Linked MaaS:
a vision for leveraging Semantic Web Technologies for Mobility as a Service

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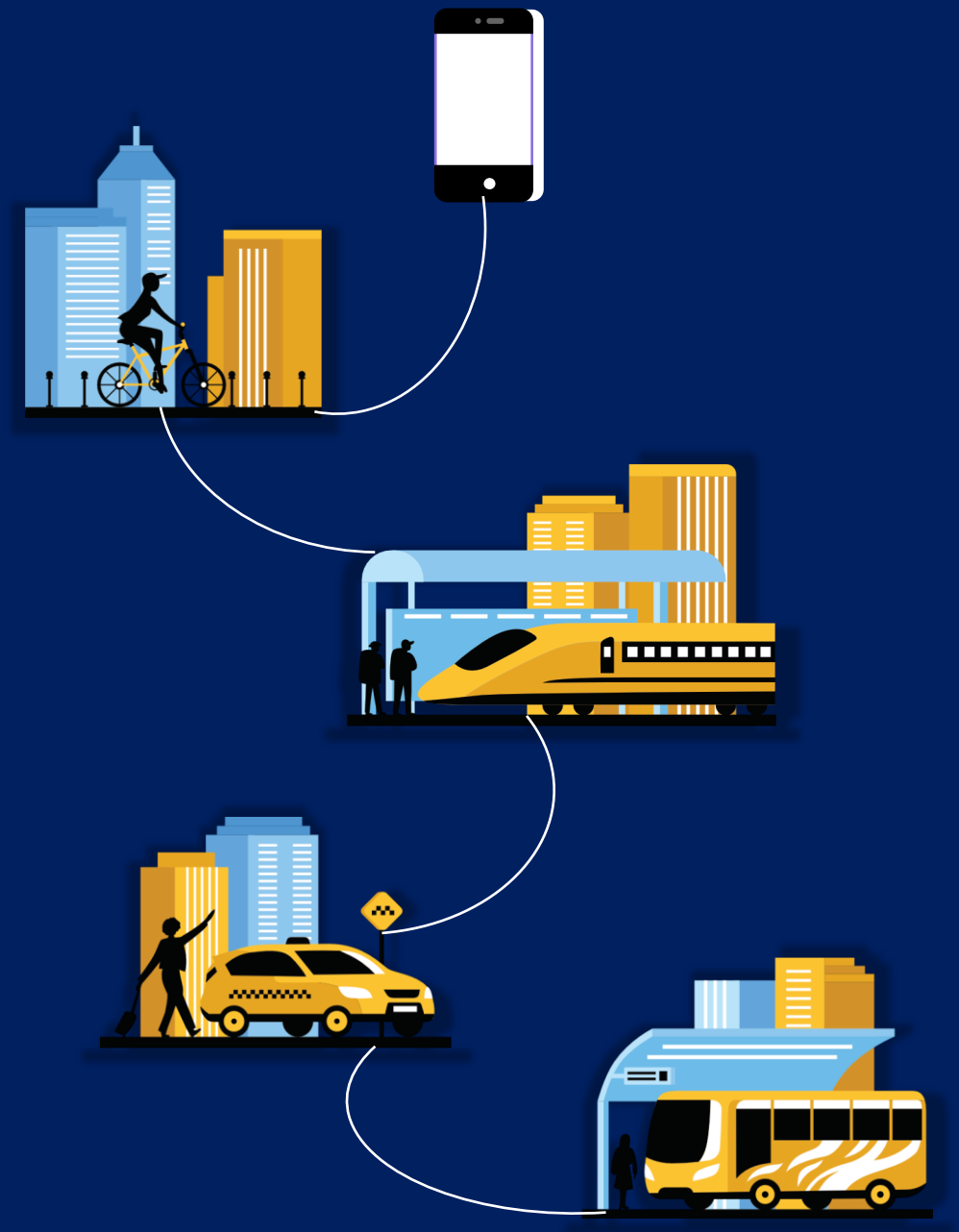
http://ceur-ws.org/Vol-2939/paper4.pdf



Mobility-as-a-Service (MaaS)

Roadmap

Integration between **public and private transport** modes in a single digital interface.

