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Connectivity for Digital Twin – Mixed Reality Solutions

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Contents of the presentation

Background on Digital Twin

- **Why?**
- **What?**
- **How?**

XR realisations

- **Cases**

IEEE Computer Society's Top 12 Technology Trends for 2020

3rd place: Digital twins, including cognitive twins…

…reality in the manufacturing industry, and major IoT platforms, like Siemens MindSphere, are supporting them.

…widespread tool in complex system operations; railways and power plants have been used in cities since Jan 1, 2019.

…cognitive digital twins are in the early stages of trial and experimentation

https://www.computer.org/press-room/2019-news/ieee-computer-societys-top-12-technology-trends-for-2020

What? – Merging the physical and virtual worlds

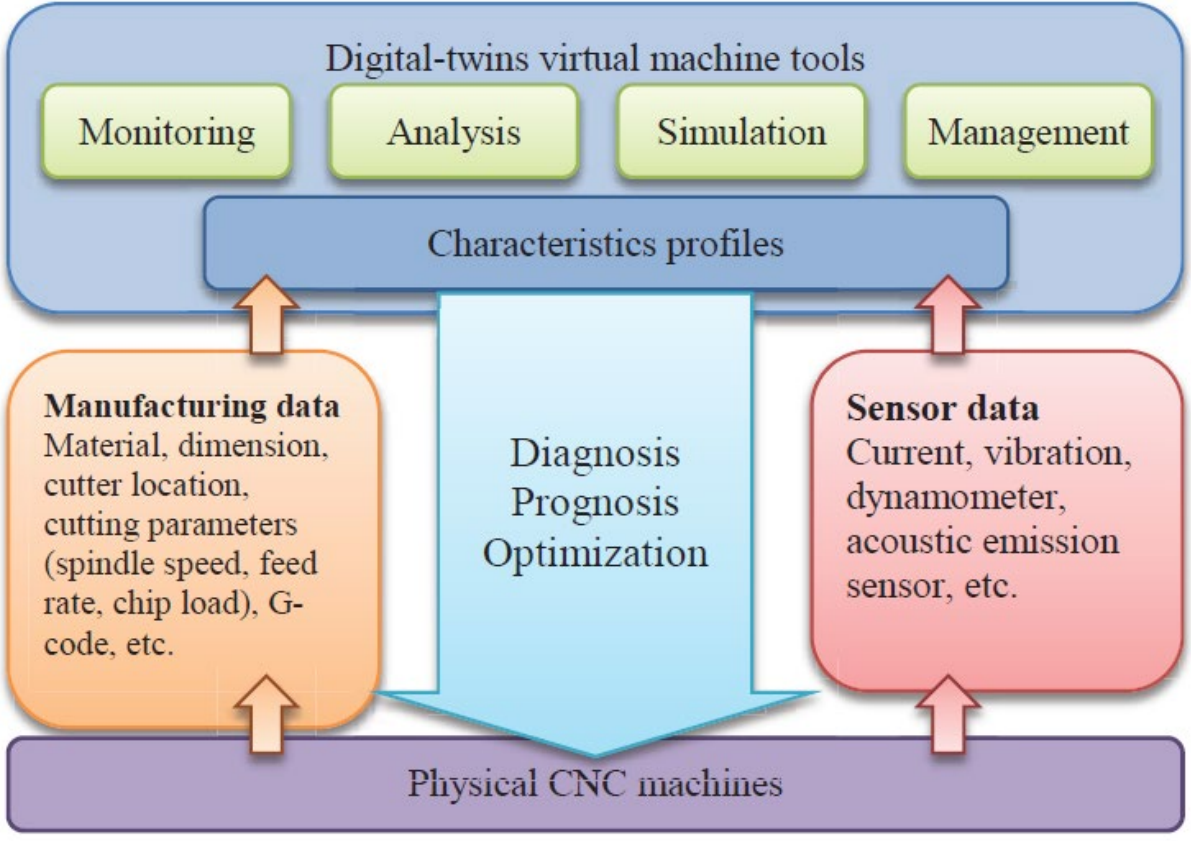
Virtual or cyber physical capabilities in modern machines

Digital twins benefit/use measurements, big data, IoT, …

“Digital Twin is the cyber part of a Cyber Physical System.” (Autiosalo, 2018)

