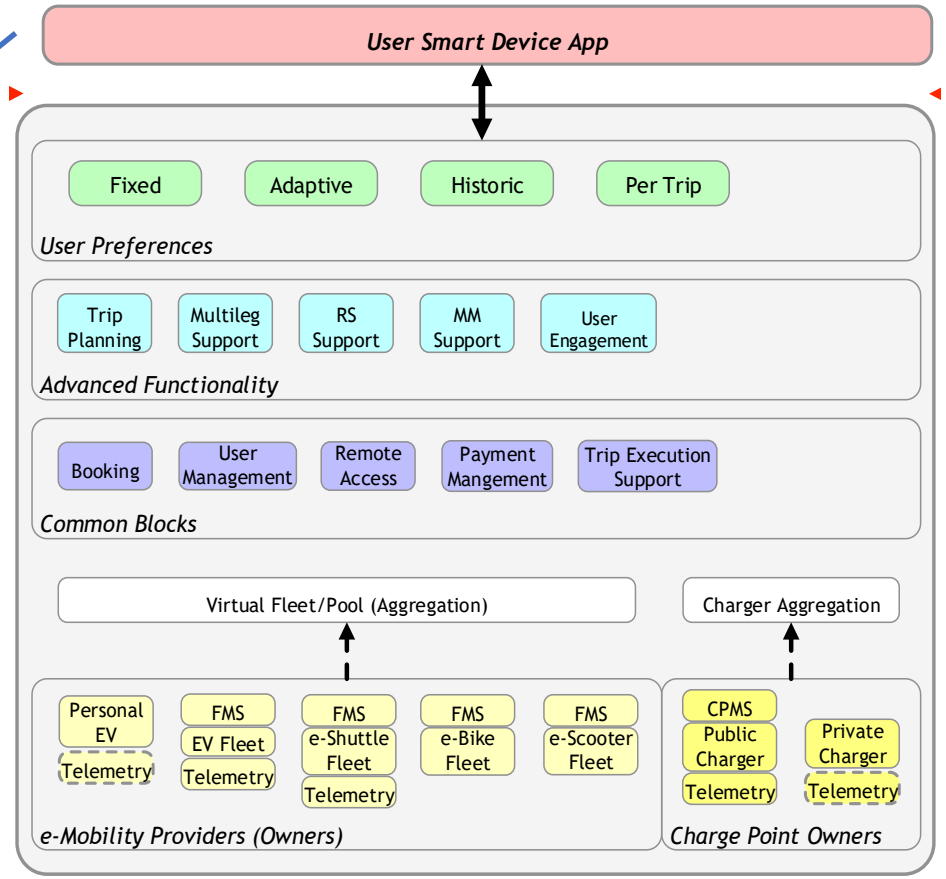


CEP: Complex Event Processing | CPMS: Charge Point Management System | DRT: Demand Responsive Transport |FMS: Fleet Management System | MM: Multi-Modal
RS: Ride Sharing | TNC: Transportation Network Company (e.g. Uber, Lyft)

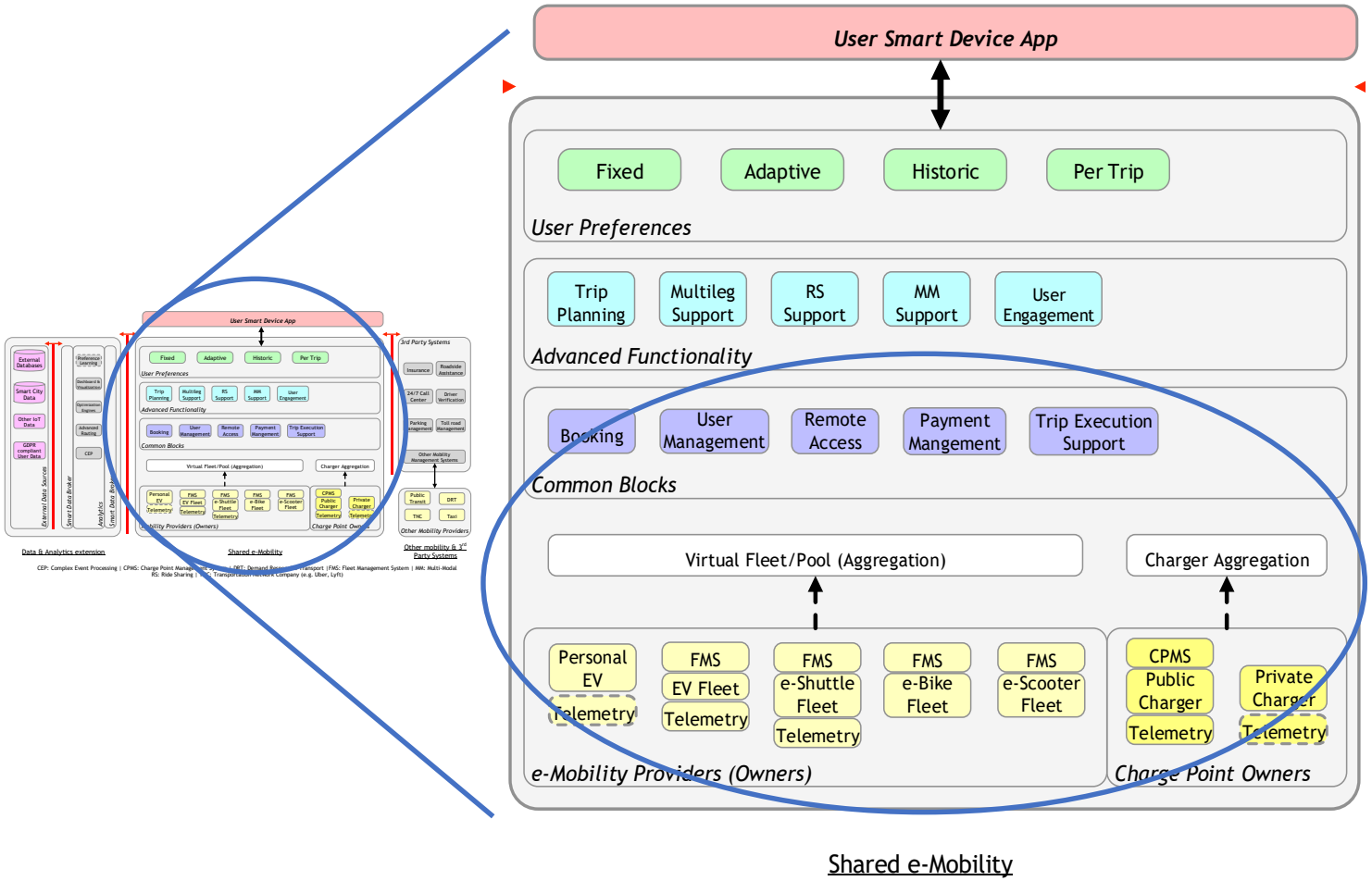
electric Mobility as a Service (eMaaS) – System Architecture