Integration of **ticketing and payment** systems.

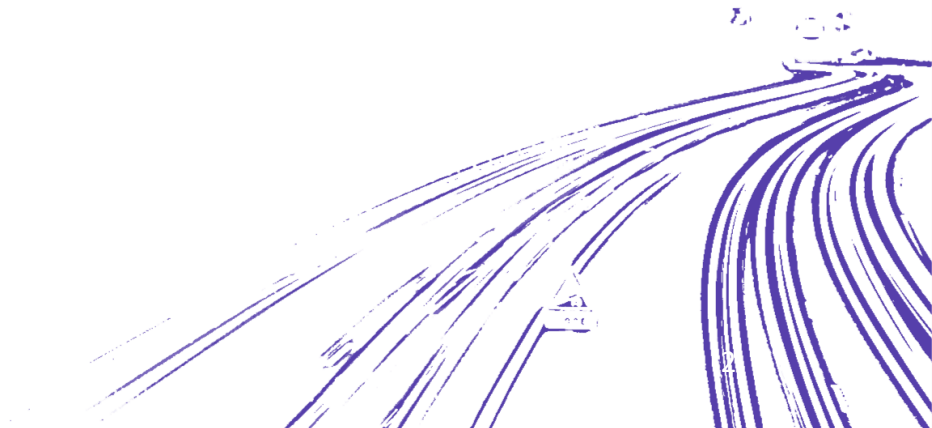
Open and accessible data for integration of information.

First and last mile solutions for passengers.

Viable **subscription**-based plans.

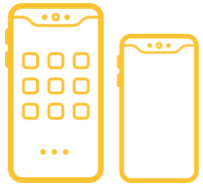
Users offered a **seamless mobility experience**, incentivizing use of sustainable transport.

Reduced use of private cars, and as a result, reduced congestion, pollution and **climate change**.



Mobility-as-a-Service (MaaS)

1. A unified digital interface for multimodal travel



2. Journey Planner

3. Ticketing & Payment Integration

4. Mobility Subscriptions

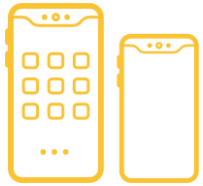
5. Intermodal and auxiliary services

6. Passenger-centric

Mobility-as-a-Service (MaaS)

What are the Interoperability Requirements of MaaS?

1. A unified digital interface for multimodal travel



2. Journey Planner

3. Ticketing & Payment Integration

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5. Intermodal and auxiliary services