Connection to data from physical world is to make a distinction to traditional physical/mathematical model

Machine tool digital twin



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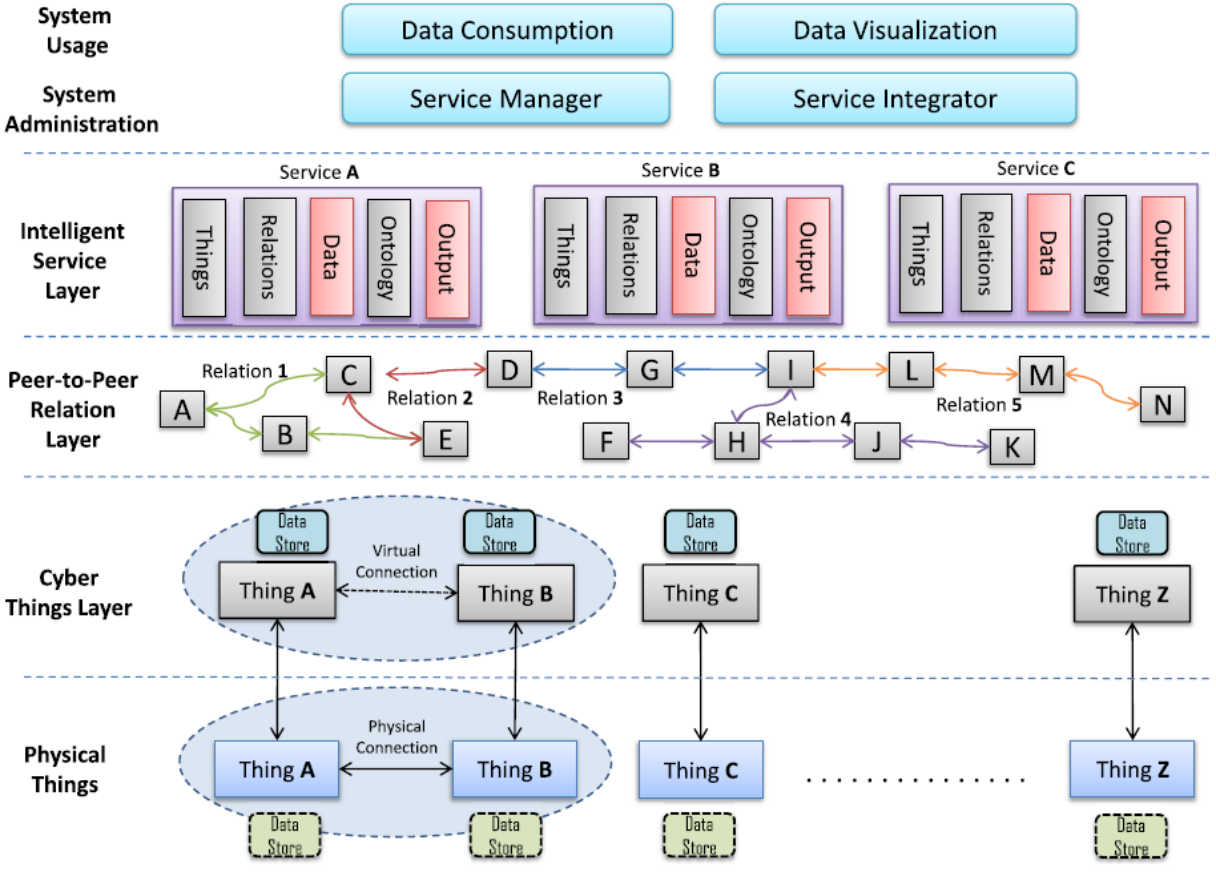
Y. Cai et al. *Sensor data and information fusion to construct digital-twins virtual machine tools for cyber-physical manufacturing.* 45th SME North American Manufacturing Research Conference