Shared e-Mobility

electric Mobility as a Service (eMaaS) – System Architecture



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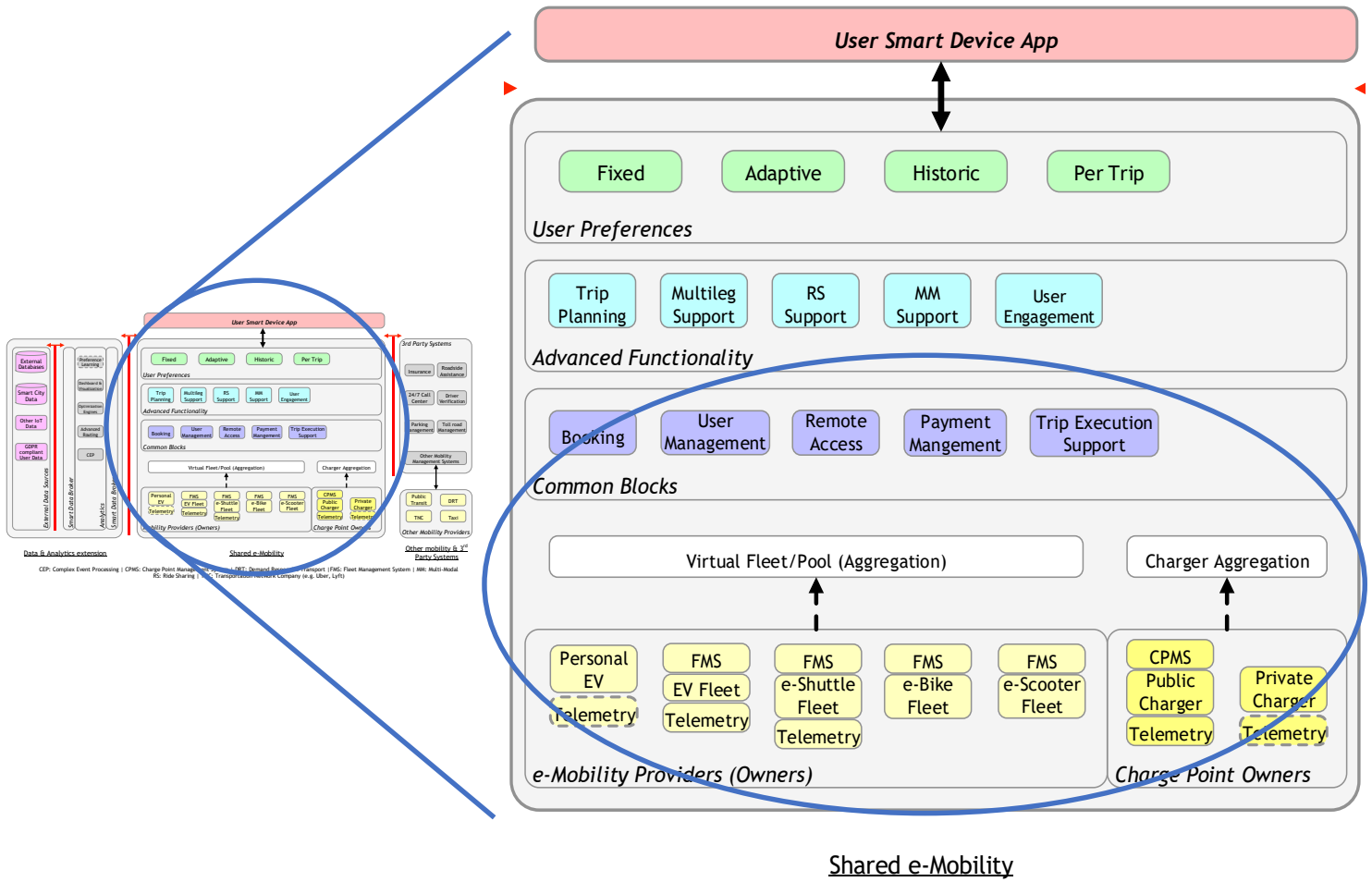
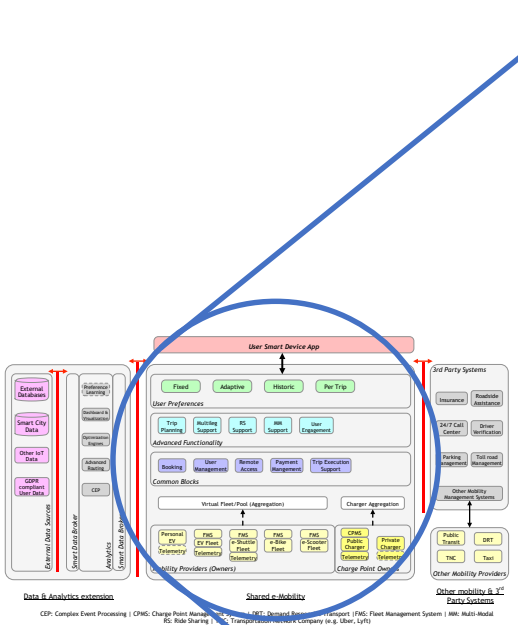


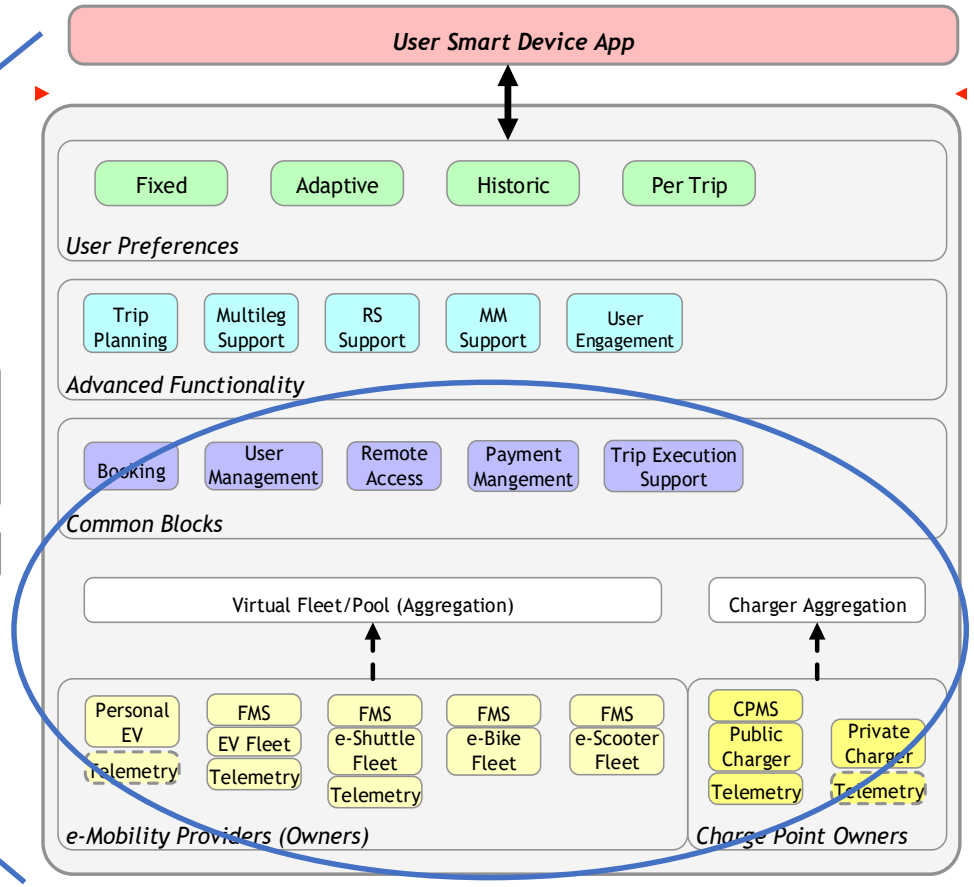
Shared e-Mobility

e-Mobility Providers - Owners of the vehicles

- Fleets (non-personal vehicles) can include FMS
- Personal EVs (and e-shuttle) fleets include telemetry hardware; private EVs **optional** telemetry hardware

electric Mobility as a Service (eMaaS) – System Architecture





Shared e-Mobility

Charge point owners

- Public infrastructure, incl. CPMS with telemetry (charger related data)
- Private chargers include **optional** telemetry

