



# State of the art of electric Mobility as a Service (eMaaS) An overview of ecosystems and system architectures

#### J. Roberto Reyes García | Steven Haveman | Maarten Bonnema University Of Twente, The Netherlands

Gadi Lenz Urban Software Institute GmbH, Germany









European Commission





# CONTENTS

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

eMaaS ecosystem and architecture - EVS 32 Lyon - Roberto Reyes









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From literature review







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From literature review

Authors proposition





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Focus of this

presentation







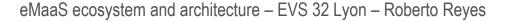
### **INTRODUCTION – About us**

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
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# **INTRODUCTION – The eMaaS project**



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





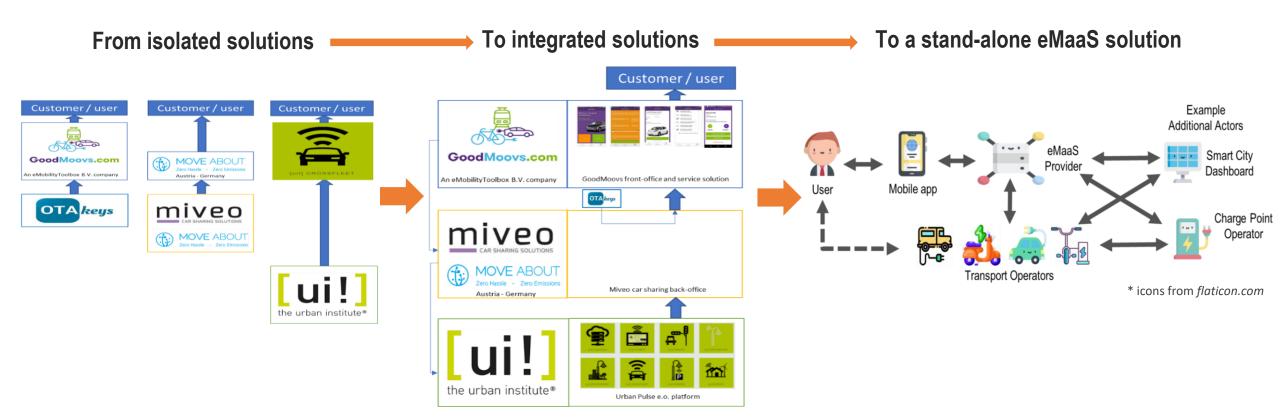








### **INTRODUCTION – The eMaaS project**



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Hietanen, S. (2014): "Mobility as a Service (Maas) is a <u>mobility distribution model</u> in which a <u>customer's</u> major transportation <u>needs are met over one interface</u> and are offered by a service provider. Typically, <u>services are bundled in to a package</u> - similar to mobile phone price-plan packages"



- **Burrows et. al. (2015):** "The provision of transport as a <u>flexible</u>, <u>personalised</u> <u>on-demand service</u> that integrates <u>all types of mobility</u> opportunities and presents them to the user in a <u>completely</u> <u>integrated manner</u> to enable them to get from A to B <u>as easily as possible</u>"
- MaaS-alliance (2017): "the integration of <u>various forms of transport</u> services into a <u>single mobility</u> <u>service accessible on demand</u> [...] <u>through</u> use of a <u>single application</u> to provide\_access to mobility, with a <u>single payment channel</u> [...] to <u>meet all users' mobility needs</u>"
- 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"

