Aalto University

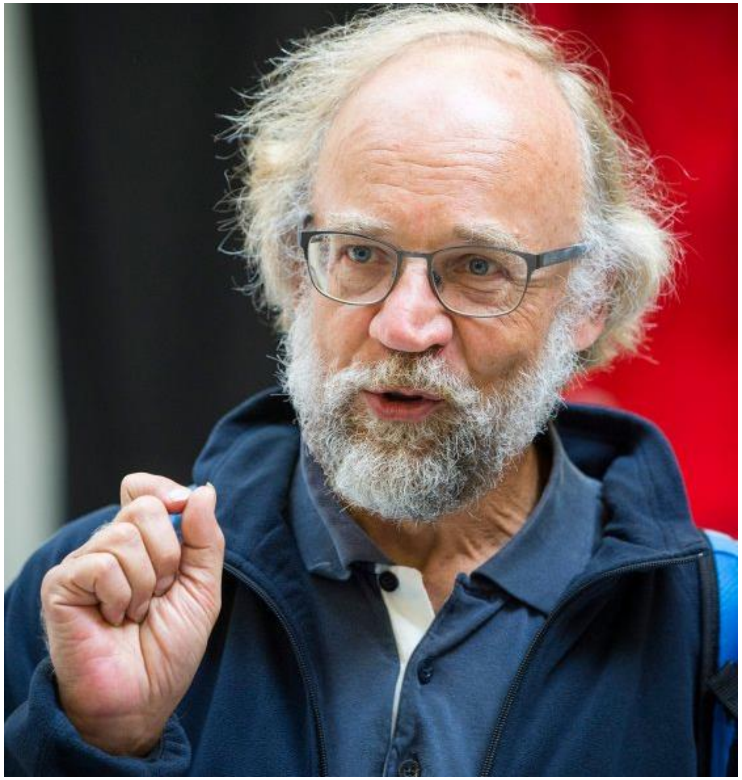
Industrial Internet, an IoT case for 5G

Martti Mäntylä
Aalto University

Martti Mäntylä – Back in business!

- Professor of Information Technology (Enterprise Systems), TKK & Aalto University 1987-
- Chief Strategy Officer, EIT ICT Labs 2009-2013
- Director, Helsinki Institute for Information Technology 1999-2008

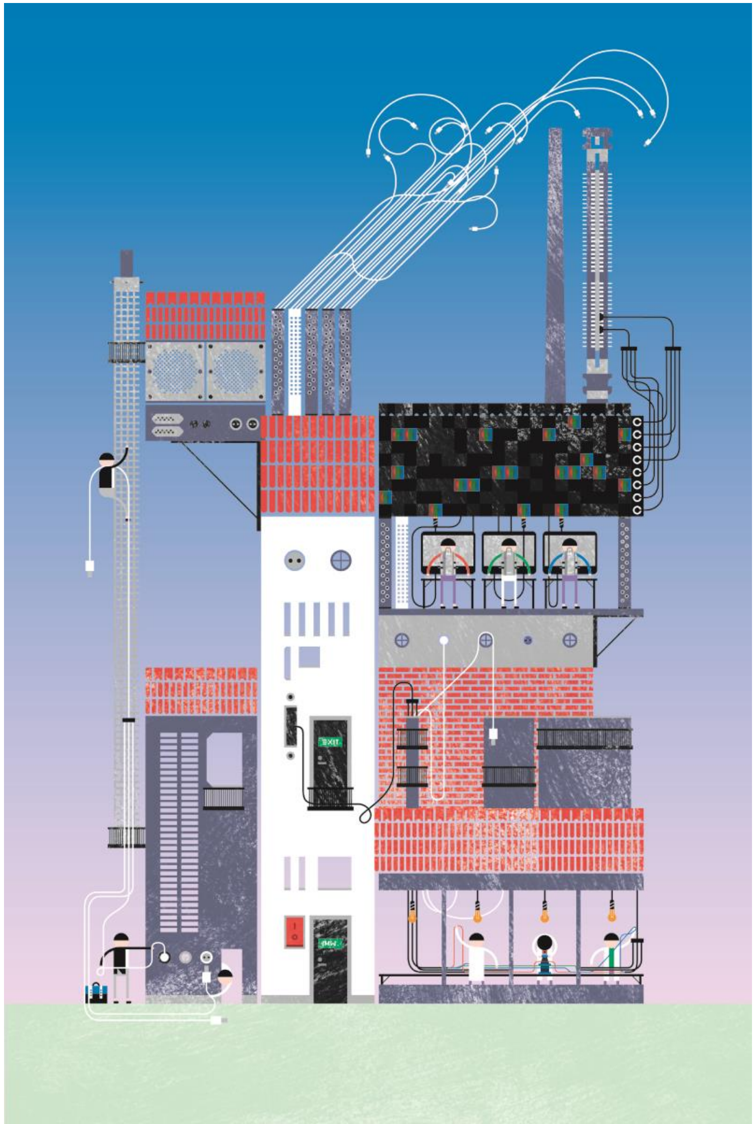
- Since 2014, catalysing Aalto's activities in Industrial Internet