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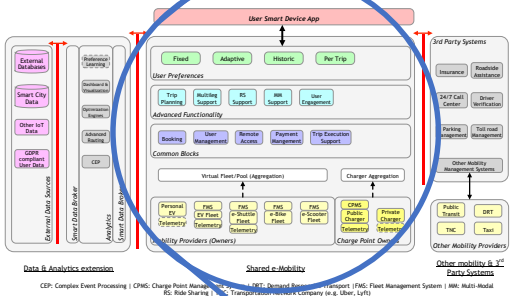

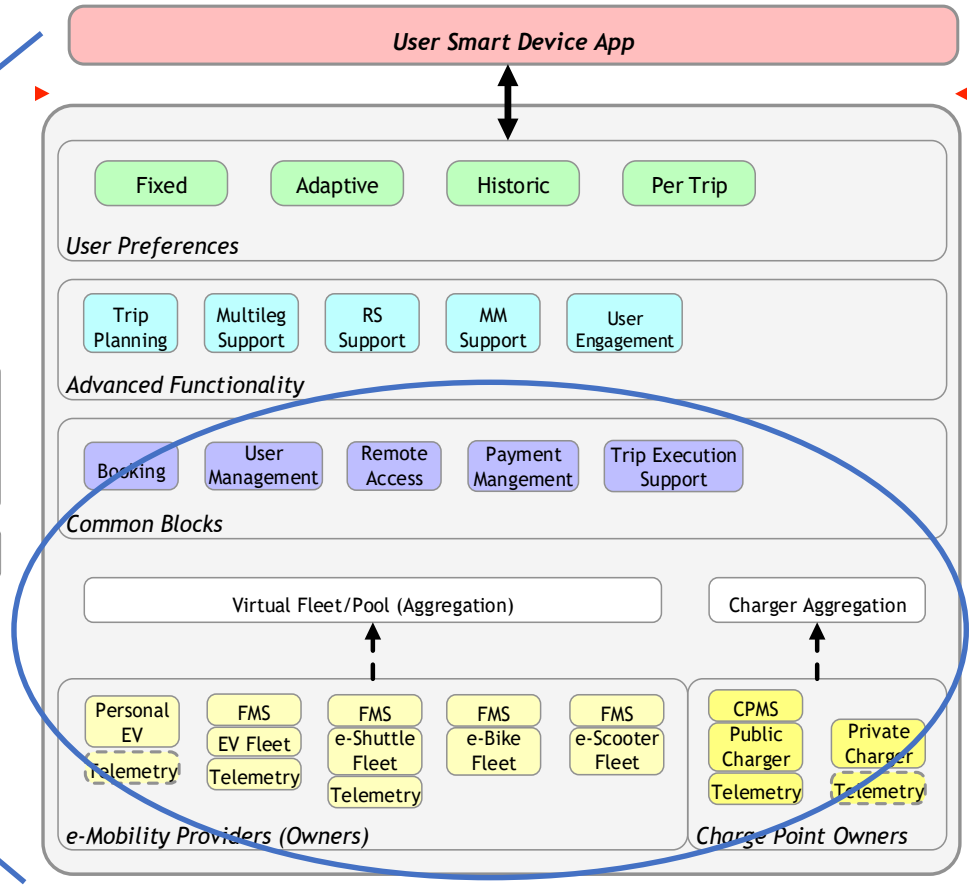

Shared e-Mobility

Virtual Fleet Aggregation - Pooling of multiple physical fleets into one virtual fleet for use by operators

Charger Aggregation - Facilitates seamless (vendor independent) charging

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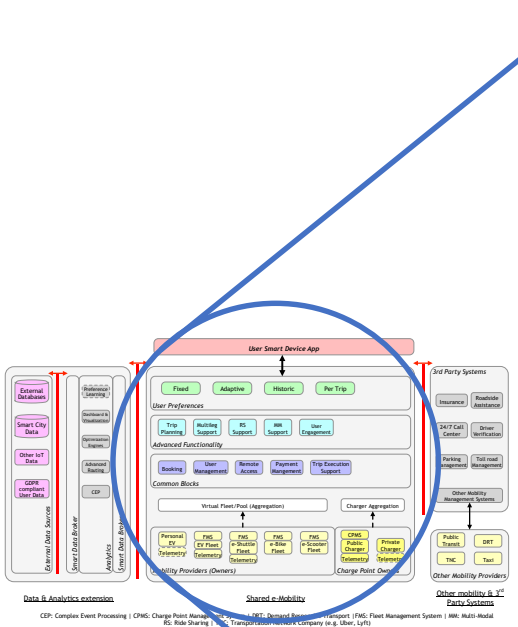

