Standards enabled Digital Twin in LSP AUTOPILOT

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Outline

- Autopilot (EU H2020 Large Scale Pilot Project)
- Goal: IoT-supported Autonomous Driving
- Digital Twin Concept
- Using Standards and Context Modelling for Information Aspects of Digital Twin
- Outlook: What is needed beyond this?
  - *Functional aspects of Digital Twin*

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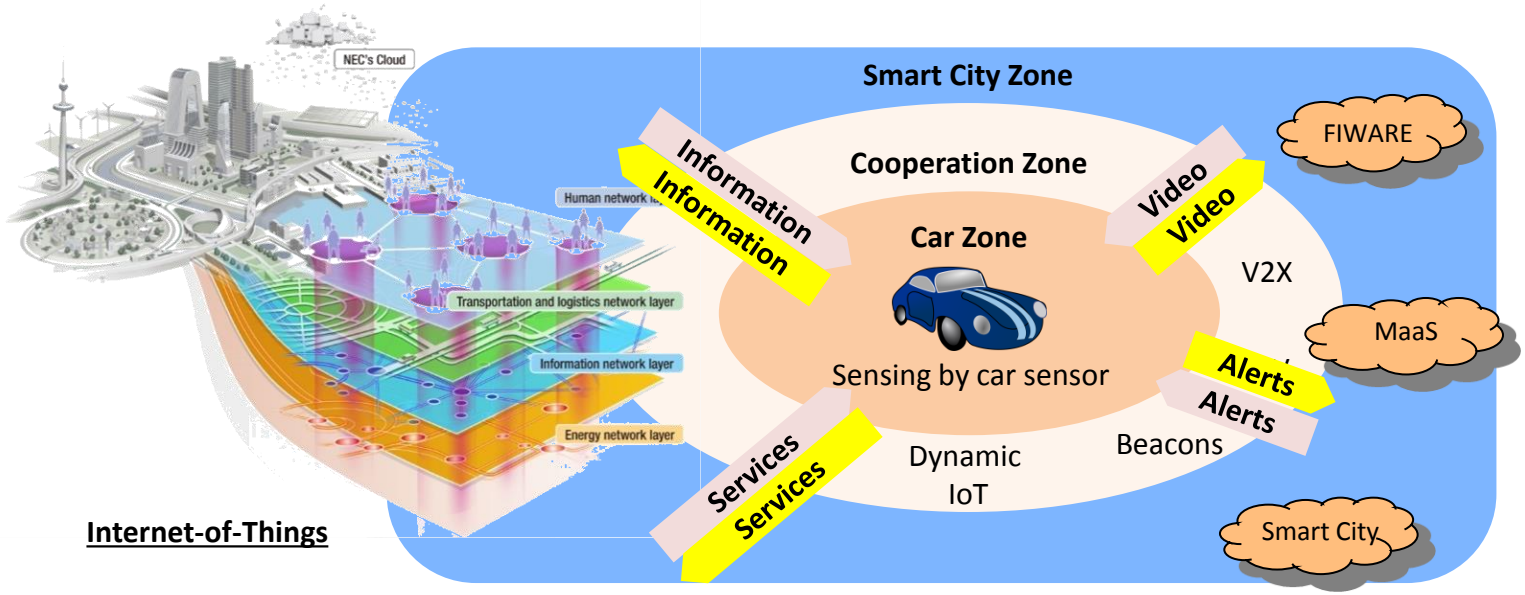
Autopilot: IoT-supported Autonomous Driving



H2020 EU Large-Scale Pilot on „IoT for Autonomous Driving“

- 44 partners from 15 European countries + South Korea
- 5 permanent large scale pilot sites in Finland, France, Netherlands, Italy and Spain

This presentation: Digital Twin Approach

Further Autopilot presentation yesterday (ETSI IoT Week: Session 2: Smart Cities - PART 3, Mariano Falcitelli, "Smart Roads" progressed by oneM2M: the experience of an EU Large Scale Pilot

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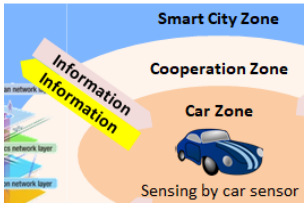
What can IoT do for Autonomous Driving?