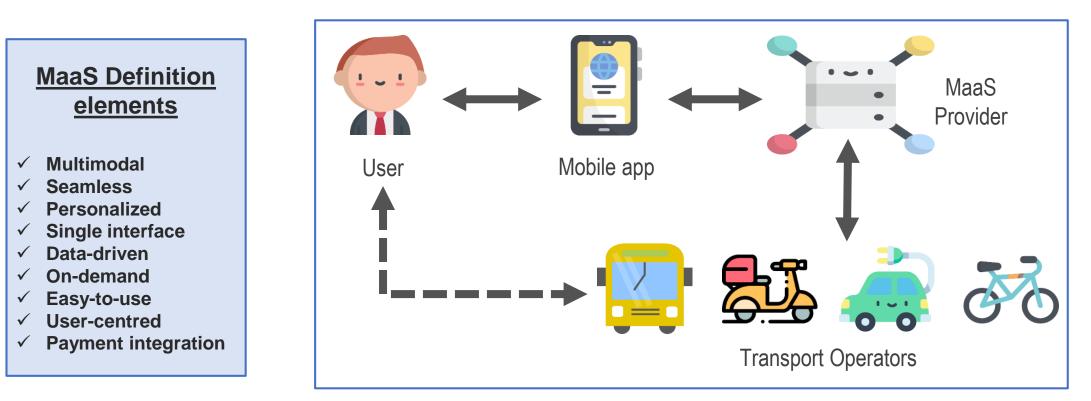








### **Mobility as a Service (MaaS) – Definition**



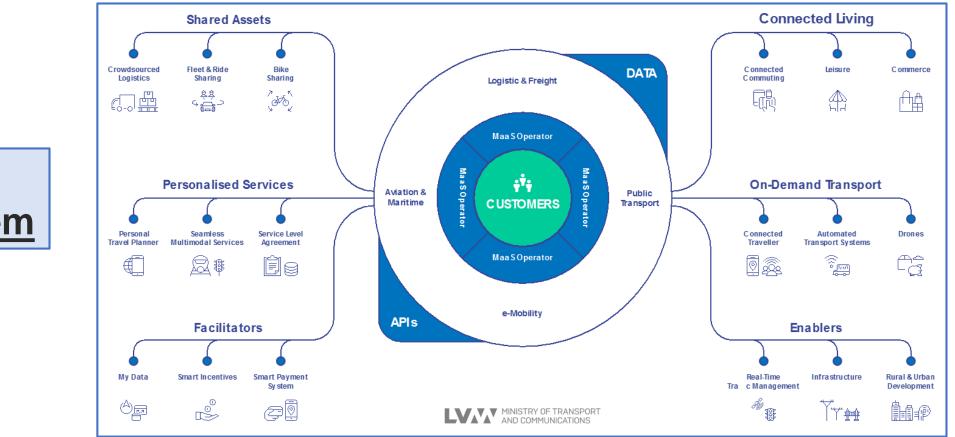
\* Icons from *flaticon.com* 



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Source: Huhtala-Jenks, K. (2017)



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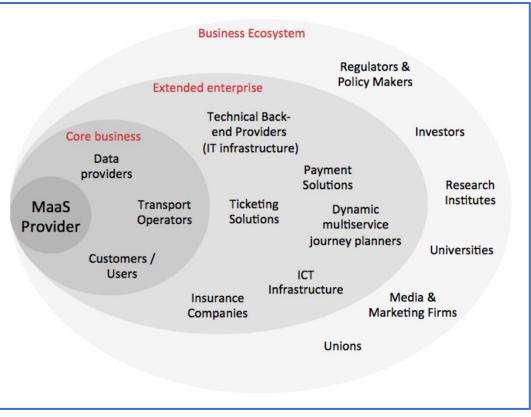












Source: Kamargianni, M. and Matyas, M. (2017)

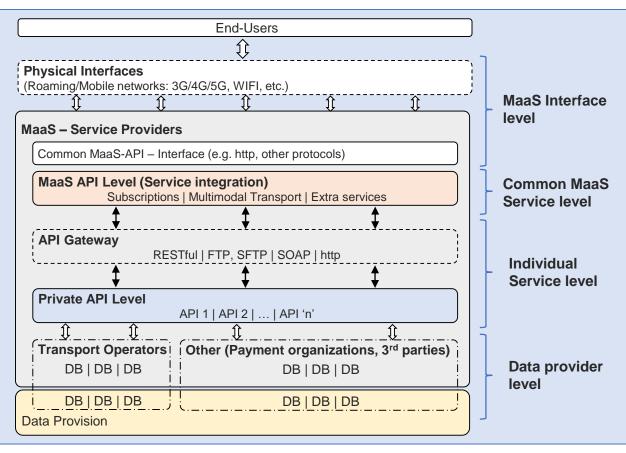












Source: Adapted from König, D. et al. (2017)









### electric Mobility as a Service (eMaaS) – Definition

eMaaS = MaaS + EVs ?

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### electric Mobility as a Service (eMaaS) – Definition



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



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**.