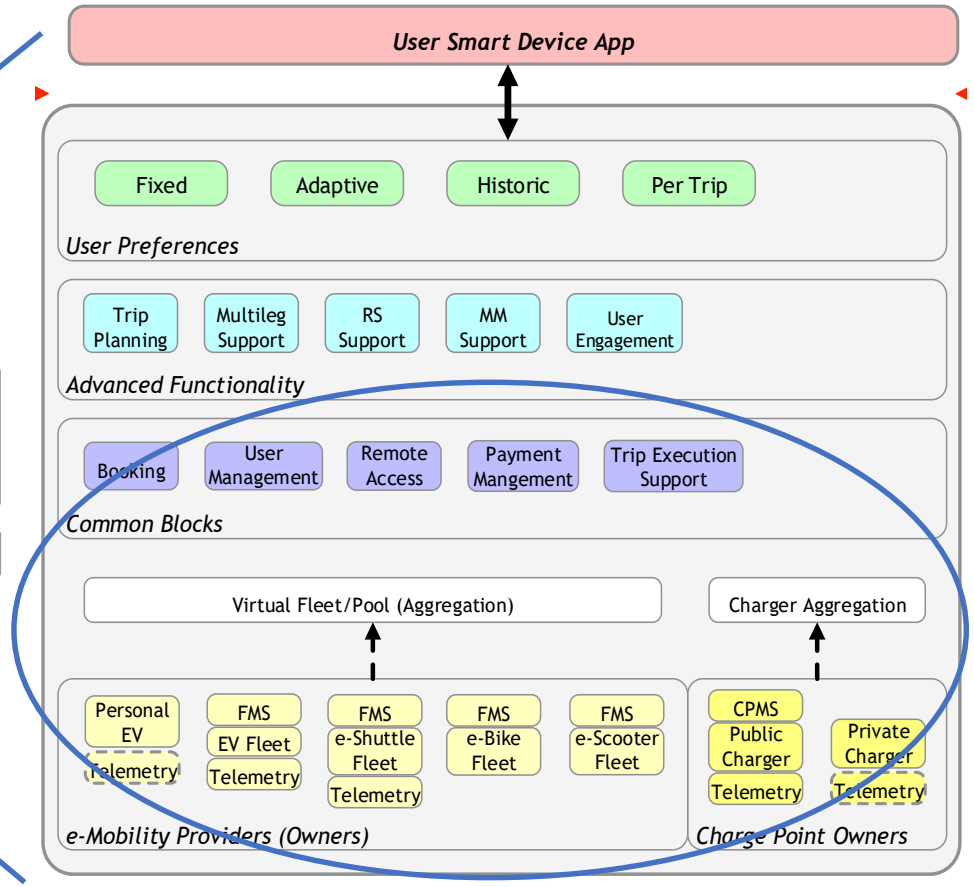

Shared e-Mobility

Common Blocks – across all (or almost all) shared mobility solutions

- Booking: Handling of user reservations (including user preferences)
- User Management: Incl. enrollment, preferences, incentive programs
- Remote Access: smart phone/card lock/unlock access
- Payment Management: All billing related functions
- Trip Support: Before-, during- or after trip
  - Optionally by 3rd party

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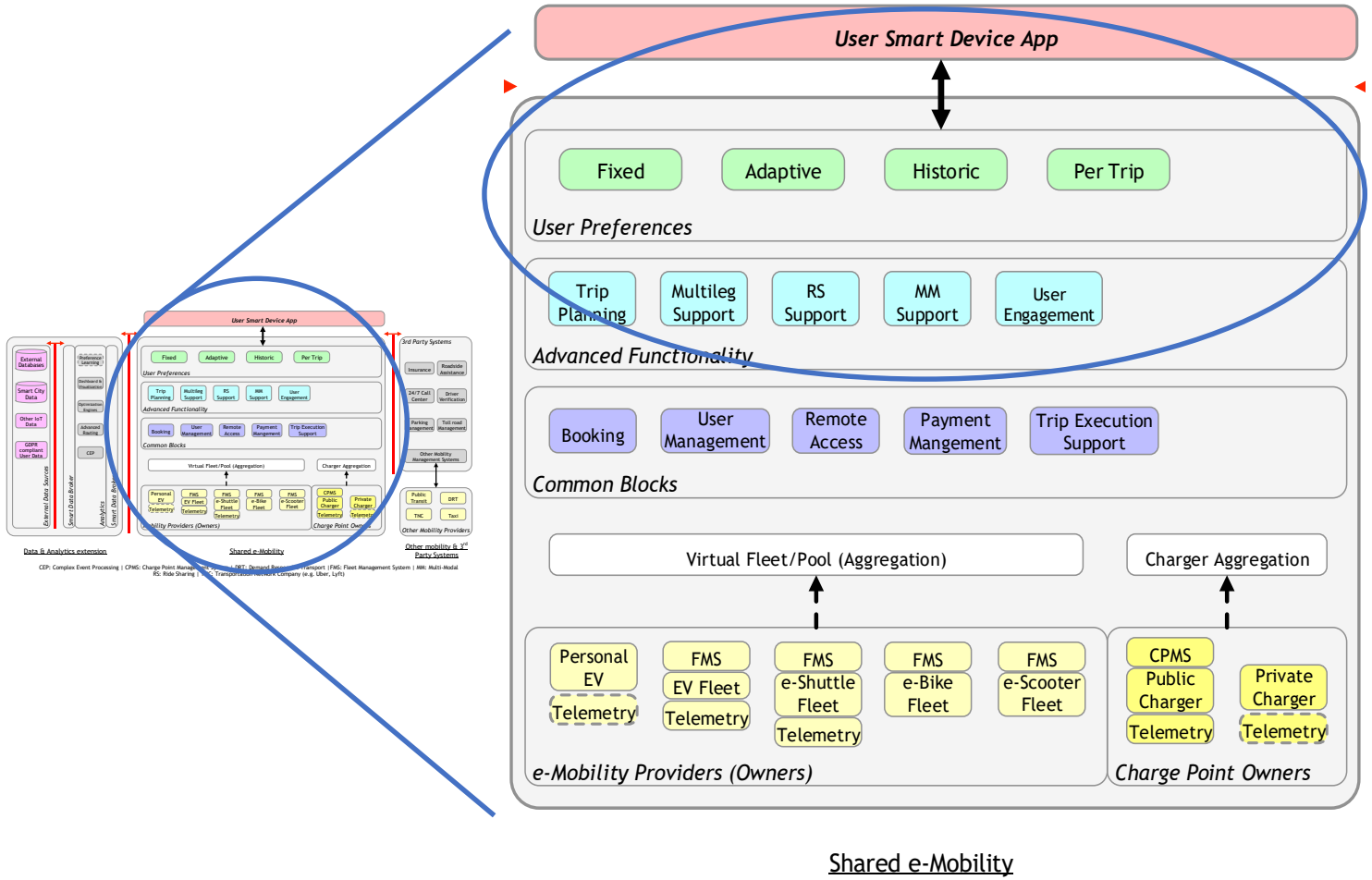
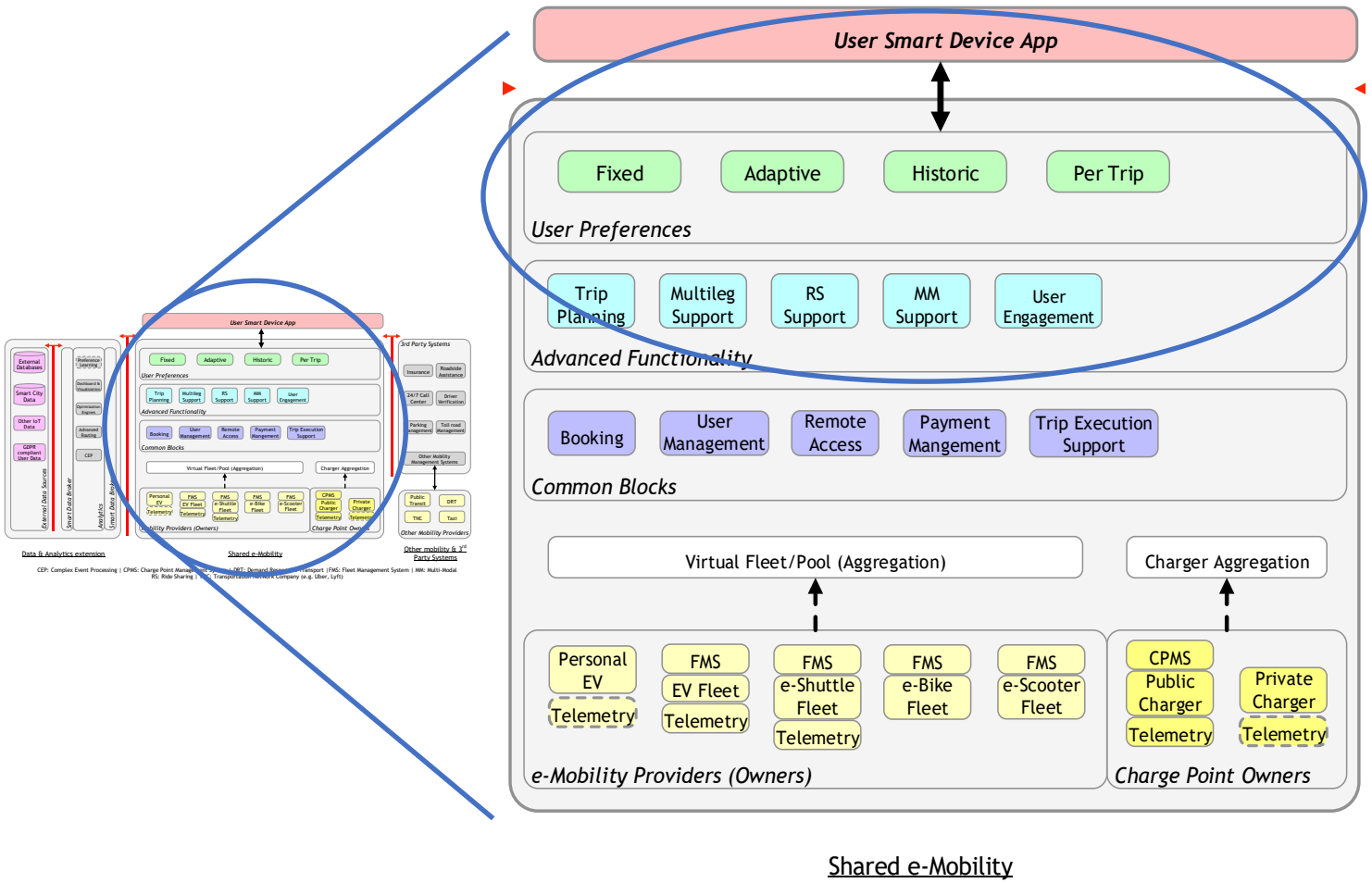