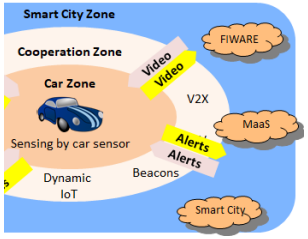


IoT enables **information exchange**...

... between the car, its cooperation zone, and the Smart City

... from the car: car data (speed, location, sensor data)

... To the car: environmental information

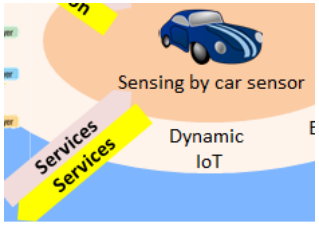


IoT enables **situation awareness** …

… sharing and processing video information

… detect situations and raise alerts to support autonomous driving

- Obstacle / accident ahead
- People on the road
- Bad road conditions (slippery, icy, muddy ...)



IoT enables **new services** combining IoT and AD …

… automatic valet parking, platooning, transportation-on-demand

… treating the car as a controllable object of the IoT

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Assumptions and Requirements

IoT system needs to process data

- from **heterogeneity** of sources
  - different data representations, abstraction levels
  - different protocols / APIs
- combination of external information with information from the car (and other cars)

→ **Common abstraction level and information representation needed**

Heterogeneous & Distributed Data Sources	
Car	location, speed, direction, destination
Environment	map, 3D Model, weather, ...
Sensor	Temperature, induction loop, pressure, ...
Relevant Information	
Road	occupancy level, driving speed, accidents, obstacles, ...
City Objects	parking spaces, city event information, ...

Alerts and Services need relevant Information

- need processing of raw data from distributed data sources

Encountered Problems

→ sharing all information between cars and smart city is techncial /economical not viable: available bandwidth vs. size and dynamics of information

→ processing information in the „right time“ (real-time, fast best effort, batch) need distribution of functionality between cyber-physical system, edge and cloud

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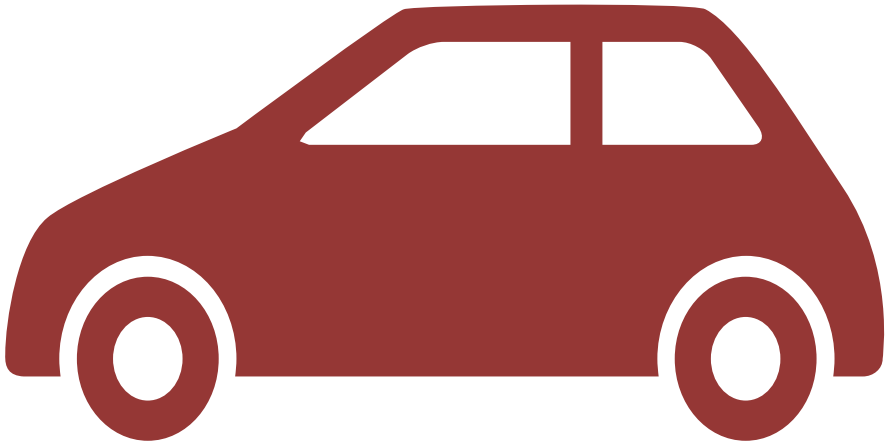
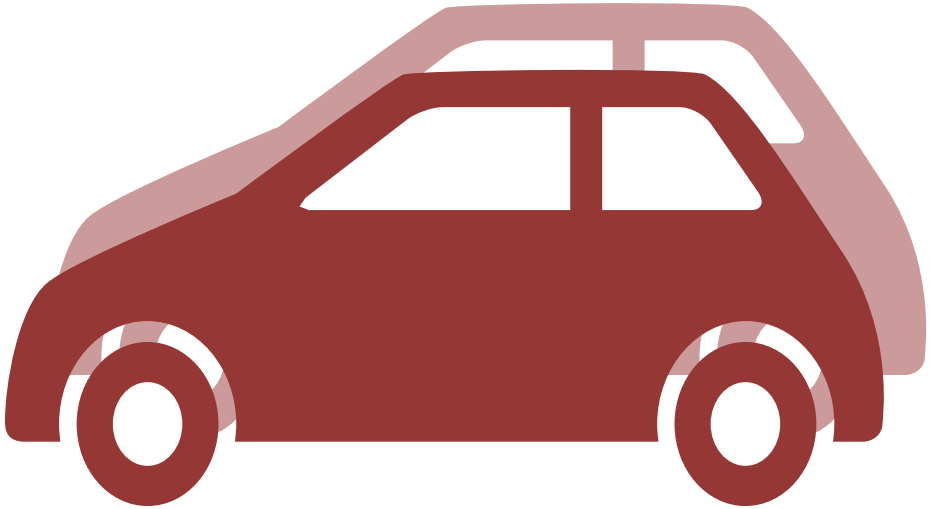
Digital Twin Concept