A platform view



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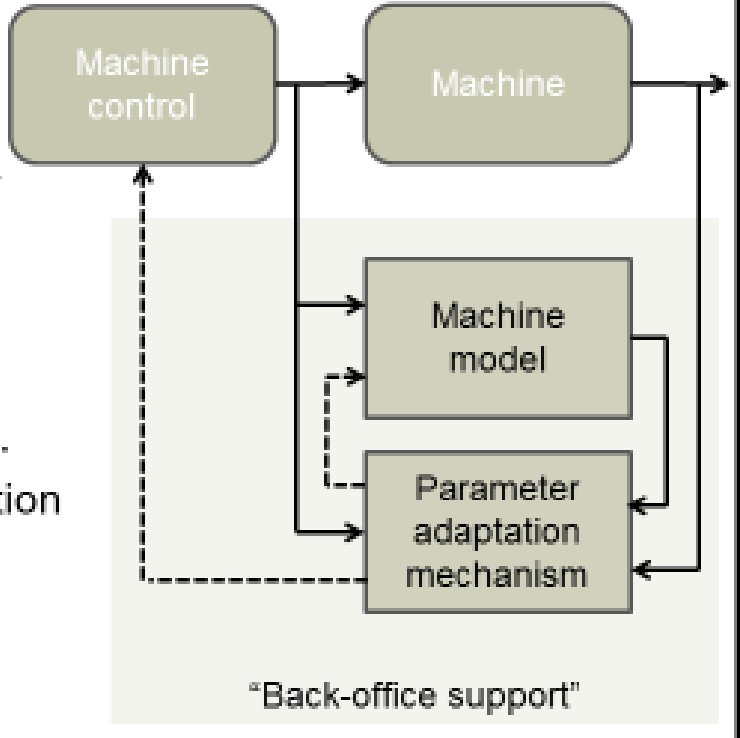
Alam et al. *C2PS: A Digital Twin Architecture Reference Model for the Cloud-Based Cyber-Physical Systems*. IEEE

TRACKING SIMULATOR IDEA

1. **Digital tracking true machine (process)**
2. **Adjust machine model**
   - Adapt model continuously
3. **Optimise performance**
   - Run operation scenarios
   - Stochastic methods, e.g. Monte Carlo, Bayesian, …
   - Control for efficient operation
   - Various control methods
4. **Plug service over IoT**
   - Realisation in industrial application



By K. Tammi

Conclusions

Some cases digital twin is physical model of system (and used as hype word)

if we want digital twin <> just model

then we need to add something

else we go along with hype

Own definition: digital twin is a model plugged to a system and providing on-line information about the system operation

Business potential is quite obvious if our capabilities to predict different things is improved by digital twin