Aalto Industrial Internet Campus

Innovation and *Encounters* backed up by *Research* and *Education*

http://aiic.aalto.fi



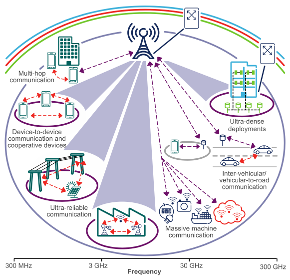
Aalto University

5G, Please Meet Industrial Internet

5G as an Industrial Internet Platform?

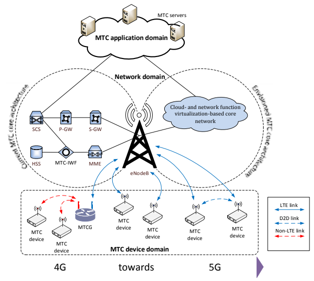
- Today, 4G/LTE architecture manages 2 billion mobile devices in a multiple actor environment, including sharing of business data across operators
- Can 5G provide a management architecture for 20 billion smart devices, including setting up “overlays” for industrial firms for data management and “joint clouds” for controlled data sharing across companies?
- If “yes”, what should we do about it?

5G: Support for heterogeneous services



Aalto University

5G: Machine type communications



- Service and organization dependent virtualized EPC
- Edge computing

- Capillary networks
- Network controlled direct device-to-device

Aalto University

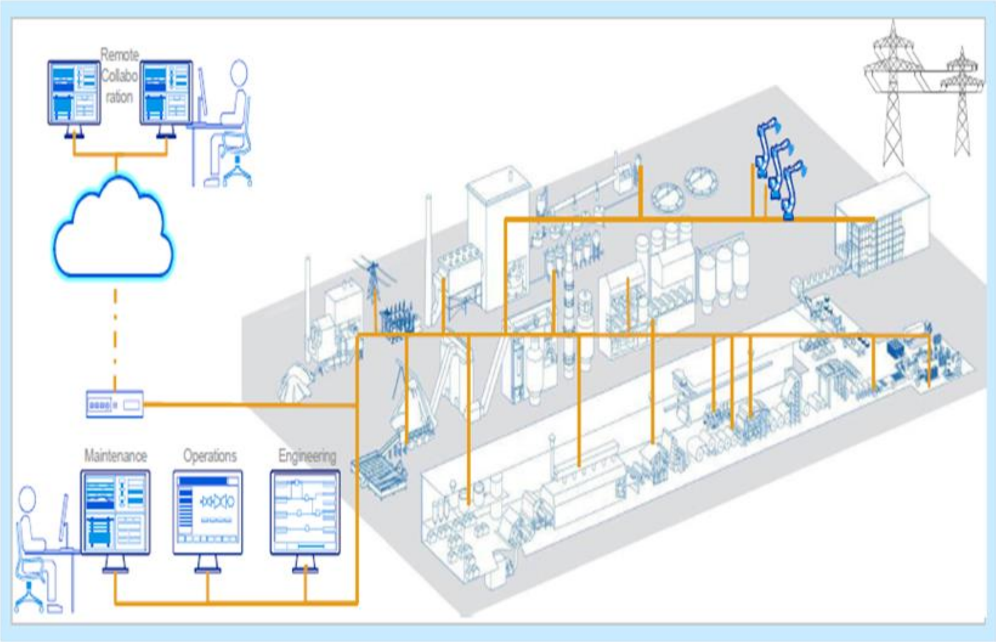
Business Case: Forest Industry

Share, analyze and utilize cross-enterprise data from a production line for win-win-win solutions