EMS = Electric Mobility Systems SeMS = Shared electric Mobility Services

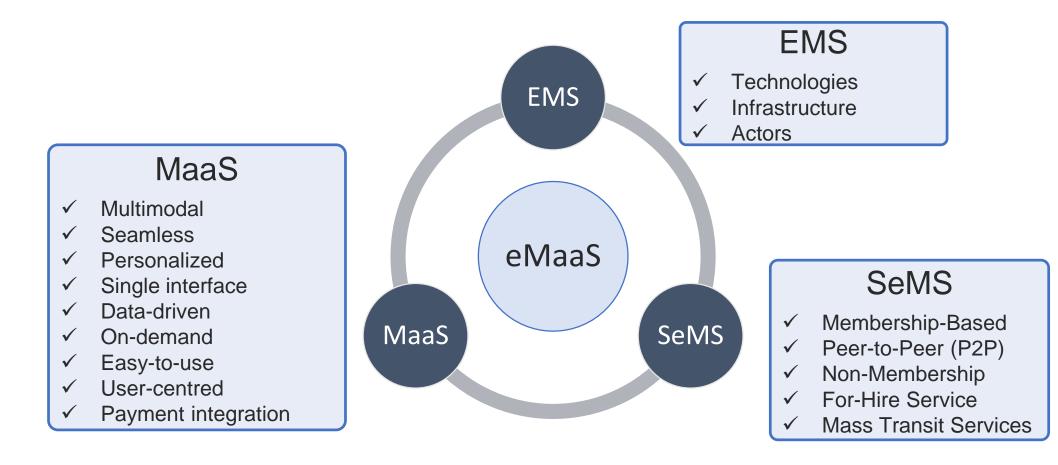
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### electric Mobility as a Service (eMaaS) – Ecosystem



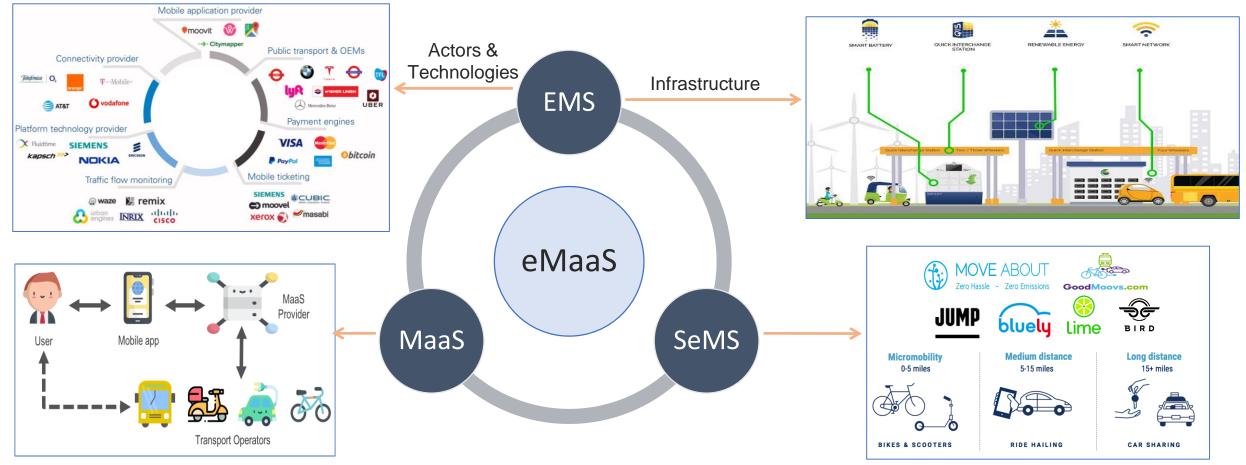








#### electric Mobility as a Service (eMaaS) – Ecosystem



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	User Smart Device App	
External (Preference) Learning	Fixed Adaptive Historic Per Trip	3rd Party Systems
Databases Dashboard & Visualization	User Preferences	Insurance Roadside Assistance
Smart City Data Optimization Engines	Trip Planning     Multileg Support     RS Support     MM Support     User Engagement       Advanced Functionality	24/7 Call Center Verification
Other IoT Data Advanced Routing	User Management         Remote Access         Payment Mangement         Trip Execution Support	Parking Management Toll road Management
GDPR compliant User Data	Common Blocks Virtual Fleet/Pool (Aggregation) Charger Aggregation	Other Mobility Management Systems
Data Sources ata Broker ata Broker	Personal FMS FMS FMS CPMS	e-Public
External Da	EV EV Fleet e-Shuttle Fleet e-Scotter Fleet Fleet Telemetry Telemetry Telemetry Telemetry E-State Fleet Telemetry Telemetry Telemetry Telemetry Telemetry	Transite-DRT(e-)TNCe-Taxi
	e-Mobility Providers (Owners) Charge Point Owners	Other e-Mobility Providers
Data & Analytics extension	Shared e-Mobility	<u>Other e-mobility &amp;</u> <u>3<sup>rd</sup> Party Systems</u>