Our view

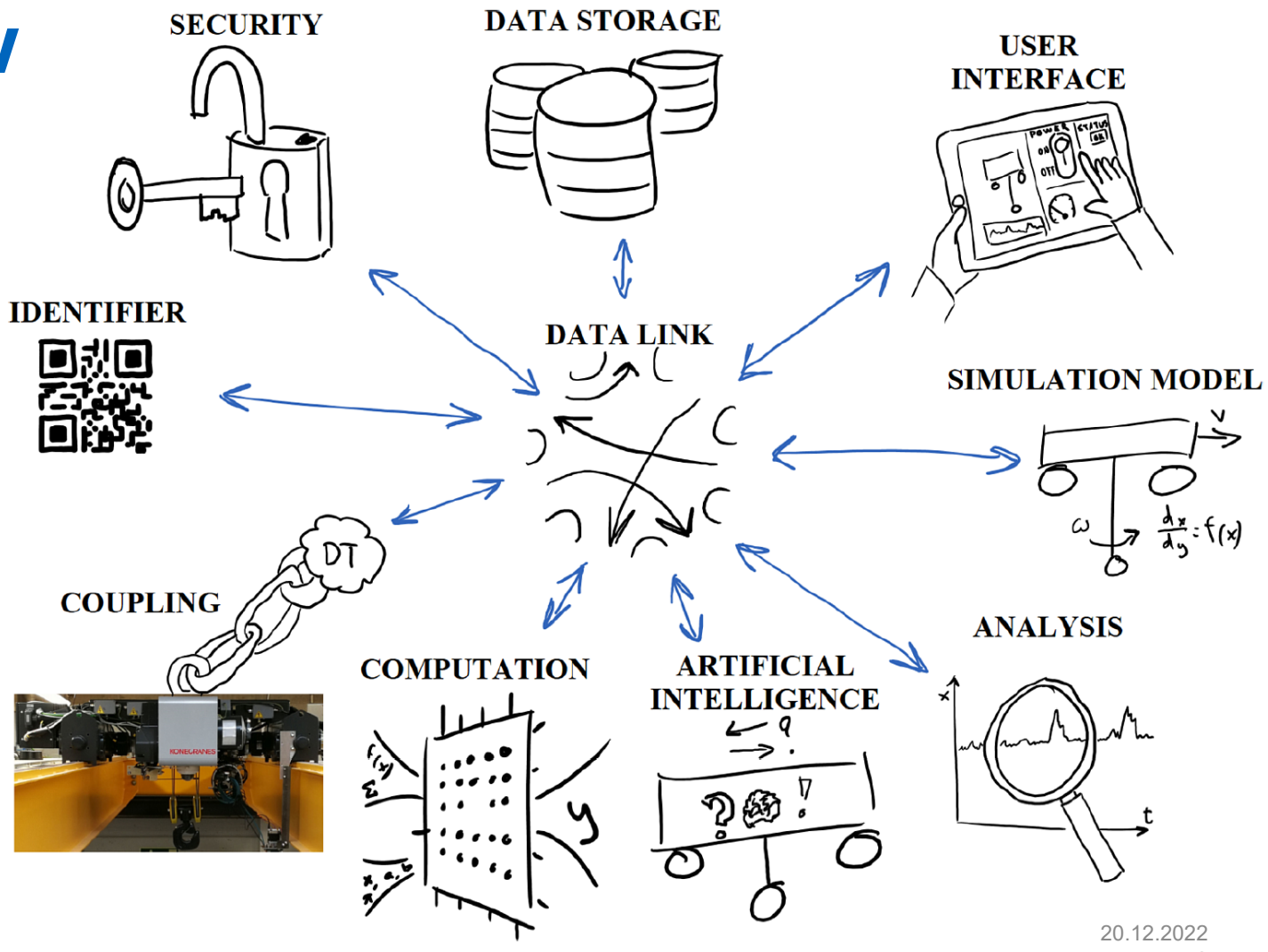
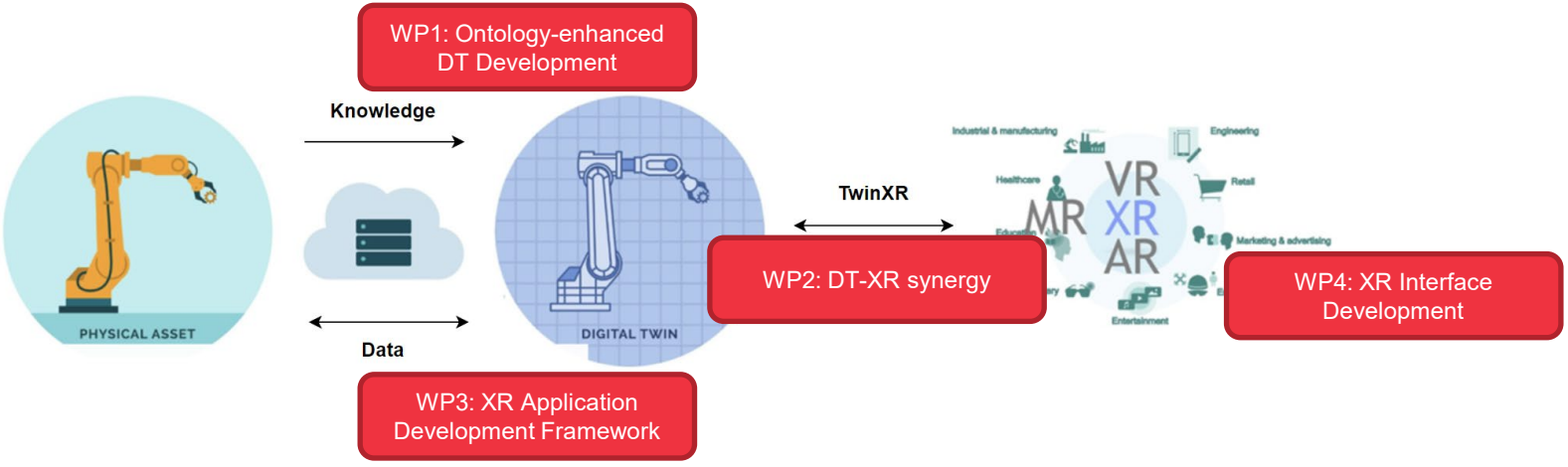


FIGURE 1. Conceptual ideal of feature-based digital twin framework.