Shared e-Mobility

electric Mobility as a Service (eMaaS) – System Architecture

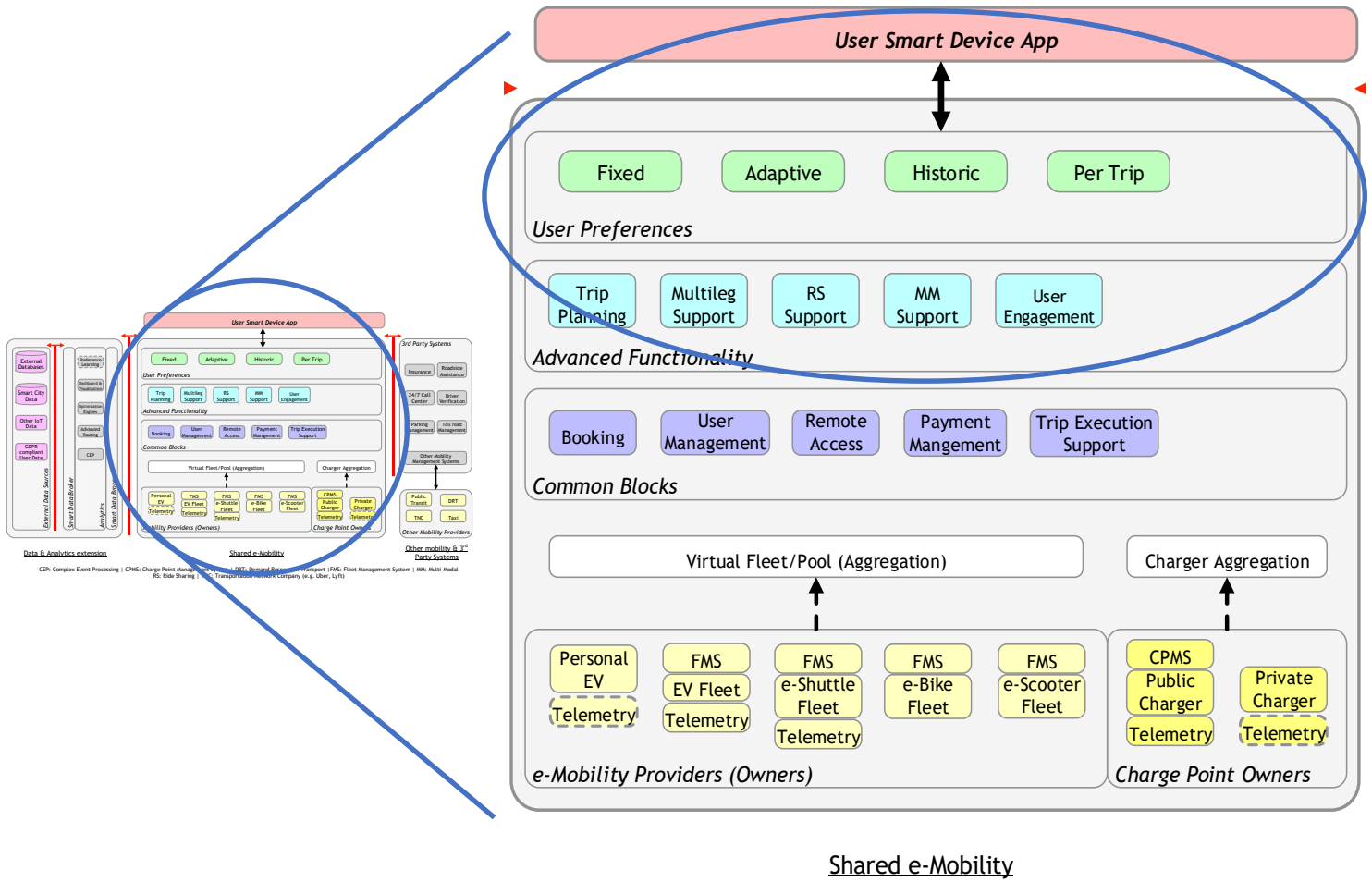


Shared e-Mobility

Advanced Functionality – To enhance shared e-mobility solutions

- Trip Planning: Routes, time/cost/traffic estimation, etc.
- Multi-leg Support: Enabling (and scheduling) multi-segment trip
- Ride Sharing Support: Enabling trips with multiple riders
- Multi-Modal Support: Interfaces and inclusion of additional transportation and mobility modes

electric Mobility as a Service (eMaaS) – System Architecture



Shared e-Mobility

User Preferences – Per each user or group of users

- Fixed: Long term (rarely changing)
- Adaptive: Automatically changing (e.g. based on season)
- Historic: Based on past choices (enable predictive capabilities)
- Per Trip: Preferences on time, range/distance, price, etc.