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)

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	User Smart Device App	
,	Fixed Adaptive Historic Per	Ггір
Lee Smit Device App	User Preferences Trip Multileg RS MM User Planning Support Support User Engagement Advanced Functionality	
Within	User     Remote     Payment     Trip Exec       Booking     Management     Access     Mangement     Support       Common Blocks     Common Blocks     Common Blocks     Common Blocks     Common Blocks	
Image: Control of Control o	Virtual Fleet/Pool (Aggregation)	Charger Aggregation
	Personal     FMS     FMS     FMS       EV     EV Fleet     e-Shuttle     e-Bike     e-Scooter       Telemetry     Telemetry     Telemetry     Telemetry	CPMS Public Charger Telemetry
	e-Mobility Providers (Owners)	Charge Point Owners

Shared e-Mobility









	User Smart Device App
	♥
	Fixed         Adaptive         Historic         Per Trip
	User Preferences
User Smart Device App	Trip PlanningMultileg SupportRS SupportMM SupportUser Engagement
The Address The Training States	Advanced Functionality
Ministry	Bosking User Remote Access Payment Trip Execution Support
	Common Blocks
Data & Analytics entension         Started # Mobility         Other mobility & 3 <sup>rd</sup> Brity Starten           GP: Complex Event Processing (CME: Complex Neuron et al., MCT; Complex Neuron	Virtual Fleet/Pool (Aggregation) Charger Aggregation
	Personal EVFMSFMSFMSCPMSEVFleetFMSe-Shuttle Fleete-Bike Fleete-Scooter 
	e-Mobility Providers (Owners) Charge Point Owners

Shared e-Mobility









	User Smart Device App         Fixed       Adaptive       Historic       Per Trip         User Preferences       Trip       Multileg       RS       MM       User         Planning       Support       Support       User       Engagement         Advanced Functionality       Management       Access       Payment       Trip Execution         Booking       User       Remote       Payment       Trip Execution         Common Blocks       Virtual Fleet/Pool (Aggregation)       Charger Aggregation         Personal       FMS       FMS       FMS       FMS	
Data & Analytics extension Shared e-Mobility Party Systems		<ul> <li><i>e-Mobility Providers</i> - Owners of the vehicles</li> <li>Fleets (non-personal vehicles) can include FMS</li> <li>Personal EVs (and e-shuttle) fleets include telemetry hardware; private EVs optional telemetry hardware</li> </ul>

Shared e-Mobility







	User Smart Device App	
Image: State	Fixed       Adaptive       Historic       Per Trip         User Preferences       User Preferences       User         Trip       Multileg       RS       MM       User         Planning       Support       Support       User         Advanced Functionality       Management       Access       Payment       Trip Execution         Booking       User       Remote       Payment       Support       Support         Common Blocks       Support       Support       Support       Support	
Image: Section of the section of t	Virtual Fleet/Pool (Aggregation) Charger Aggregation	<ul> <li>Charge point owners</li> <li>Public infrastructure, incl. CPMS with telemetry (charger related data)</li> <li>Private chargers include optional telemetry</li> </ul>
	Personal EV     FMS     FMS     FMS       EV     Fleet     FMS     FMS       relemetry     Telemetry     FMS     FMS       relemetry     Telemetry     FMS     FMS       e-Bike     Fleet     Fleet     Fleet       relemetry     Telemetry     Fleet     Fleet       relemetry     Telemetry     Fleet     Fleet       relemetry     Commercial     Fleet     Fleet       relemetry     Commercial     Charger       relemetry     Charger     Charger       relemetry     Commercial     Charger	<ul> <li><i>e-Mobility Providers</i> - Owners of the vehicles</li> <li>Fleets (non-personal vehicles) can include FMS</li> <li>Personal EVs (and e-shuttle) fleets include telemetry hardware; private EVs optional telemetry hardware</li> </ul>