Autiosalo et al. *A Feature-Based Framework for Structuring Industrial Digital Twins*

Connectivity is the core of well-working digital twin

Virtual, augmented and mixed reality as connectivity



- ***WP1***: *Based on the draft "Semantic-driven Digital Twin of Production Process: an OPC UA-based Overhead Crane Case"*
- ***WP2***: *Based on the submitted Manuscript "TwinXR: Method for using Digital Twin Descriptions in eXtended Reality Applications" in the journal "Frontiers in Virtual Reality"*
- ***WP3***: *Based on the published article "Extended Reality Application Framework for a Digital-Twin-Based Smart Crane"*
- ***WP4***: *Based on the published article "A Mixed Reality Interface for a Digital Twin Based Crane"*

TwinXR advances synergies between DT and XR with high efficiency, scalability, and interoperability

- Allow creating an XR solution once, then scaling it widely to multiple instances
- Enable on-demand composition without XR dev knowledge
- Open up opportunities for multiple types of developers and users

- Bridge data silos, boost interoperability among machines and applications
- Increase data visibility and production transparency
- Enable user-friendly workflows of information viewing and modification

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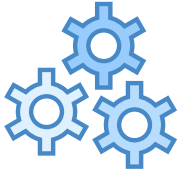
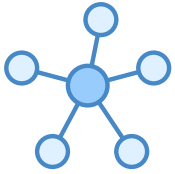
Future work includes introducing principles of Semantic Web, and developing factory-level TwinXR applications