Autonomous Car A



Autonomous Car A with Digital Twin

Wikipedia:
Digital twin refers to a digital replica of physical assets (physical twin), processes and systems that can be used for various purposes.[1]

The digital representation provides both the elements and the dynamics of how an Internet of Things device operates and lives throughout its life cycle.[2]

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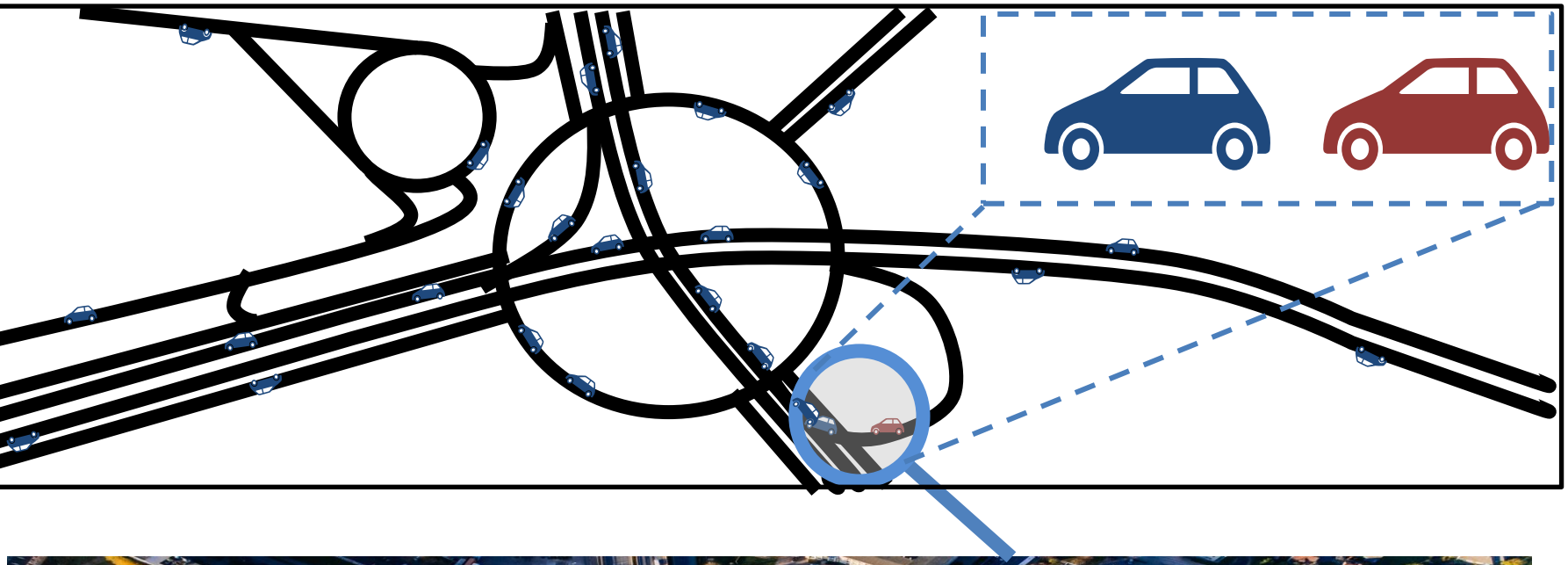
Digital Twin Vision for Autopilot