6. Passenger-centric

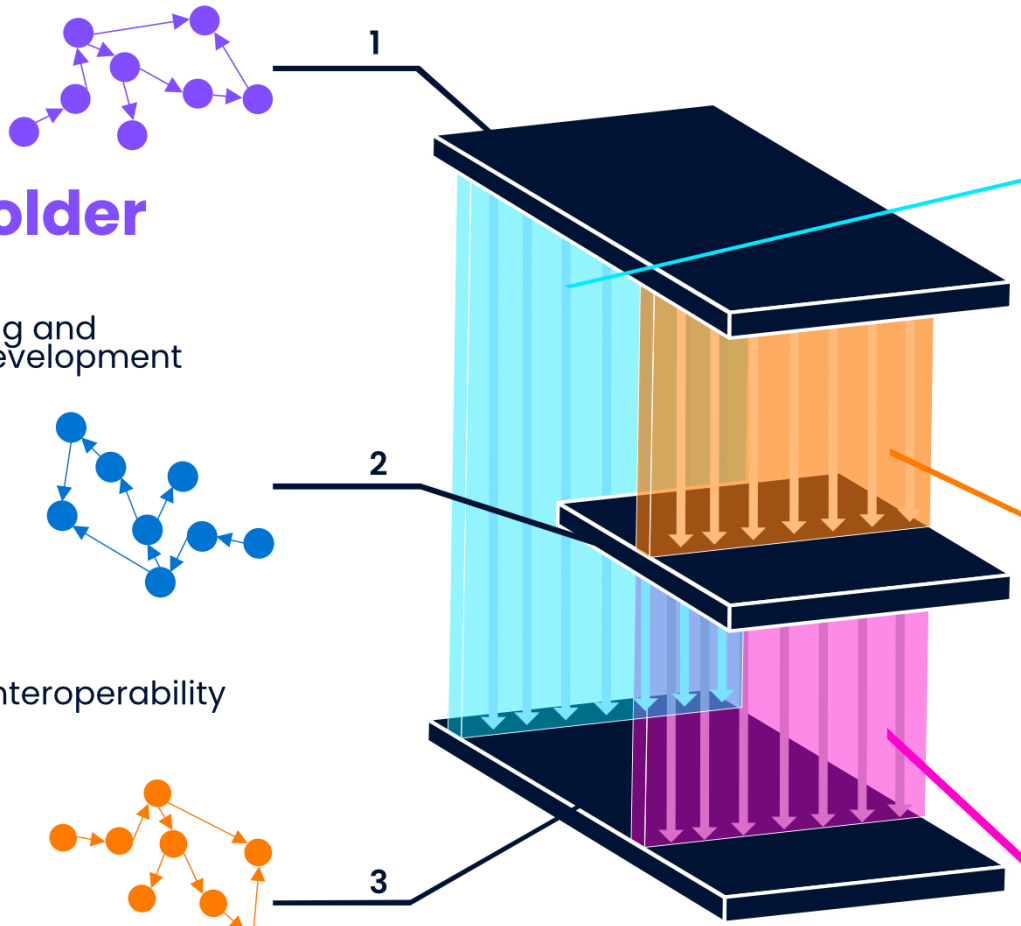
Interoperability

“

the ability of disparate and diverse organizations to interact towards mutually beneficial and agreed ***common goals****, involving the* ***sharing of information and knowledge*** *between the organizations, through the* ***business processes*** *they support, by means of the* ***exchange of data*** *between their respective* ***ICT systems****.*

European Interoperability Framework (2010)

The Linked MaaS Framework



The **Stakeholder** Layer

Decision Making and Contractual Development

The **Data** Layer

Integration & Interoperability

The **Infrastructure** Layer

System Resilience

4 The **Ownership** Layer

Asset Ownership. Risk Distribution. Work Orders. Rights and Responsibilities. Liabilities.

5 The **Auth** Layer

Authorization and Authentication.
Data Access/Sharing Principles.
Data Ownership.
Data Management

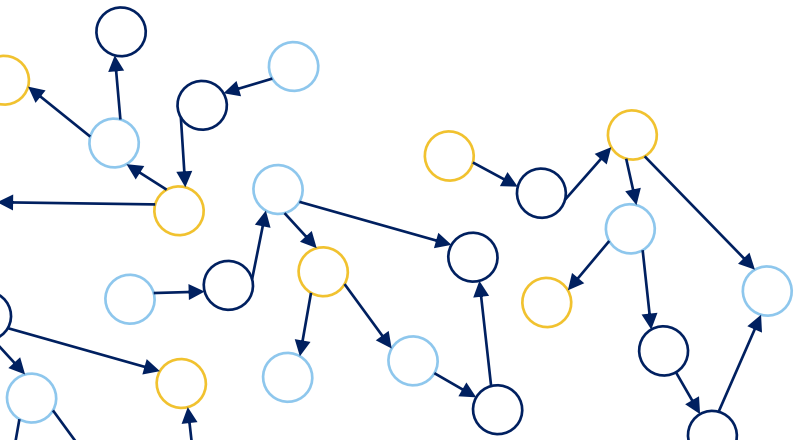
6 The **Connection** Layer

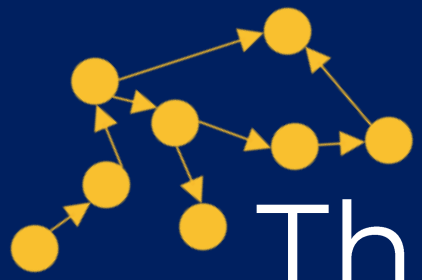
Facility Management. Internet of Things.

Linked Data

?