Semantic Web

Standardized linked data format

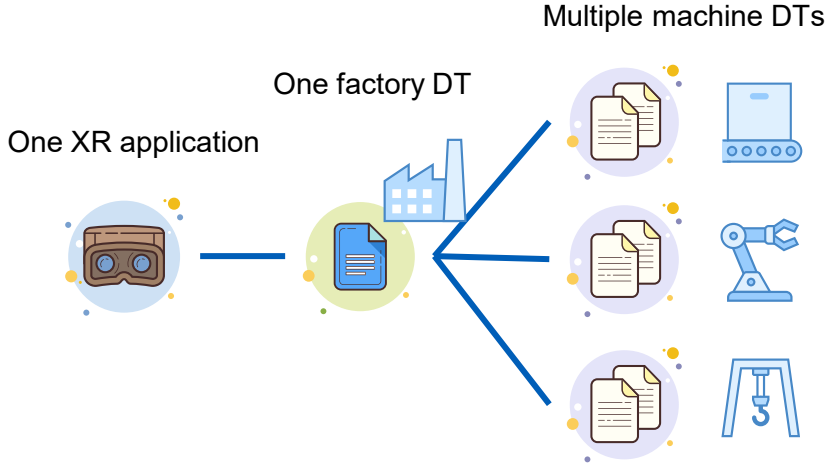


Machine readability



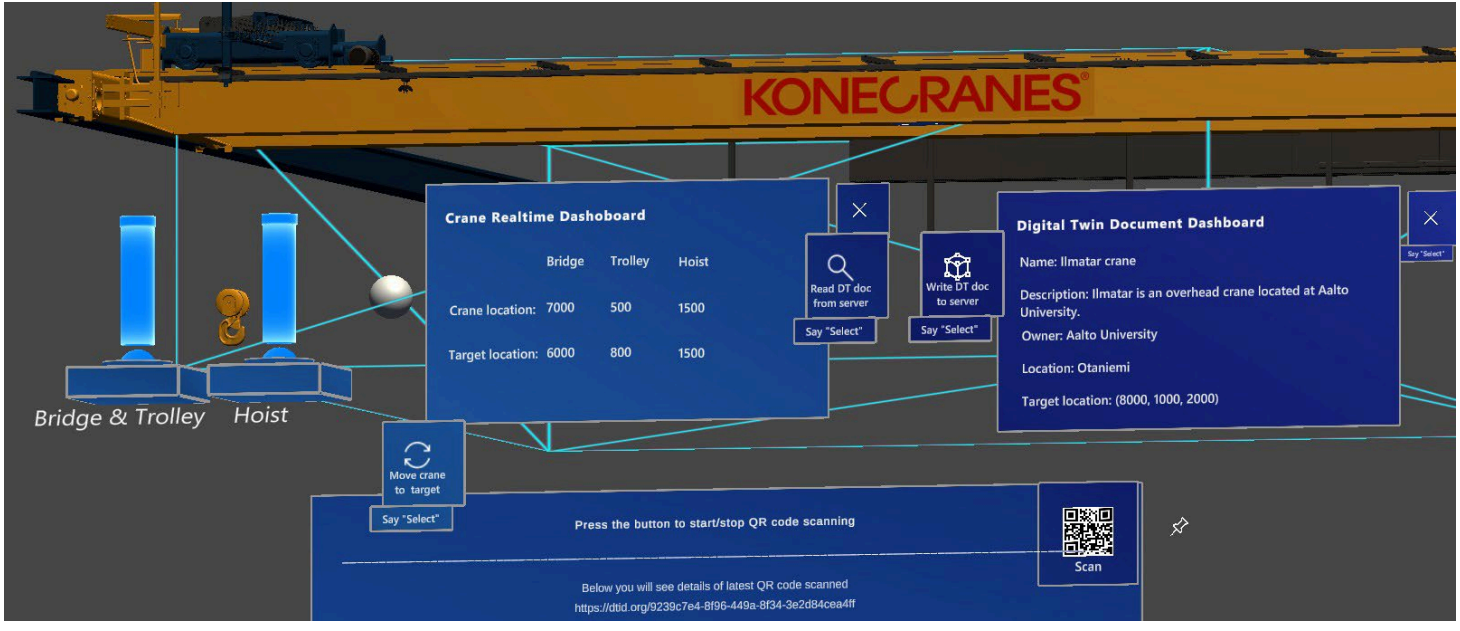
Knowledge Graph

Factory-level TwinXR



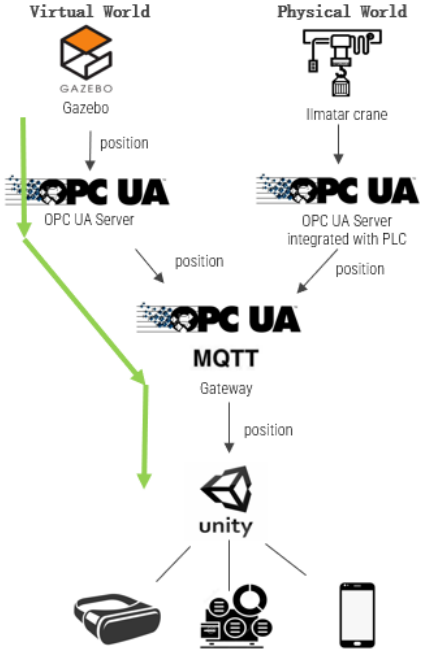
TwinXR

TwinXR-compatible MR interface enables to operate a crane, while reading or modifying its DT document

