VTT

Edge AI in Cyber-Physical Digital Services Provisioning

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25/10/2021   **VTT – beyond the obvious**

Introduction (1/2):
Evolution of Digital Service Offerings and Provisioning Infrastructure

Today:

- Cloud based, Internet and mobile platforms mediated digital services
- Information-, Iot- & cyber-physical systems with ML/DL components
- E.g. IoT & on-line services, apps & voice assistants

Future?:

- End-to-end managed distributed computing (including various edge computing nodes extending cloud computing)
- Connected everything and **digital services for efficient Human-Machine co-operation**
  - H2H, H2M, M2H and M2M interaction
- E.g. Digital twin services, AI assistants/coaches/mediators & autonomous service robotics, autonomous operations


Edge AI
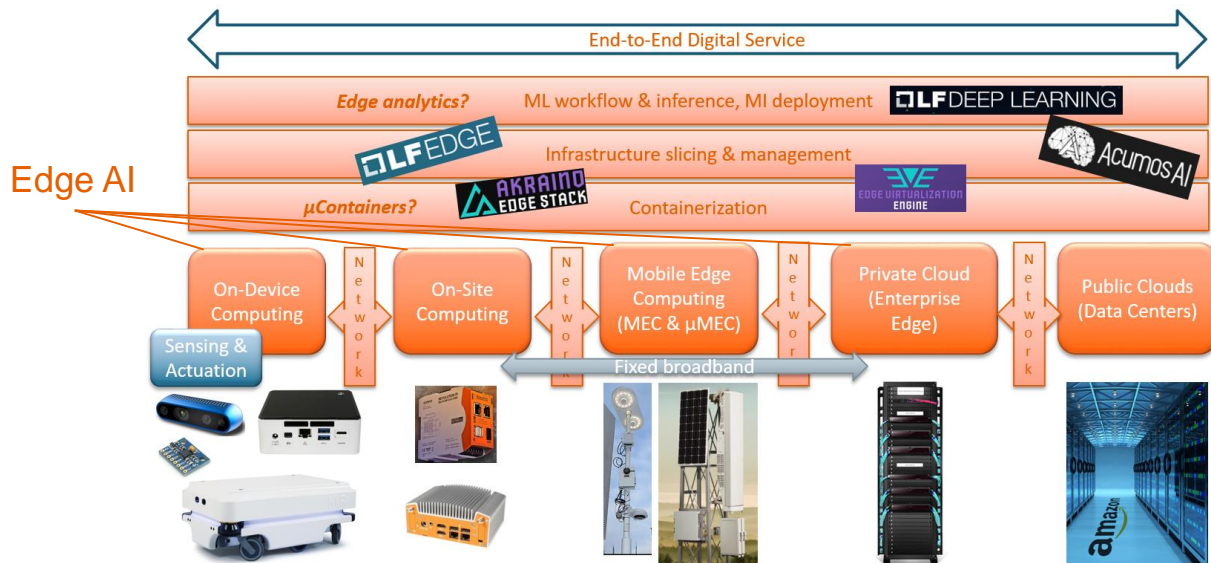
Pääkkönen, Pekka, and Daniel Pakkala. "Extending reference architecture of big data systems towards machine learning in edge computing environments." *Journal of Big Data* 7.1 (2020): 1-29. https://doi.org/10.1186/s40537-020-00303-y

Pääkkönen, Pekka, and Daniel Pakkala. "Architecture for enabling edge inference via model transfer from cloud domain in a kubernetes environment." *Future Internet* 13.1 (2021): 5.
https://doi.org/10.3390/fi13010005