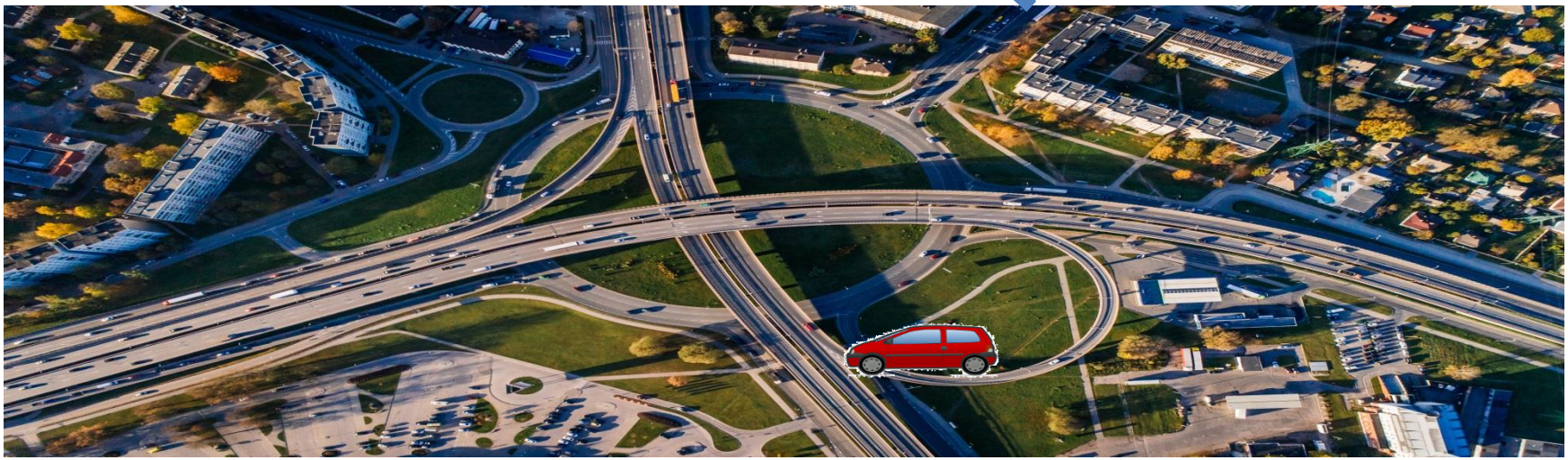


Photo by Aleksejs Bergmanis from Pexels

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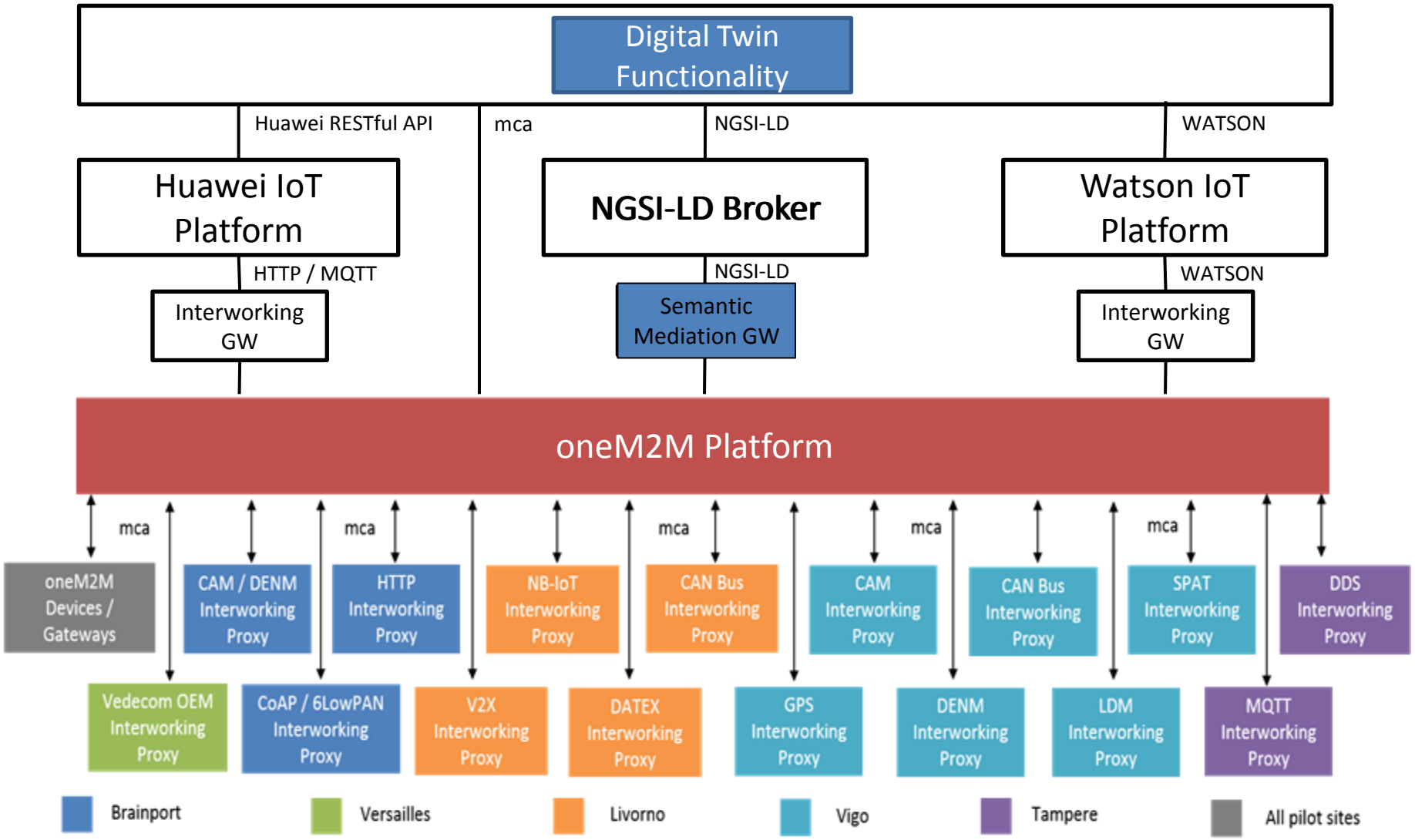
IoT Architecture in Autopilot



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Realising the Digital Twin Vision in Autopilot

Autopilot oneM2M Platform as Basis

+ Relevant IoT information is available in IoT infrastructure (oneM2M platform)
+ Homogeneous API + binding to access information (oneM2M Mca)
+ Agreements on a set of information models to use for different kinds of information
- No common high-level abstraction (e.g. car)
- No information-based access API, i.e. requesting information by only specifying what information is needed

→ **NGSI-LD modelling + API**

Functional aspects of Digital Twin:

- *Analytics functionality for functional augmentation*
- *Cognitive situation understanding*
- *Goal-directed behaviour for assistance*