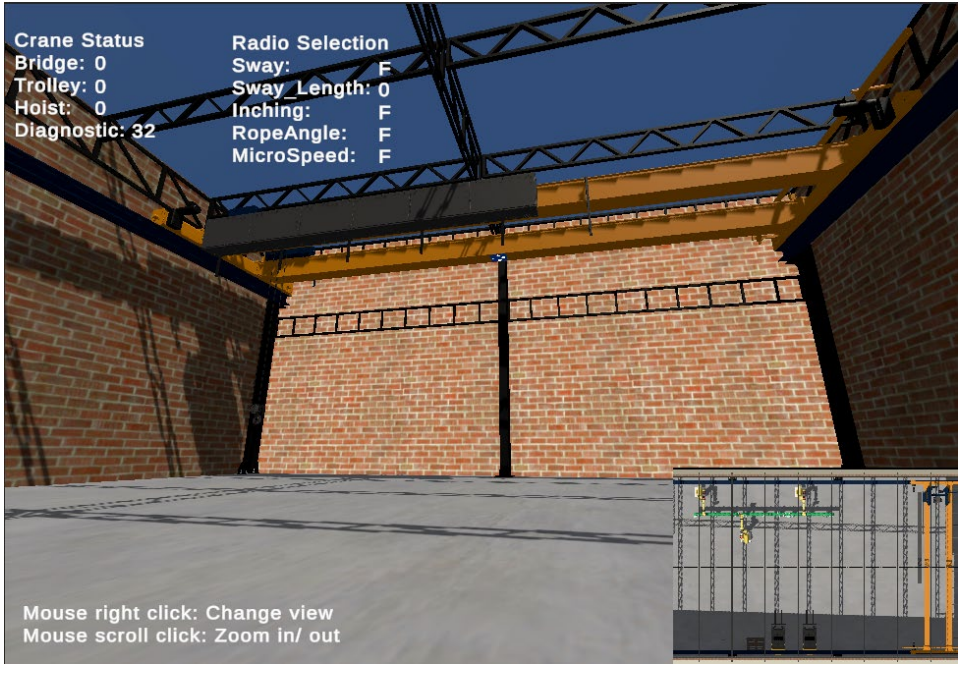


Use cases – Remote monitor

Technical architecture



Prototyping Application

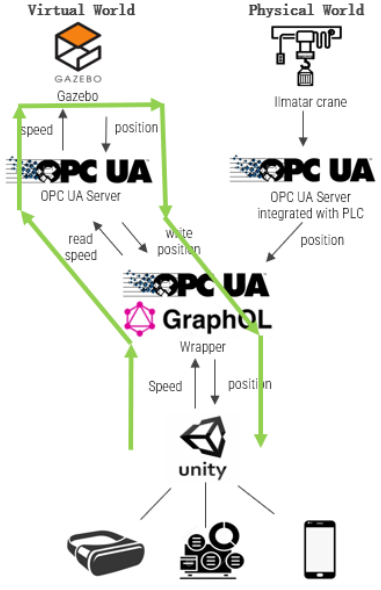


Use cases – Remote monitor

Remote monitor

Use cases – Remote control

Technical Architecture



OPC UA-GraphQL Wrapper

OPC UA GraphQL Wrapper GitHub

OPC UA Node browser

Node arguments for GraphQL queries

server:

nodeId:

cranekos

grindingMachinekos

grindingMachine

GraphQL queries are POST in JSON format to URL:

http://80.50.x.x:5447777/graphql

Queries can be tested and more documentation can be found at the same URL.

Autofilled example queries

Read:

```
query {
  node(server: , nodeId: ) {
    name
    variable {
        value
        dataType
    }
  }
}
```

Write:

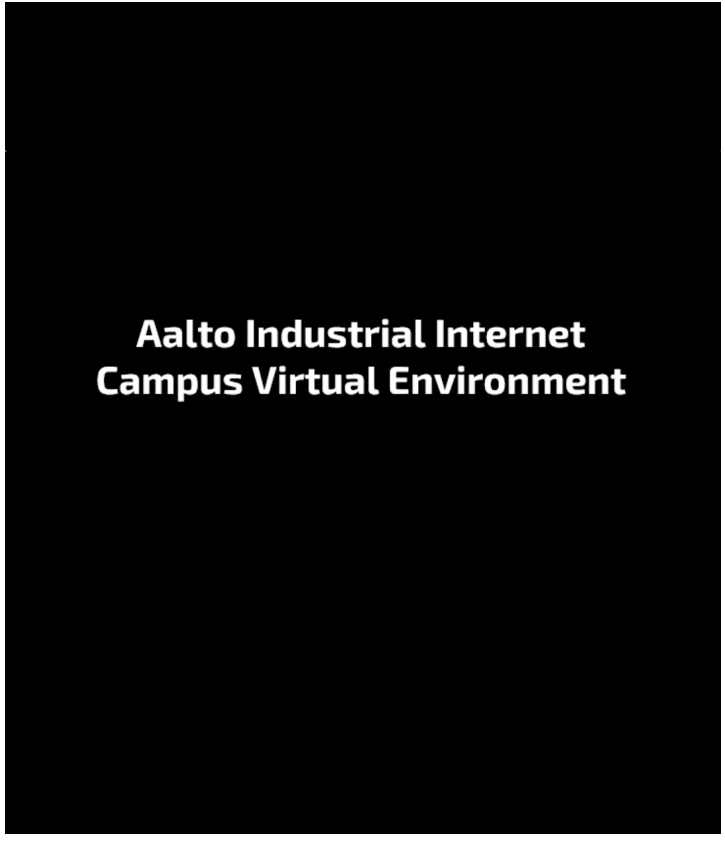
```
mutation {
  setValue(server: , nodeId: , value: value, dataType: "dataType") {
    ok
  }
}
```