- Shared benefits across production life-cycle in
  - Engineering
  - Operations
  - Maintenance

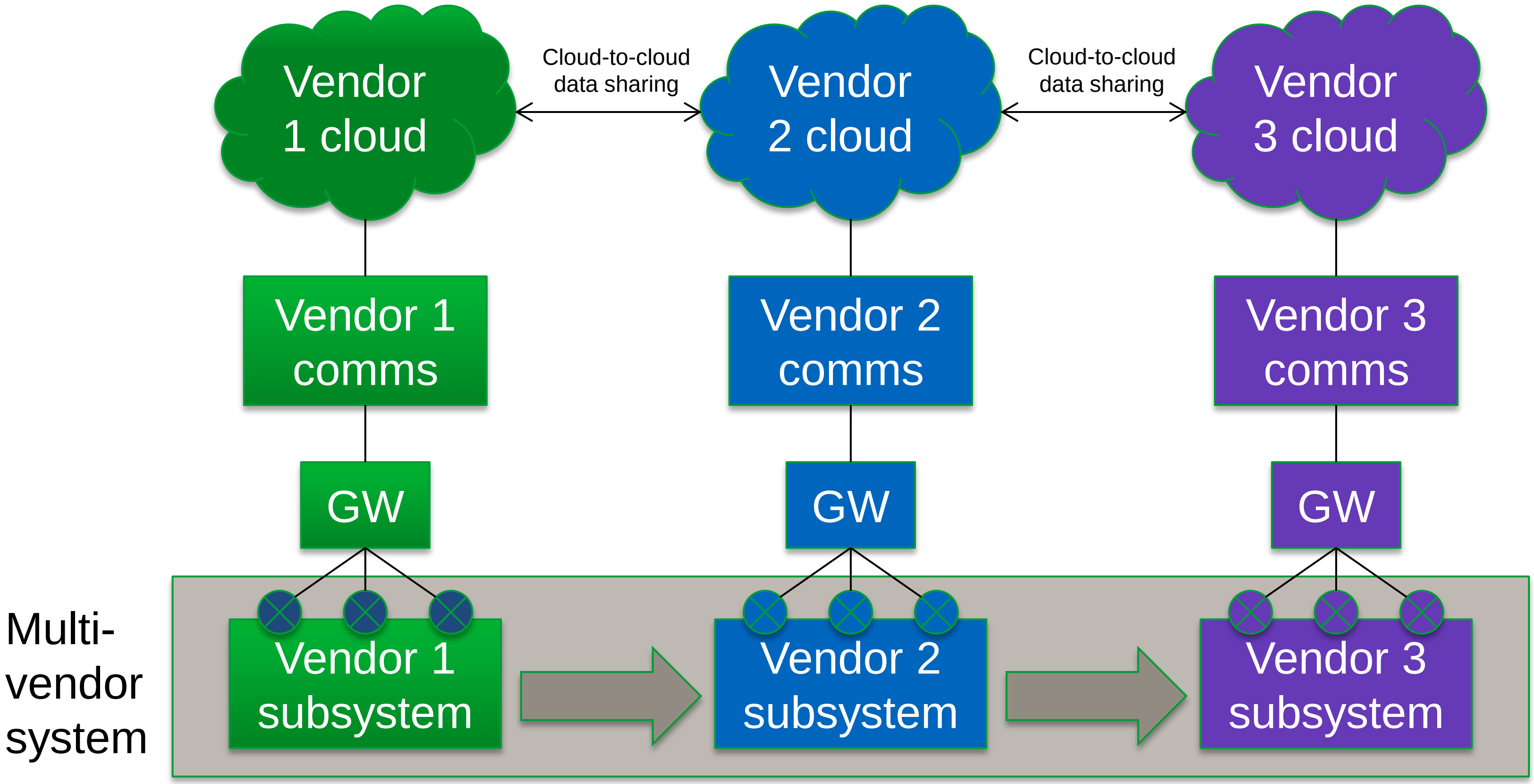
- Key characteristics of the solution
  1. Real-time data
  2. Mobile & remote operations
  3. Predictive actions
  4. Increased automation