Introduction (2/2)
Cyber-Physical Digital Service

- Digitalization and Servitization are changing business processes, workflows and interaction of individuals and organizations on societal level.
  - Rapid technological progress (IoT, CPS, automation, robotics & AI) is enabling re-distribution of tasks and workflows, both physical and cognitive, between people and machines.
- Fully automated scalable digital service provisioning is an attractive goal for many companies.
  - IoT, CPS, robotics and edge AI are enablers for full automation various industrial tasks/workflows
- Examples on mobile robotics and integrated CPS based cyber-physical digital services R&D at VTT
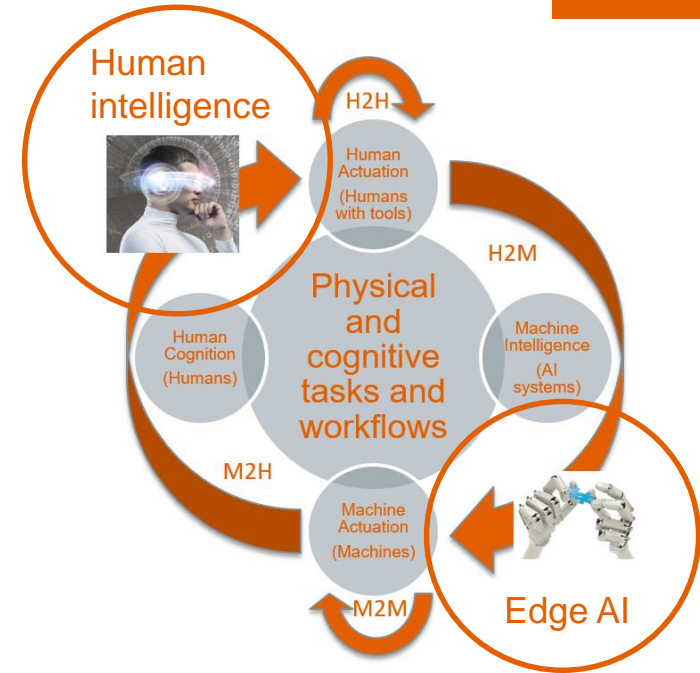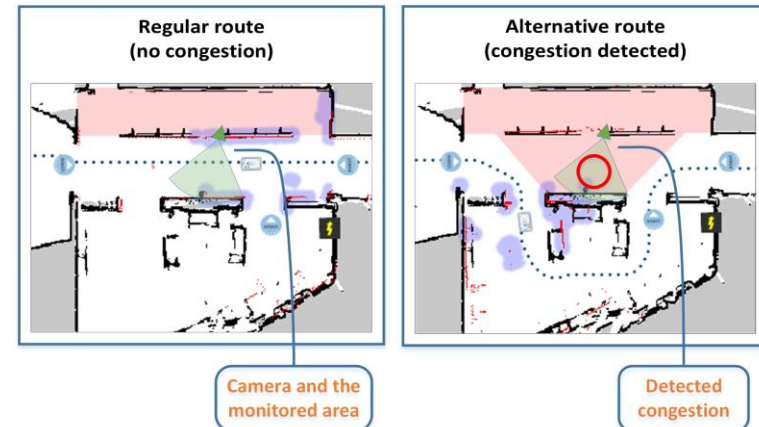

Pakkala, Daniel, et al. "An experimental case study on edge computing based cyber-physical digital service provisioning with mobile robotics." *Proceedings of the 53rd Hawaii International Conference on System Sciences.* 2020. URL: http://hdl.handle.net/10125/63884
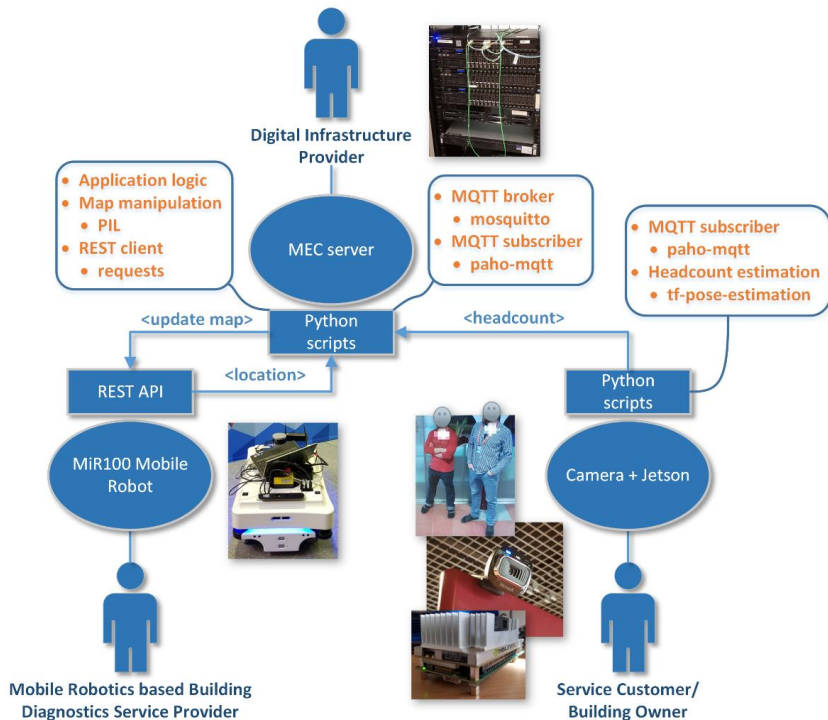
Cyber-physical digital service: "*a service executed by operationally autonomous ICCAT based system co-creating value for service user via interaction with physical environment, objects or artefacts in spatiotemporal situated context.*"