Shared e-Mobility







	User Smart Device App	
	Fixed       Adaptive       Historic       Per Trip         User Preferences       Trip       Multileg       RS       MM       User         Planning       Support       Support       Support       Engagement         Advanced Functionality       Booking       User       Remote       Payment       Trip Execution         Booking       User       Remote       Payment       Trip Execution         Common Blocks       Virtual Fleet/Pool (Aggregation)       Charger Aggregation         Personal       FMS       FMS       FMS       Public         Personal       EV       Fleet       Fleet       Fleet       Fleet       Public       Private         Personal       FMS       FMS       FMS       PMS       Private       Charger       Private         Virtual Fleet/Pool (Aggregation)       Charger Aggregation       Image: Charger       Private       Charger       Charger         Ev       FMS       FMS       FMS       PS       Philer       Private       Charger       Charger         Virtual Fleet/Pool (Aggregation)       Charger Option Owners       Charger Point Owners       Charger       Charger       Charger	<ul> <li>Virtual Fleet Aggregation - Pooling of multiple physical fleets into one virtual fleet for use by operators</li> <li>Charger Aggregation - Facilitates seamless (vendor independent) charging</li> <li>Charge point owners         <ul> <li>Public infrastructure, incl. CPMS with telemetry (charger related data)</li> <li>Private chargers include optional telemetry</li> </ul> </li> <li>e-Mobility Providers - Owners of the vehicles         <ul> <li>Fleets (non-personal vehicles) can include FMS</li> <li>Personal EVs (and e-shuttle) fleets include telemetry hardware; private EVs optional telemetry hardware</li> </ul> </li> </ul>

Shared e-Mobility









	User Smart Device App	Common Blocks – across all (or almost all) shared mobility solutions
	Fixed Adaptive Historic Per Trip User Preferences	<ul> <li>Booking: Handling of user reservations (including user preferences)</li> <li>User Management: Incl. enrollment, preferences, incentive programs</li> <li>Remote Access: smart phone/card lock/unlock access</li> <li>Payment Management: All billing related functions</li> <li>Trip Support: Before-, during- or after trip         <ul> <li>Optionally by 3<sup>rd</sup> party</li> </ul> </li> <li>Virtual Fleet Aggregation - Pooling of multiple physical fleets into one virtual fleet for use by operators</li> <li>Charger Aggregation - Facilitates seamless (vendor independent) charging the second sec</li></ul>
Image: Section of the sectio	Trip Planning       Multileg Support       RS Support       MM Support       User Engagement         Advanced Functionality       Image: Support Support       Image: Support Support Support       Image: Support Support Support         Booking       User Management       Remote Access       Payment Mangement       Trip Execution Support         Common Blocks       Image: Support Support       Support       Support	
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	Personal       FMS       FMS       FMS       FMS       PMS         EV       EV       Fleet       Fleet       Fleet       Fleet       Public       Charger       Charger         Telemetry       Telemetry       Telemetry       Telemetry       Comparison       Charger       Telemetry         e-Mobility Providers (Owners)       Comparison       Charger       Charger       Charger	<ul> <li><i>e-Mobility Providers</i> - Owners of the vehicles</li> <li>Fleets (non-personal vehicles) can include FMS</li> <li>Personal EVs (and e-shuttle) fleets include telemetry hardware; private EVs optional telemetry hardware</li> </ul>

Shared e-Mobility







	User Smart Device App	
	+	
	Fixed         Adaptive         Historic         Per	r Trip
	User Preferences	
Der fannt Perios Age	Trip Multileg RS MM User Planning Support Support Support Engagement Advanced Functionality	
Dechards User Preferences		
Image: Constraint of the second function of the second functin of the second function of the second function of th	User         Remote         Payment         Trip Exe           Booking         Management         Access         Payment         Supp	
	Common Blocks	
Data & Analytics extension         Shared e Hobility         Other mobility & 3" Bath & Analytics extension           CP: Condex Event Processing I ONE: Charry Point Neuron 1: 10: 10: 10: 10: 10: 10: 10: 10: 10:	Virtual Fleet/Pool (Aggregation)	Charger Aggregation
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	I	
	Personal EV EV Fleet Telemetry EV Fleet Fleet Fleet Fleet Fleet	CPMS Public Charger
	Telemetry	Telemetry Telemetry
	e-Mobility Providers (Owners)	Charge Point Owners