Prototyping Application

Use cases – Remote control

Remote control

Use cases – VR training



Features

- *Physical VR hand model*
- *Multi-Interactor*
- *Multi-modal interaction capabilities*
- *Multi-scene*
- *Data parameter synchronization*

Future Research

1. Remote controller development

2. Physical demonstration and test

- Remote control

- Remote monitor (VPN/Local)

3. Semantic-enhanced Information Search using NLP

4. Semantic-based Asset Management

5. Adaptive Contextual Augmented Reality Interface

6. Factory-scale Information and Data Management, including Machine, Environment, Operator, Task

- Overhead Crane, AGV, Elevator, (Arm Robot)

- Edge Cloud & Center Cloud

7. Dynamic Device Positioning and Information Visualization

Future Research

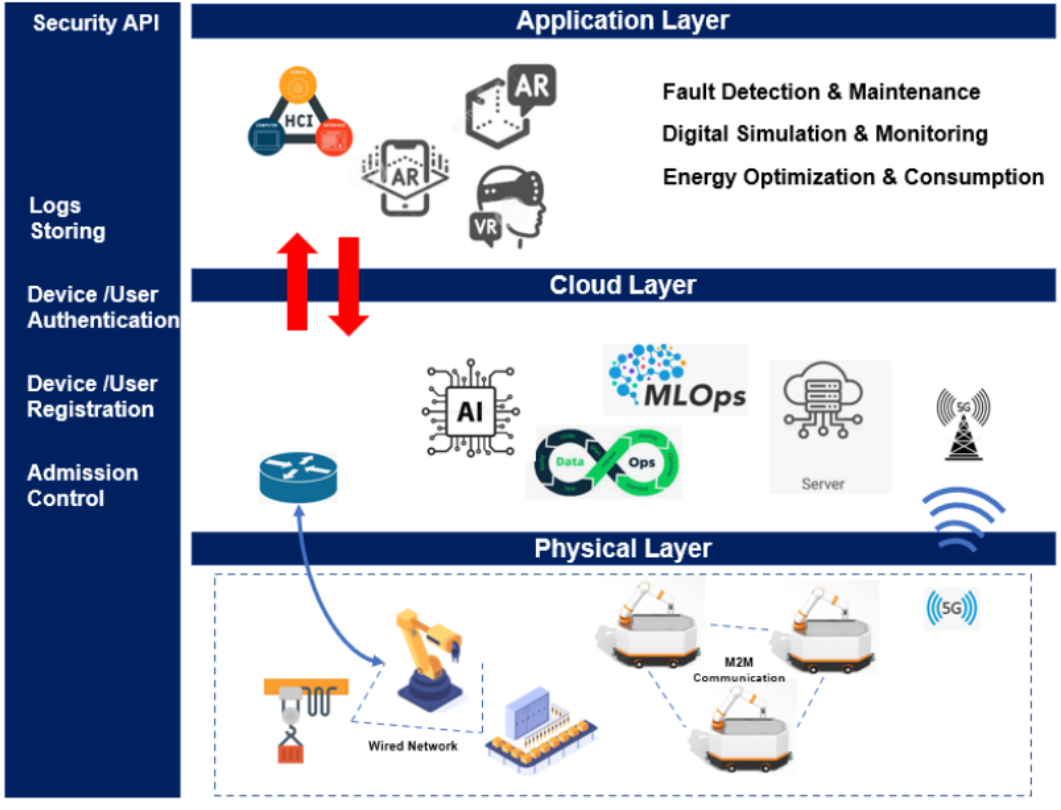


Figure 3: Wireless Communication Architecture for a Smart Factory.

Future Research