Mobility as a Service

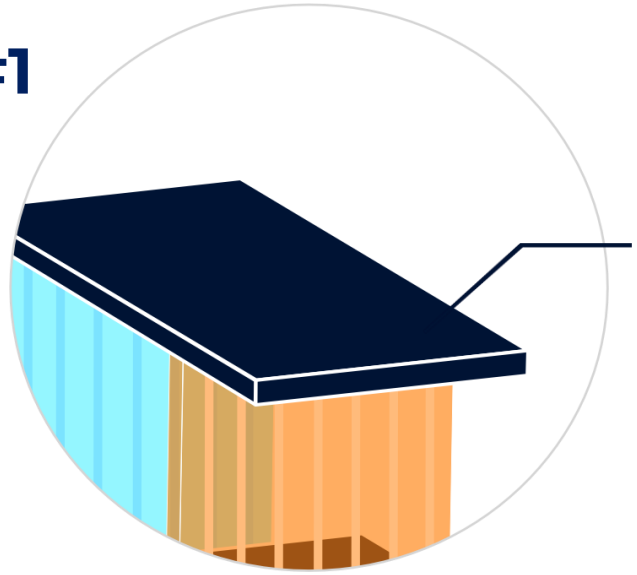




The Graph Layers

The Graph layers can be viewed as independent domains of analysis

#1



The
Stakeholder
Layer

Gap

In MaaS workflows, it is often the case that a single decision can have direct or indirect effects on any MaaS stakeholder, whether taken collectively or individually. In such a case, delineating the relationships and dependencies between these key players is needed

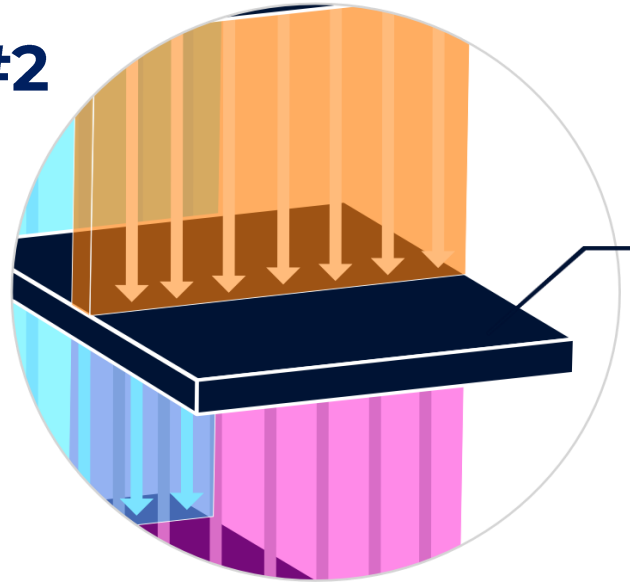
Example Use-cases

1. Standard and shared definitions of the different stakeholders can be used for applying policies and conditions for participating in the ecosystem (e.g. A transport operator must have a registration number with a specific authority).
2. Convenient retrieval of information on stakeholders and their connections will be enabled (e.g. querying the available MaaS providers in a specific region).
3. Analyzing the graph to derive new information and conclusions (e.g., Analyzing the centrality of the nodes to detect how important is a particular stakeholder in a defined region).

Function

to build an abstract model of the business ecosystem of MaaS

#2



The
Data
Layer

Example Use-cases

1. Automated integration of data from heterogeneous sources through the alignment with existing standards
2. Performing simple and complex queries and algorithms over MaaS data (e.g. querying for availability of bike lanes, running route-optimization algorithms).
3. Reasoning over the graph to derive new information and conclusions (e.g. Inferring which factors affect the operations of which modes, for example, an if rule can state that if an increase in a specific factor (e.g. traffic) affects a property of a transport mode (e.g. decreases the speed) then this factor should be taken into account by the routing algorithm).