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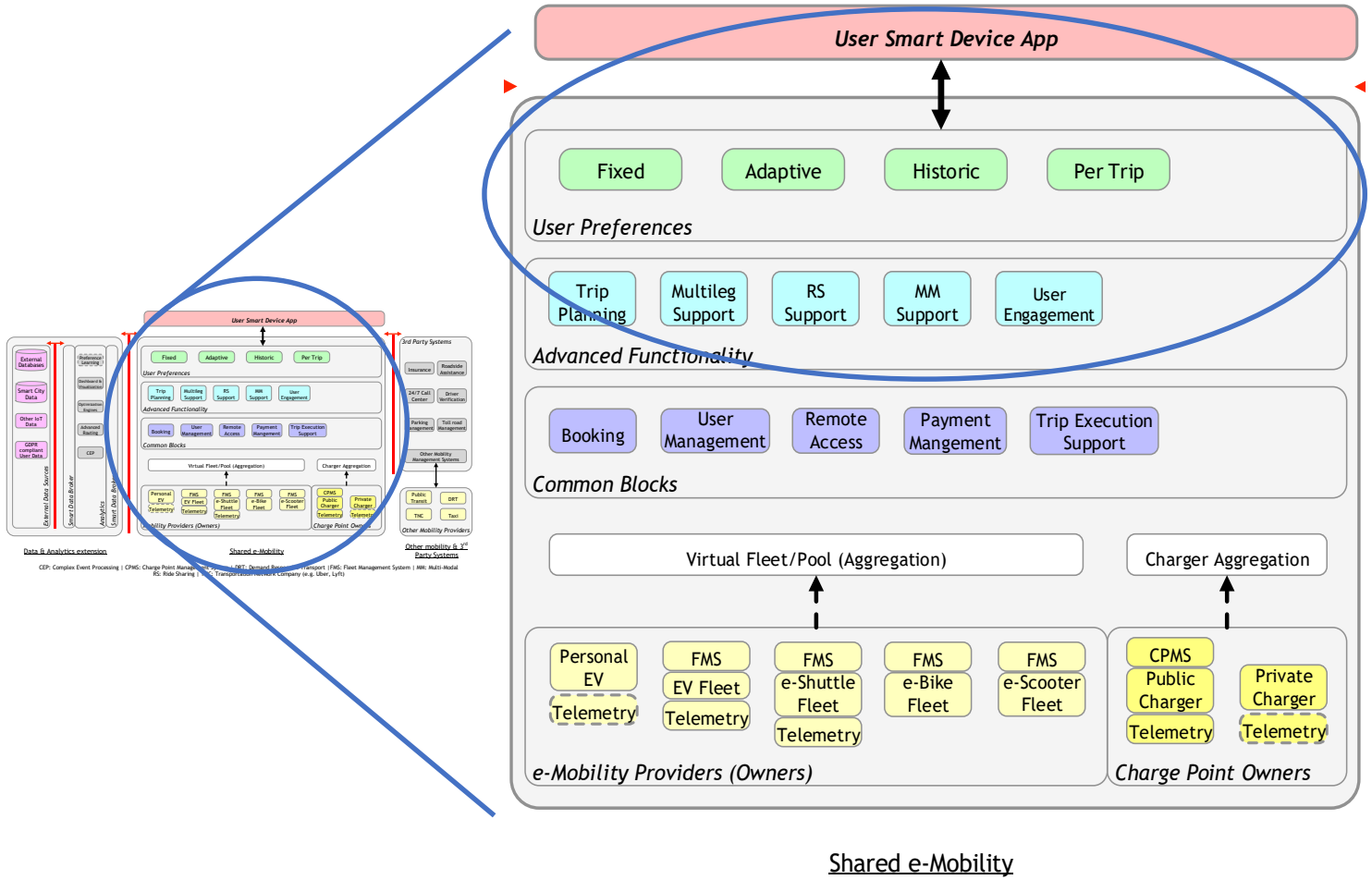

User Smart Device App
- **Single** mobile app to **all** user eMaaS features and capabilities
- Including all preferences, bills, real time status

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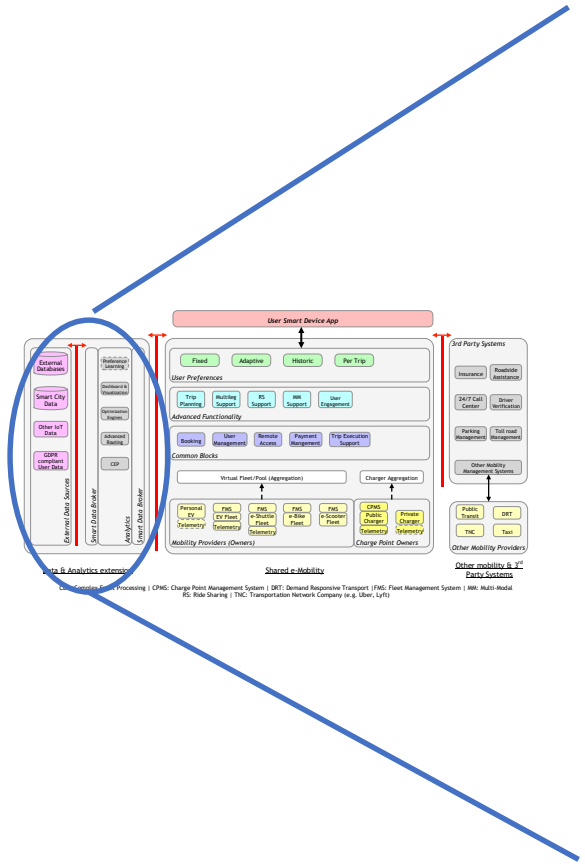
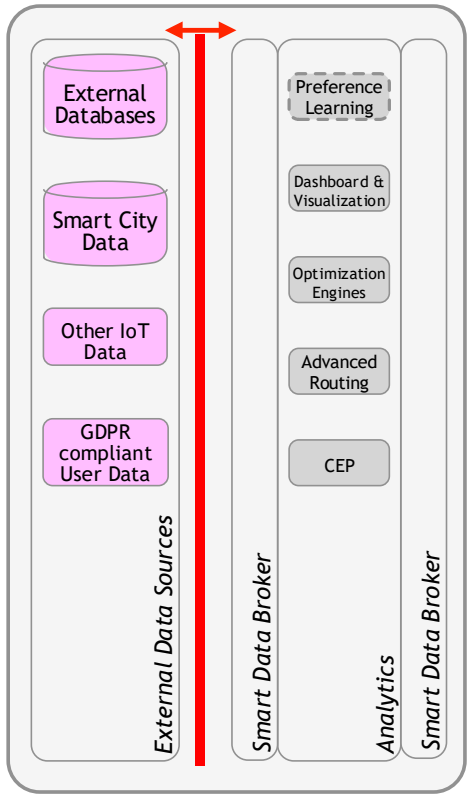
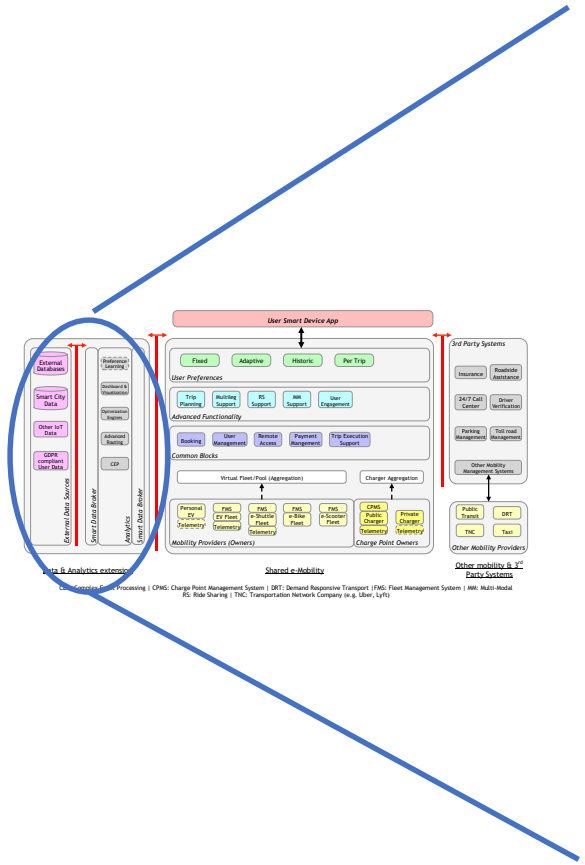
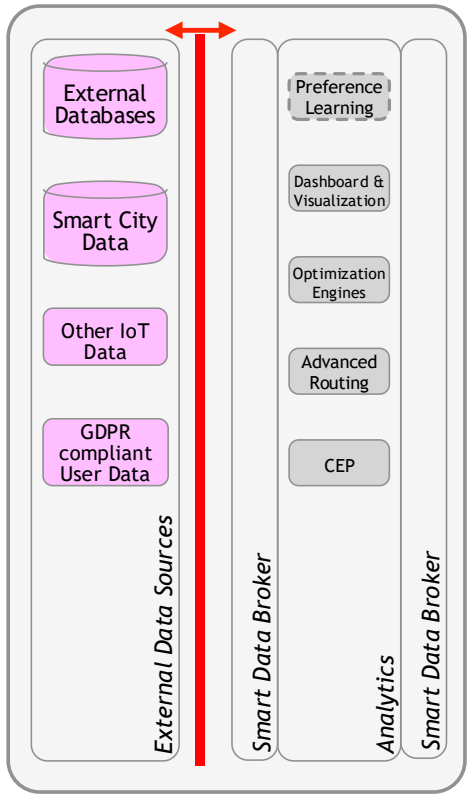