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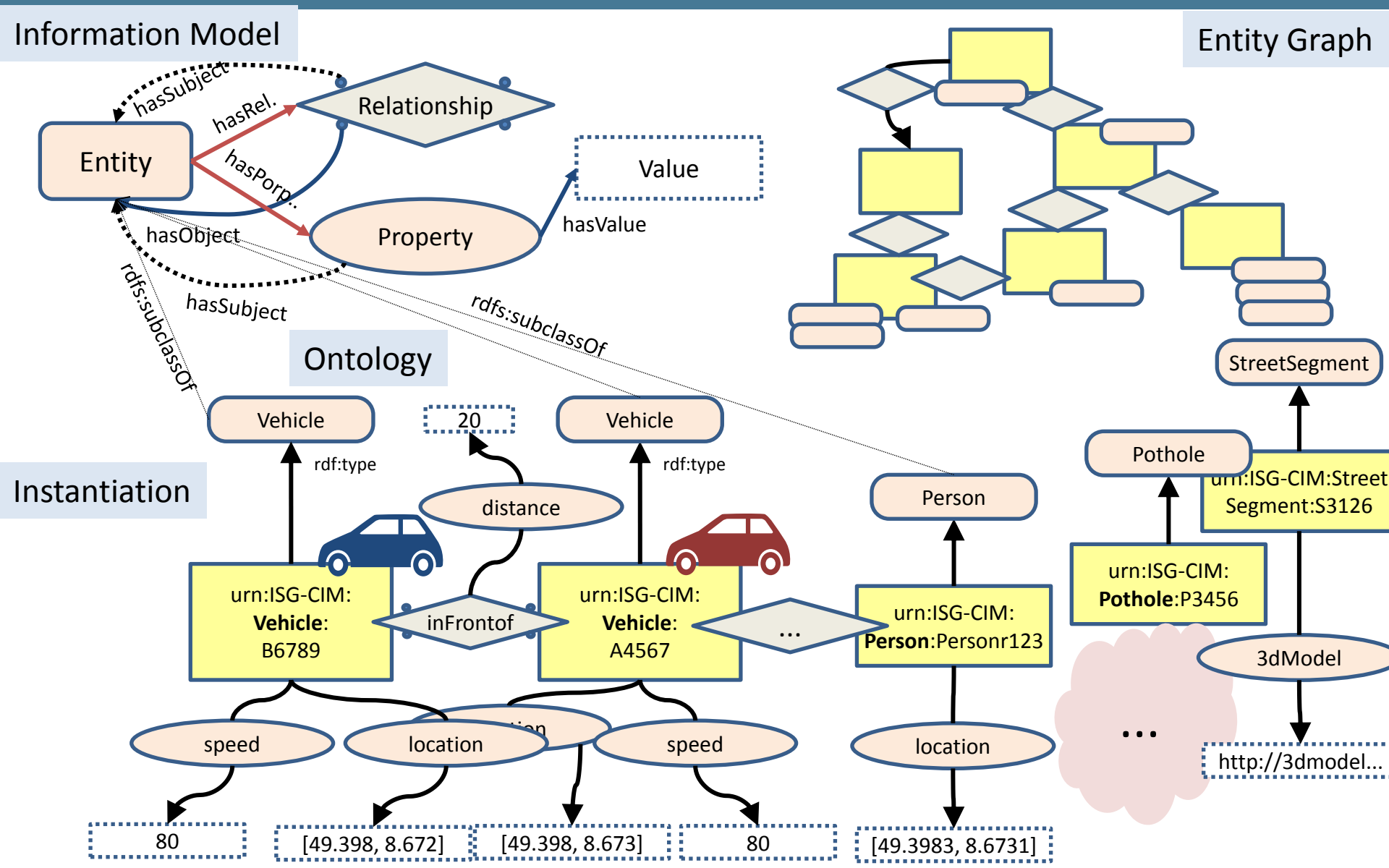
ETSI ISG CIM – *Information Model*



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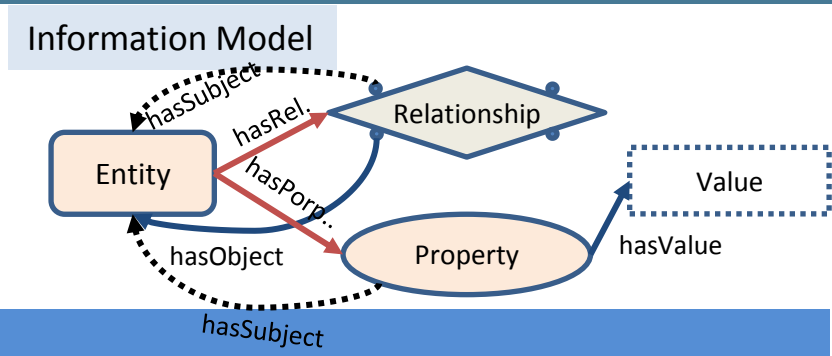
ETSI ISG CIM – *NGSI-LD API*

- NGSI-LD API is defined based on Core Information Model
- NGSI-LD is the evolution of NGSI context interfaces and is represented in JSON-LD → semantic grounding
- Entities request based on identifier (id), id pattern and/or entity type (e.g. car)
- Entity filtering by property value/relationship object & geographic location (GeoJSON)
- Synchronous queries and asyn. subscriptions
- Usable in centralized, distributed and federated architectures




```
{
   "id": "urn:ngsi-ld:Vehicle:A4567",
   "type": "Vehicle",
   "speed": {
      "type":  "Property",
      "value": 80
   },
   "location": {
      "type": "GeoProperty",
      "value": {
         "type": "Point",
         "coordinates": [49.398, 8.673]
      }
   },
   "@context": [

   "http://uri.etsi.org/coreContext.jsonld",
      "http://example.org/cim/vehicle.jsonld"
   ]
}
```