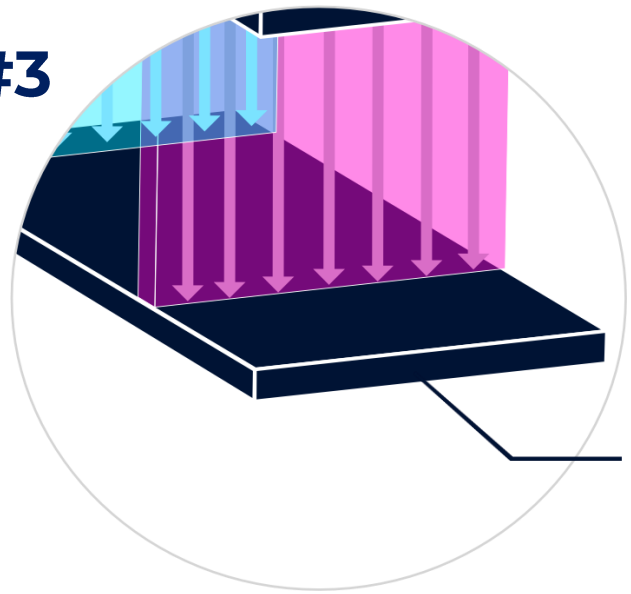
Gap

The digitization of transportation data led to the development of multiple standards such as GTFS static, GTFS real-time, GBFS, MDS, The TOMP-API, NeTEx10, SIRI, DATEX II, OSLO Mobility, and more. An escalation in interoperability issues, such as incompatibility of protocols, syntax, and other basic building blocks, occurs when the source of the different standards stems from different standards' bodies, each with their own approach to doing things. The data islands, formed through multi-organizational standardization, represents the current situation of data standards in the realm of mobility.

Function

to explicitly model MaaS data with its interconnections

#3



The
Infrastructure
Layer

Gap

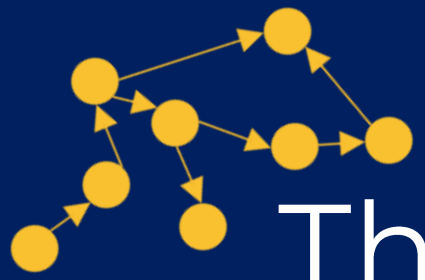
The implementation of MaaS relies on the existence of physical infrastructure. Physical transportation infrastructure is a prerequisite for actualizing MaaS. *How can we shift people to more sustainable modes of transport if we are lacking the infrastructure for it?*

Example Use-cases

1. Through graph theory approaches, various analysis can be performed to determine System Resilience, identifying the weakest links and bottlenecks in the infrastructure. This can aid in deriving multimodal disaster mitigation and recovery plans.
2. Analysis of the system to identify missing infrastructure links at different locations, both physical and digital, which require installation. Through such analytics, investments can be directed to the right infrastructure sectors and locations.
3. Inter-dependencies between modes and the dynamics of a multi-modal system can be derived from the model for usage in smart city mapping and planning.

Function

to provide a digital twin of both physical and digital infrastructure as well as the relationships between them.



The Linking Layers

Represent relationships between elements from different graph layers

#4

Gap

Relationships between stakeholders and infrastructure include which infrastructure belongs to a stakeholder's assets, who is responsible for the maintenance or development of specific infrastructure, etc. These questions mainly depend on the ownership of assets.

