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
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
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**

**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 technical / 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

### Heterogeneous & Distributed Data Sources

<table>
<thead>
<tr>
<th>Car</th>
<th>location, speed, direction, destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>map, 3D Model, weather, ...</td>
</tr>
<tr>
<td>Sensor</td>
<td>Temperature, induction loop, pressure, ...</td>
</tr>
<tr>
<td>Relevant Information</td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>occupancy level, driving speed, accidents, obstacles, ...</td>
</tr>
<tr>
<td>City Objects</td>
<td>parking spaces, city event information, ...</td>
</tr>
</tbody>
</table>
Digital Twin Concept

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](https://en.wikipedia.org/wiki/Internet_of_things) device operates and lives throughout its life cycle.\[2\]
Digital Twin Vision for Autopilot

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Photo by Aleksejs Bergmanis from Pexels
IoT Architecture in Autopilot

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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 – 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 async. subscriptions
- Usable in centralized, distributed and federated architectures
• 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
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
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)
Thank you for your attention!