Data & Analytics extension

electric Mobility as a Service (eMaaS) – System Architecture





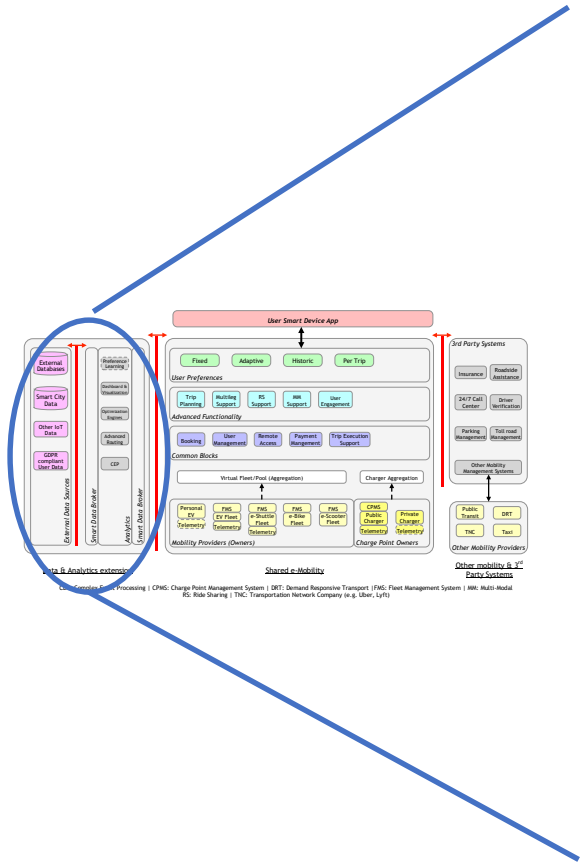
Data & Analytics extension

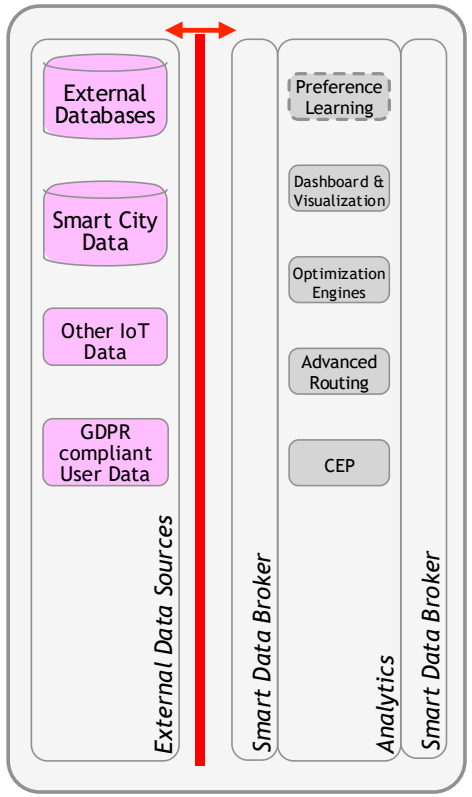
Smart Data Broker - Brokering between data sources using "adapters" (per data source type)

Analytics – To facilitate enhanced functionalities of baseline systems

- Complex Event Processing: Processing of streaming (real time) data
- Advanced Routing: Dynamic and adapting to (near) real time changes
- Optimization Engines: For scheduling, route planning, charging during trip, etc.
- Dashboard and Visualization: Visualization tools both for operators and (app) users
- Preference Learning: Of user behavior, trends, patterns - For enhanced predictive capabilities

electric Mobility as a Service (eMaaS) – System Architecture





Data & Analytics extension

External Data Sources - For delivering advanced data services and enhanced features

- External Databases: Any third party database with relevant data (mostly relational)
- Smart City Data: Available Open Data both historic and near real time; city proprietary data
- Other IoT Data: Third party, accessible IoT devices data (mostly streaming and real time)
- GDPR Compliant User Data: Data that users are willing to share subject to GDPR