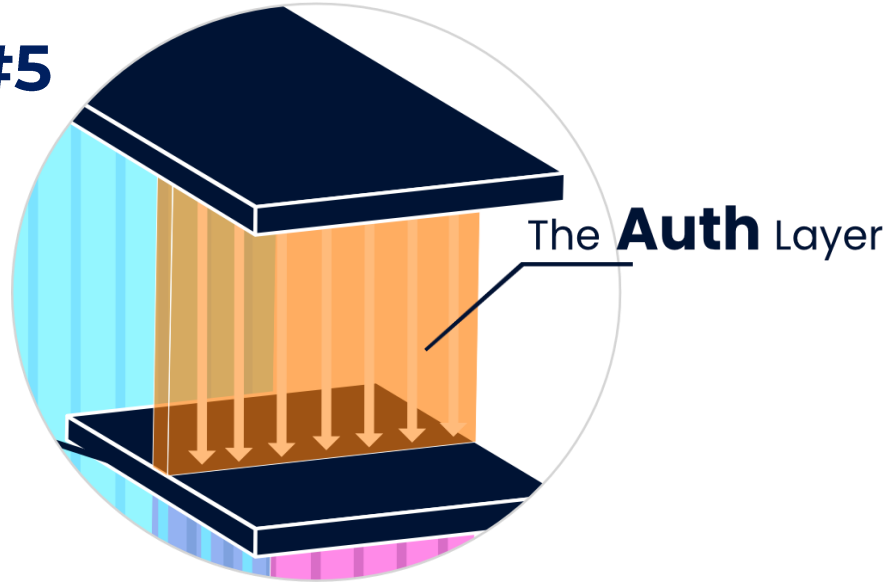
Example Use-cases

1. Analysis of risk. Through the links between the stakeholders and their assets, an optimum risk distribution model can be determined for a given MaaS ecosystem.
2. Maintenance schedules and work orders can be linked taking into account the effects of surrounding infrastructure.
3. The layer can be used in synergy with other layers for the development of suitable contracts and agreements based on stakeholders' assets and liabilities.

Function

to model the links between the stakeholders and the infrastructure

#5



Gap

A major debate within MaaS falls under the umbrella of data management. Some of the questions include Who will have the authority over MaaS users' data? Will MaaS Providers contribute to the monopolization of data, or will there be a decentralized data access?– How do we authenticate the user/agent accessing the data?

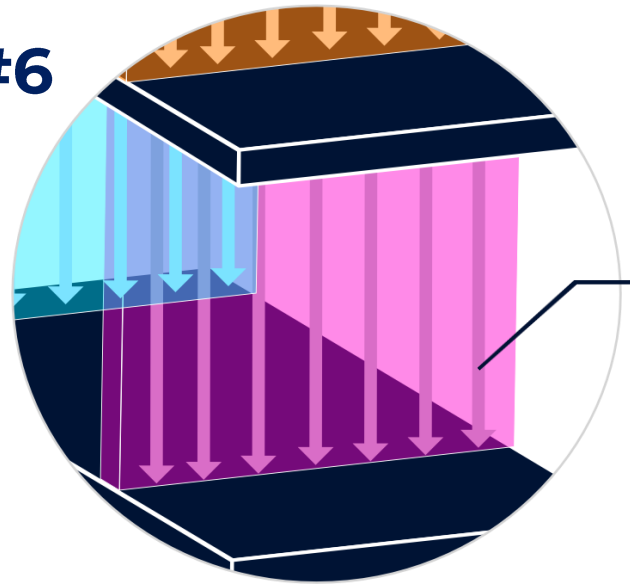
Example Use-cases

1. Explicit identification of read-write access rules to different data entities, perhaps through the Access Control List Ontology.
2. Explicit definitions of roles and responsibilities of the stakeholders for data management
3. Incorporation of data pods following the Solid14 Project for decentralization of user data.

Function

to model the links between stakeholders and data

#6



The
Connection
Layer

Gap

While the Infrastructure layer models the physical and digital assets of the ecosystem, and the Data layer models data derived from that infrastructure, a linking layer is proposed between them to delineate their relationships.

Example Use-cases

1. Can be used to power the development of Internet of Things in transportation, providing insights on which parts of the infrastructure is connected over the internet, what types of connections do they have, for instance, having vehicle location data for a train but lacking sensor data for facility management.

2. Policies on the usage of data for certain infrastructure can be formalized within this layer.

Function

to model the interconnections, policies, and business rules between data and infrastructure