Shared e-Mobility





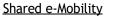




	User Smart Device App	
Image: Constraint of the constr	Advanced Functionality           User         Remote         Payment         Trip Execution           Booking         Management         Access         Mangement         Support           Common Blocks         Common Blocks         Common Blocks         Common Blocks         Common Blocks	A
Construction     C	Virtual Fleet/Pool (Aggregation) Charger Aggregation	•
	Personal       FMS       FMS       FMS       FMS       Private         EV       EV Fleet       e-Shuttle       e-Bike       e-Scooter       Public       Charger         Telemetry       Telemetry       Telemetry       Telemetry       Telemetry       Telemetry       Telemetry         e-Mobility Providers (Owners)       Conners       Charge Point Owners	•
	e-Mobility Providers (Owners) Charge Point Owners	

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

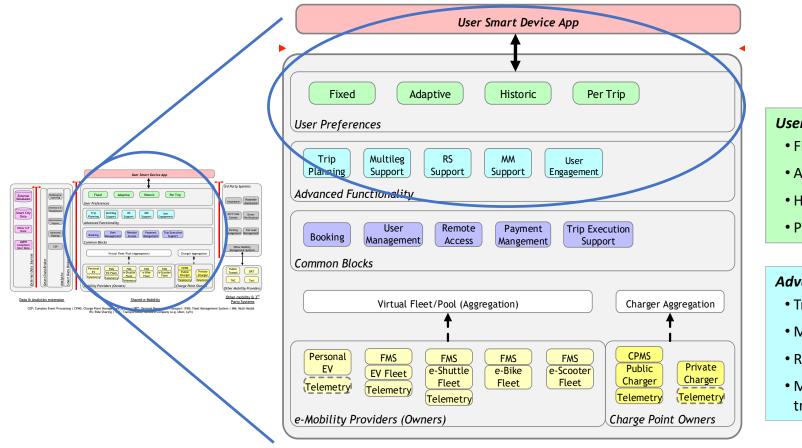








### electric Mobility as a Service (eMaaS) – System Architecture

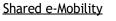


User Preferences – Per each user or group of users

- 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.

#### Advanced Functionality - To enhance shared e-mobility solutions

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#### User Smart Device App

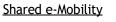
- Single mobile app to all user eMaaS features and capabilities
- Including all preferences, bills, real time status

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#### Advanced Functionality – To enhance shared e-mobility solutions

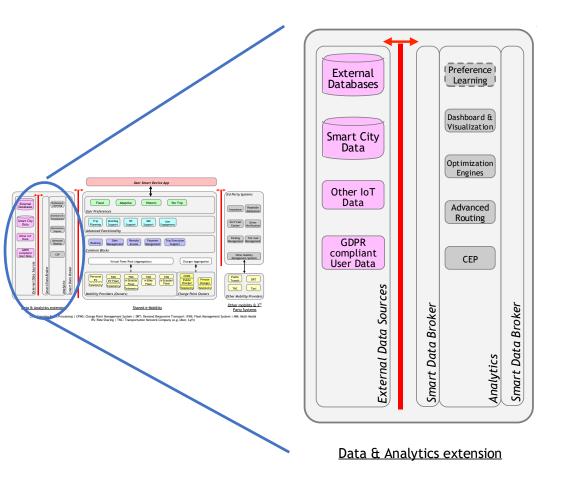
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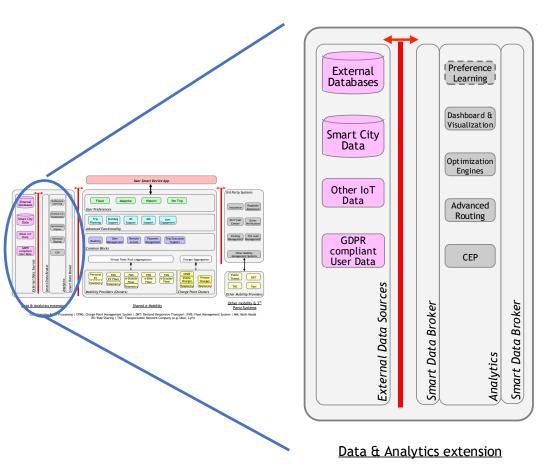