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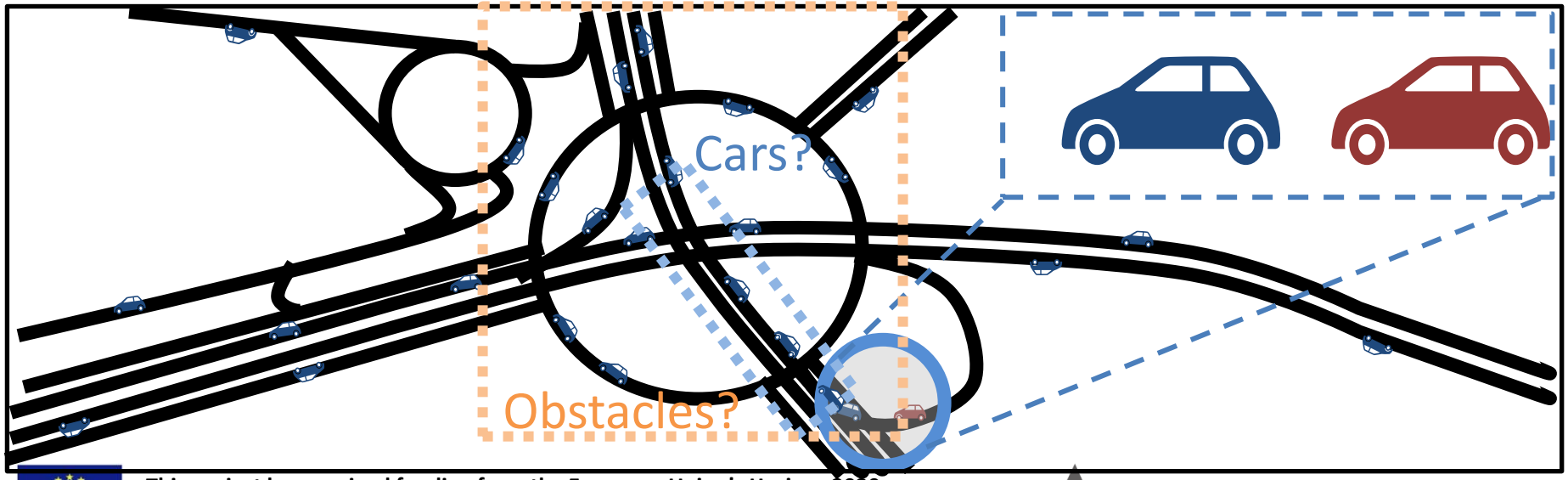
Digital Twin for Autopilot

- To support autonomous driving based on Digital Twins, the following information needs to be efficiently retrievable:
  - about the car itself, other cars and other traffic participants & environment
- NGSI-LD enables the modelling as entities, relationships and properties
- NGSI-LD enables specifying relevant entities, relationships and properties and filtering according to values/objects and geographic location

→ **NGSI-LD provides a suitable basis for Digital Twin modelling**



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Future Work: Functional Aspects of a Digital Twin

Digital Twins consists of information + intelligent processing

NGSI-LD enabled

- knowledge representation of Digital Twins
- relationships between Twins
- efficient search & discovery of relevant Digital Twins

Digital Twins contain active objects ("Augmentations") that realize

- analytics functionality & simulations
  - analyze environment for factors influencing the driving car
  - simulate future manoeuvres and effect of actions taken by the car
- cognitive situation understanding
  - on the basis of raw, analyzed and simulated data understand situation of the car
  - represent shared situation understanding (real-time adaptive knowledge graph)
- goal-directed behaviour for assistance
  - use the situation understanding

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Summary

- Autonomous Driving Cars will use the IoT for information exchange, alert handling and for the creation of new services
- Processing all information in the car is not feasible
- Digital Twins represent the *cyber aspect* of the real world objects
- Broker technologies based on NGSI-LD connect the real twin with the digital twin
- Digital Twin contains information and processing
- Both (information and processing) can be distributed between cloud, edge, and CPS systems (such as drones, cars, or robots)

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Thank you for your attention!

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