Use Case: Building health diagnostics with mobile robotics

- *Conference article on exploring mobile robotics as an enabler in cyber-physical digital service provisioning*

    - Pakkala, Daniel, et al. "An experimental case study on edge computing based cyber-physical digital service provisioning with mobile robotics." *Proceedings of the 53rd Hawaii International Conference on System Sciences. 2020. URL:* http://hdl.handle.net/10125/63884

- Mobile robot is autonomously moving in a building and navigating among people to collect sensor information on building health.

- Certain areas in a building can become congested by people, creating a need to re-route the robot to an alternative route.

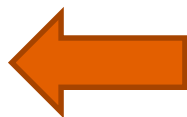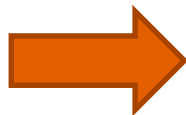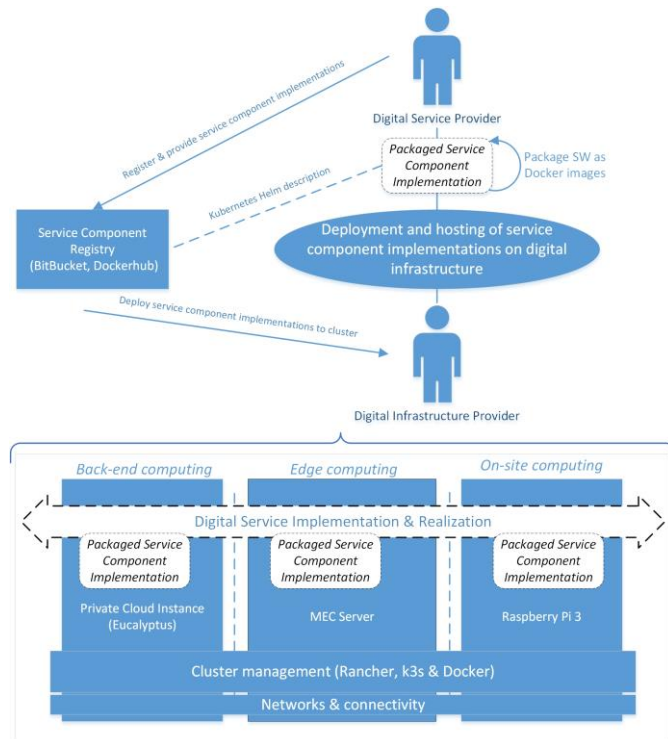- Edge AI applied for situation-aware governance of the robot via edge computing.

Regular route (no congestion)

Alternative route (congestion detected)

Camera and the monitored area

Detected congestion

Use Case: Prototypes

Requirements

Support for design, development and operation of digital service.

Prototype 1: Digital service functionality

Prototype 2: Edge computing infrastructure

Results – Design Challenges

- Based on evaluation of designed, developed and demonstrated trial system, the following design challenges for cyber-physical digital service provisioning were identified:

1. DC#1: Shared coordinate system for spatiotemporal information exchange between service actors.
2. DC#2: Design of autonomous features and machine intelligence in cyber-physical service to minimize customer responsibilities and skill requirements for service use.
3. DC#3: Design of autonomous workflows in a way that enables dynamic adaption to changes in physical context.
4. DC#4: Scalable automated provisioning of distributed edge computing infrastructure for cyber-physical digital service software deployment and operation
5. DC#5: Secure automated network configuration in multi-network distributed computing cluster management

Results – Digital Infrastructure Requirements

- Based on evaluation of designed, developed and demonstrated trial system, the following digital infrastructure requirements for cyber-physical digital service provisioning were identified:
  1. DIR#1: Micro-service offerings for connectivity, message exchange and event management.
  2. DIR#2: Micro-service offerings for data streaming, storing and preprocessing.
  3. DIR#3: Network slicing and/or compression of point cloud data streams should be supported
  4. DIR#4: Provisioned edge computing infrastructure needs to support repository and specified description language for service component software implementations.