Smart Data Broker - Brokering between data sources using "adapters" (per data source type)

- 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

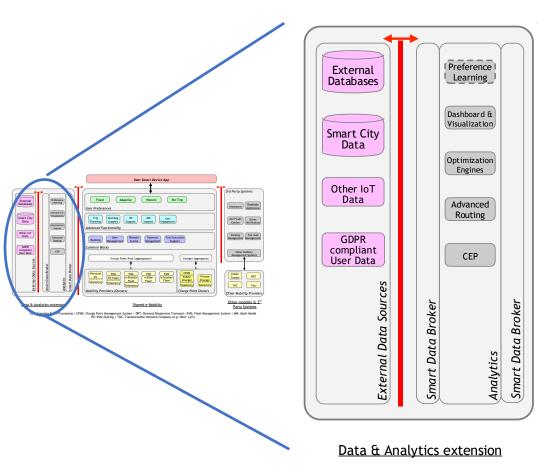
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External Data Sources - For delivering advanced data services and enhanced features

- 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

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

- Analytics To facilitate enhanced functionalities of baseline systems
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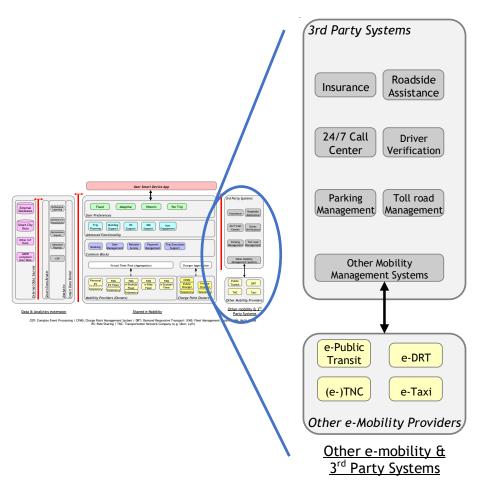




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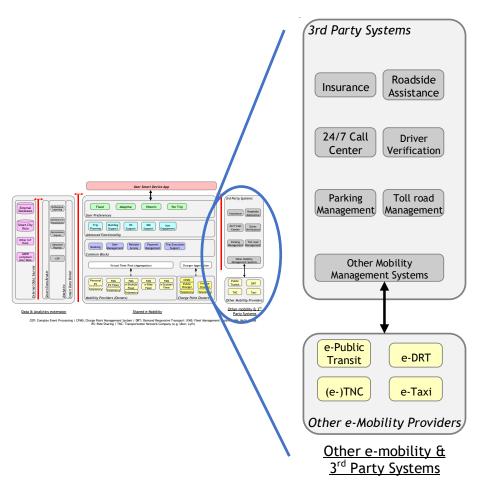
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#### Other e-Mobility Providers

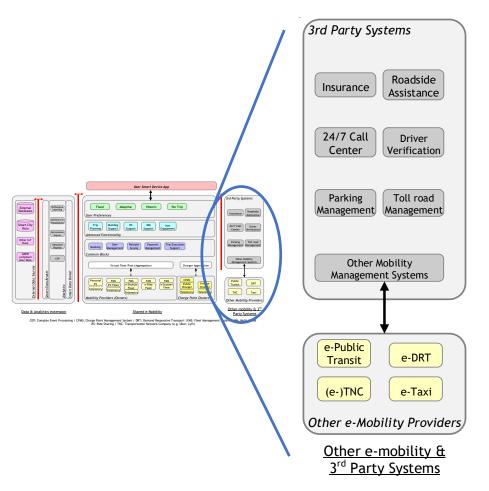
- (e-)TNC: Transport Network Companies (e.g. Uber and Lyft) with EVs (e.g. EV programme of Uber in London)
- e-DRT: Demand Responsive Transport, e.g. electric bus-on demand (e.g. MOIA in Hamburg, DE )
- e-Taxi service (e.g. tim in Graz, AT)
- e-Public Transit (e.g. e-buses from Flixbus running in FR)











3<sup>rd</sup> 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!

### J. Roberto Reyes García Junior Researcher Electric Mobility System j.r.reyesgarcia@utwente.nl









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