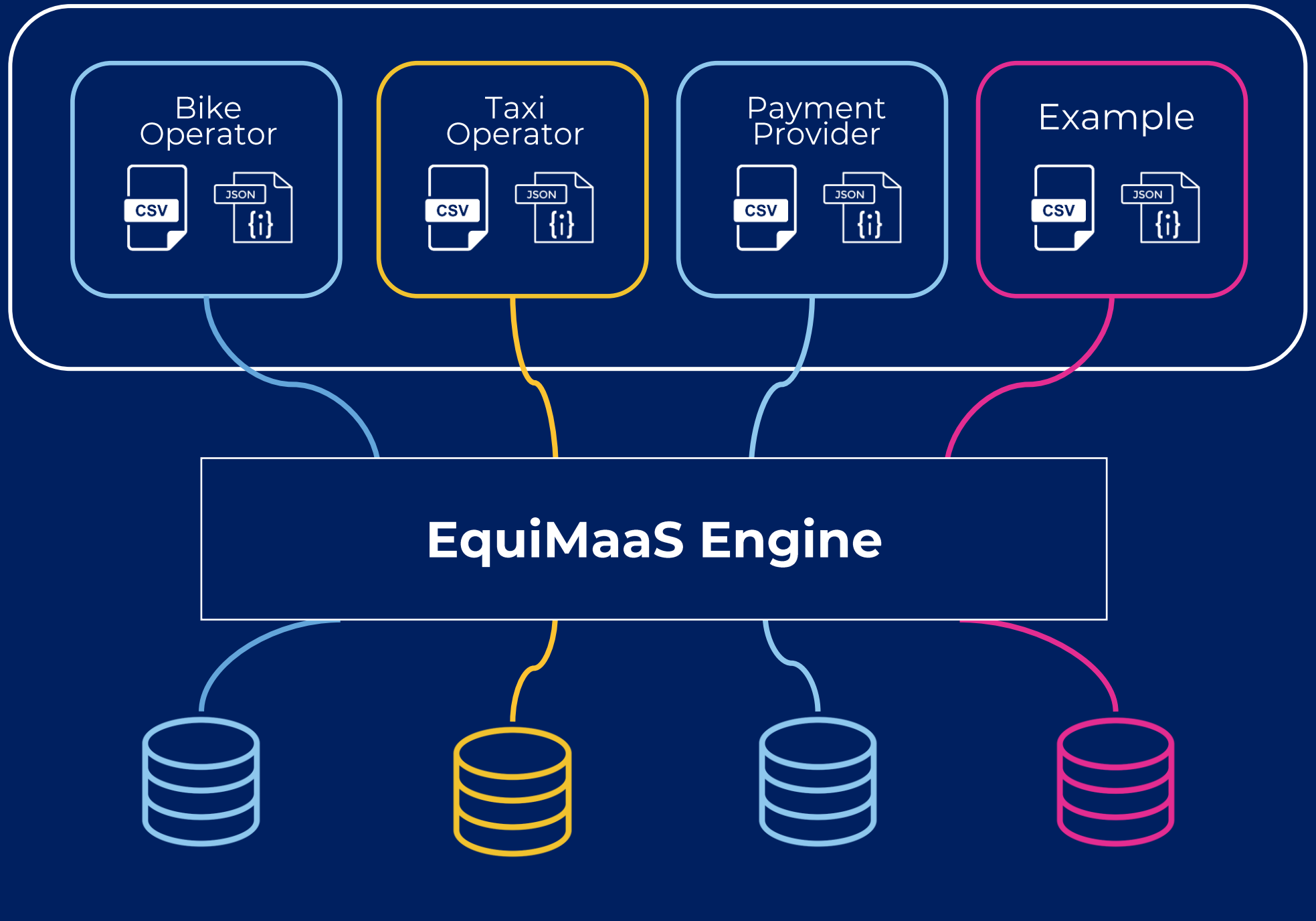
What about the framework **as a whole**?

Synergistic Use-cases

1. Generation of data-driven contracts, based on the analysis of the stakeholders' relationships with infrastructure, with data, and with each other.

2. A simulation engine can be derived to predict the effects of adding, removing, or changing any elements in the system (e.g. a merger between two companies, construction of a new highway, incorporation of a new technology)

3. Data Governance, including policies, roles, standards, and metrics, can be formalized through the Stakeholder layer, the Auth layer, and the Data layer.


Bike Operator
CSV
JSON
Taxi Operator
CSV
JSON
Payment Provider
CSV
JSON
Example
CSV
JSON
EquiMaaS Engine

We invite researchers of MaaS and the Semantic Web community to bring the Linked MaaS vision to reality through novel contributions to the 6 layers.

Any Questions?

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