# Additional Edge AI Cyber-Physical Digital Service Cases Under R&D at VTT

VTT

- Mobile Robotics:

  - Mobile robot assistants for human workers
  - Parts collection, pre-assembly and delivery in manufacturing
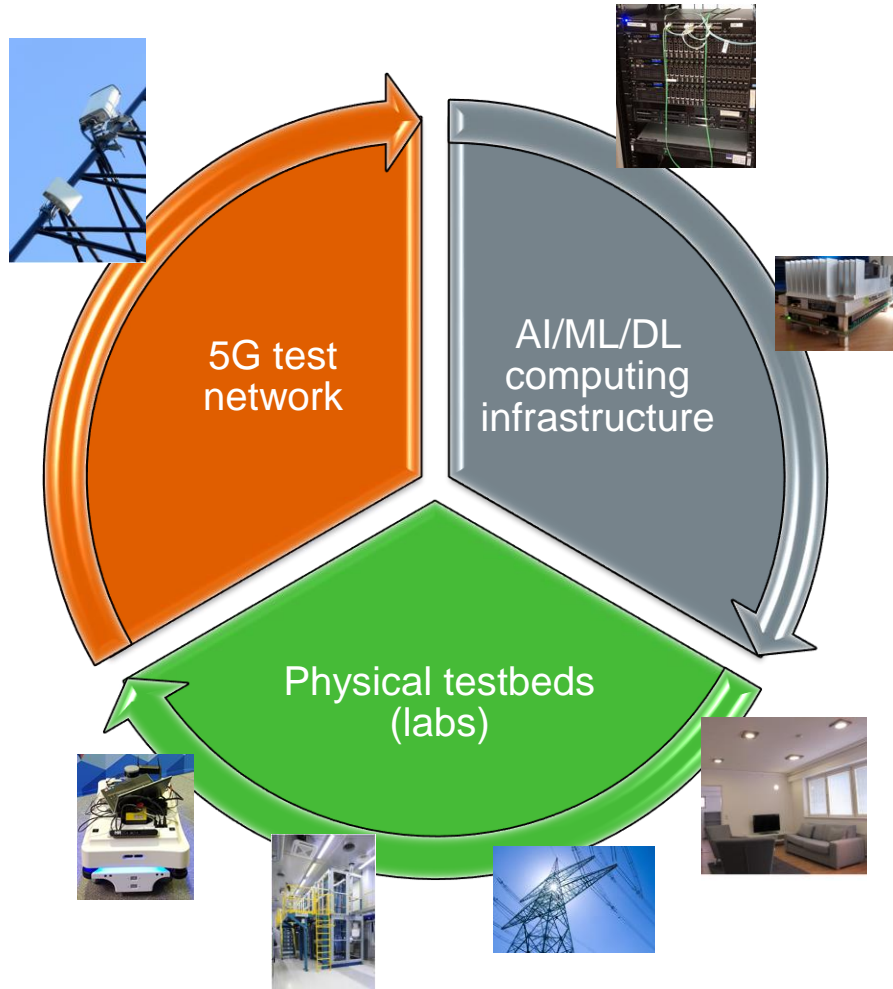 - Flexible digital data-driven manufacturing operations

- Integrated CPS:

  - Forecasting and control of building energy consumption
  - Building energy optimization and integration to demand flexibility markets
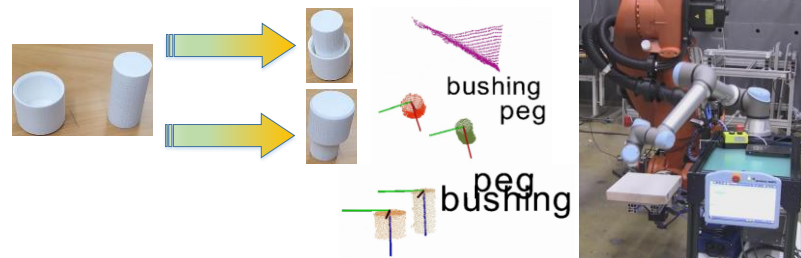
VTT Research Infrastructure for Edge Intelligence

5G test network

AI/ML/DL computing infrastructure

Physical testbeds (labs)

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