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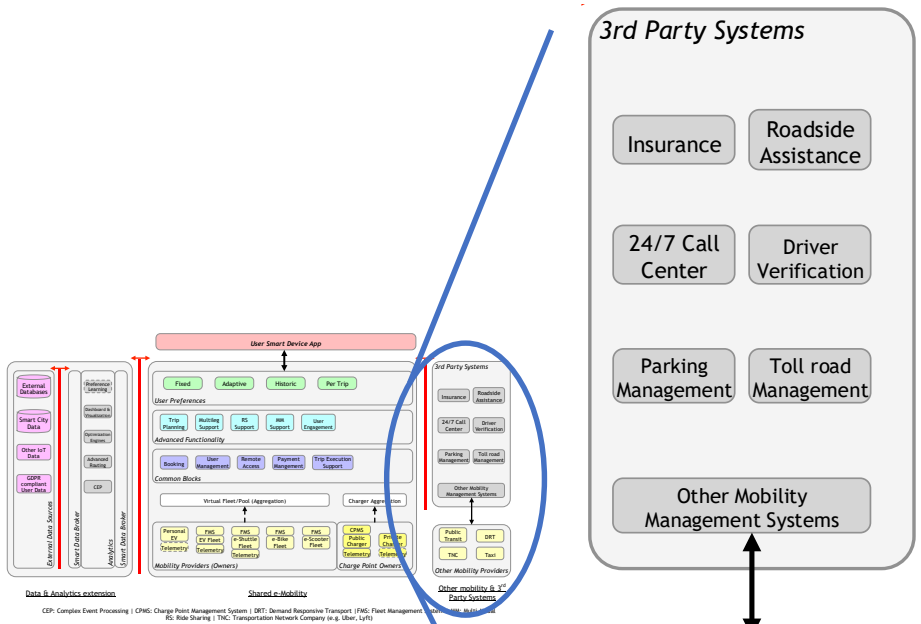
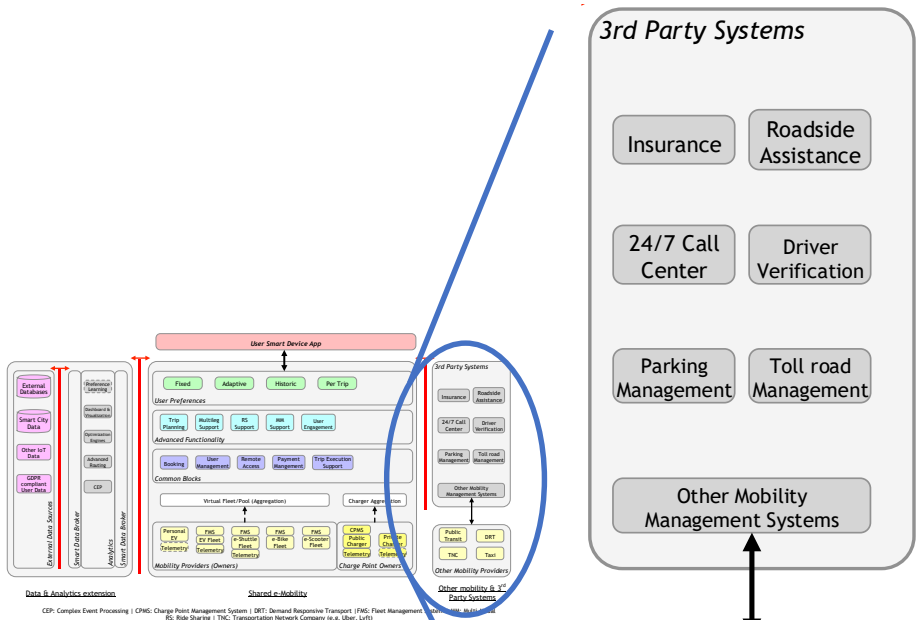


Other e-mobility & 3rd Party Systems

electric Mobility as a Service (eMaaS) – System Architecture

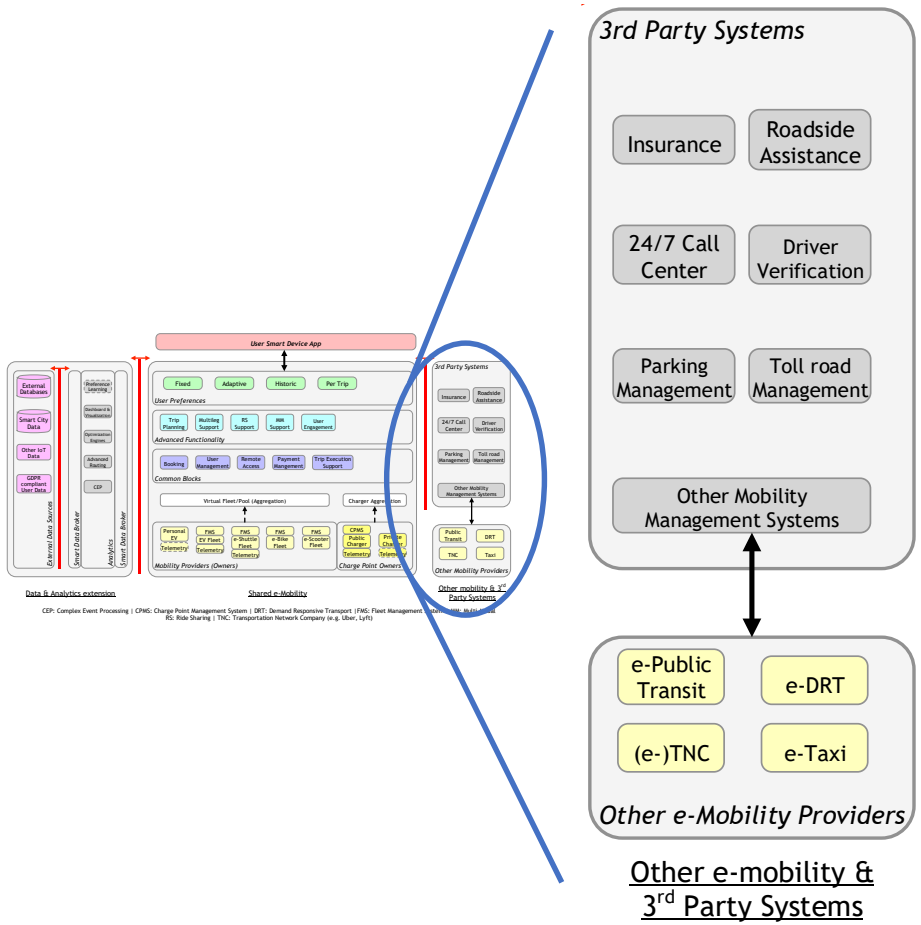


Other e-mobility & 3rd Party Systems

Other e-Mobility Providers

- (e-)TNC: Transport Network Companies (e.g. Uber and Lyft) with EVs (e.g. EV programme of Uber in London)
- e-DRT: Demand Responsive Transport, e.g. electric bus-on demand (e.g. *MOIA* in Hamburg, DE)
- e-Taxi service (e.g. *tim* in Graz, AT)
- e-Public Transit (e.g. e-buses from *Flixbus* running in FR)

electric Mobility as a Service (eMaaS) – System Architecture



3rd Party Systems - Complementary services, to facilitate users' mobility and improve their experience

- Insurance: For the vehicles and travelers. Per trip, part of the trip or per leg
- Road assistance: Per trip or per time-based contract
- 24/7 Call center: For users' support before-, during-, and/or after the trip
- Parking management: To ensure parking and charging station availability
- Driver verification: Verification of driver license validity
- Toll road management: Special access, tariffs and support for users

Other e-Mobility Providers

- (e-)TNC: Transport Network Companies (e.g. Uber and Lyft) with EVs (e.g. EV programme of Uber in London)
- e-DRT: Demand Responsive Transport, e.g. electric bus-on demand (e.g. *MOIA* in Hamburg, DE)
- e-Taxi service (e.g. *tim* in Graz, AT)
- e-Public Transit (e.g. e-buses from *Flixbus* running in FR)

TAKEAWAYS

- Current state of the art regarding (e)MaaS ecosystems and systems architectures is fairly limited
  - Some examples can be found in literature (incl. functional MaaS models, e.g. SMILE projeckt)

- eMaaS is a concept that builds upon the MaaS model
  - MaaS ecosystem and MaaS system architectures serve as a foundation for the development of eMaaS and its system architecture
  - The addition of the eMaaS concept over MaaS is that the former guarantees eco-friendly mobility while offering at least the same benefits as the latter

- Having a clear overview of the elements in the eMaaS ecosystem and in the system architecture helps in the development of eMaaS by identifying the requirements, functions, stakeholders and interfaces that need to be covered when developing the eMaaS services

Thank you for your attention!

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