- The scope covers all major functional units of the selected production line

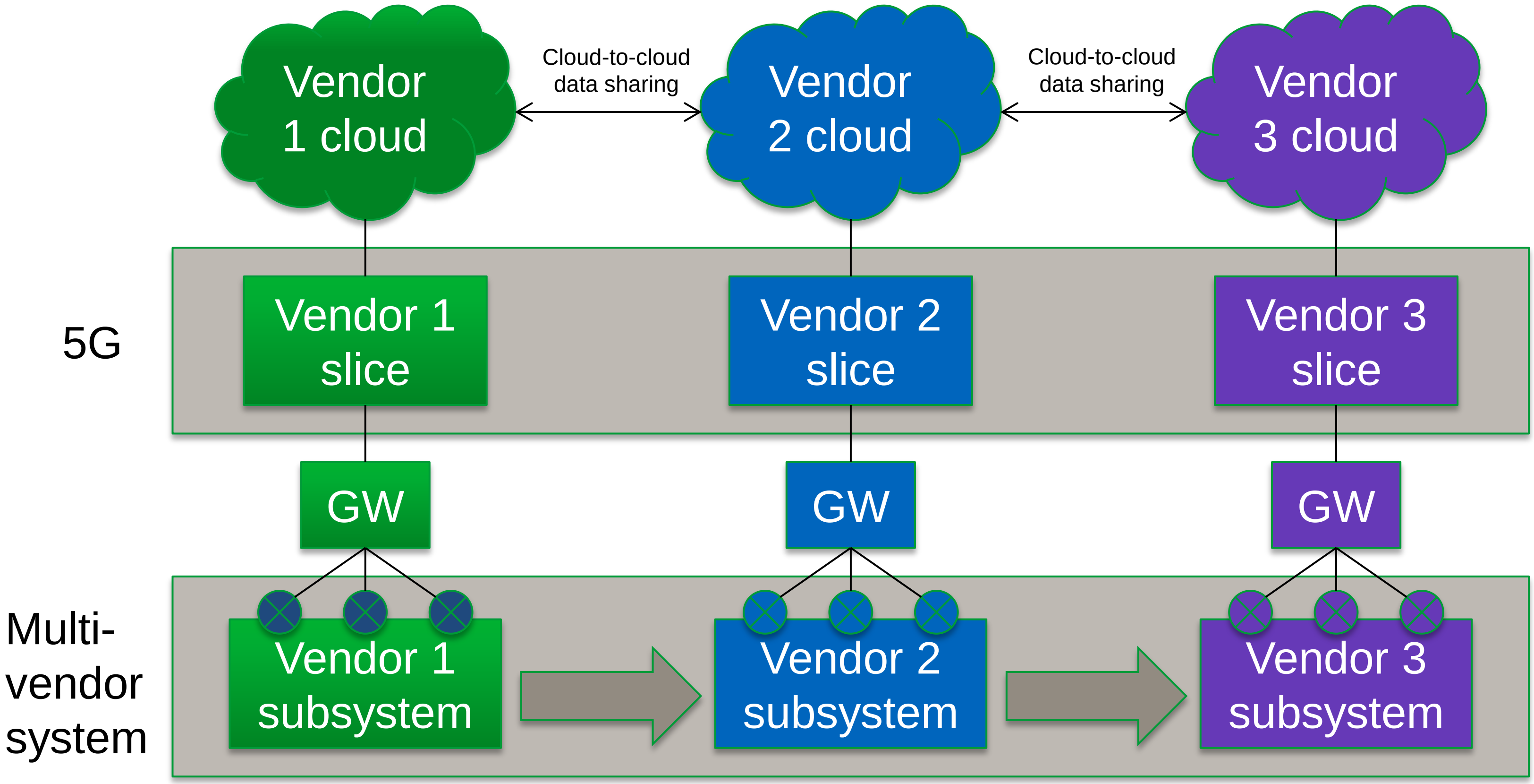


Open the sensor data of machines from a selected production line to boost operational innovations for all stake holders.

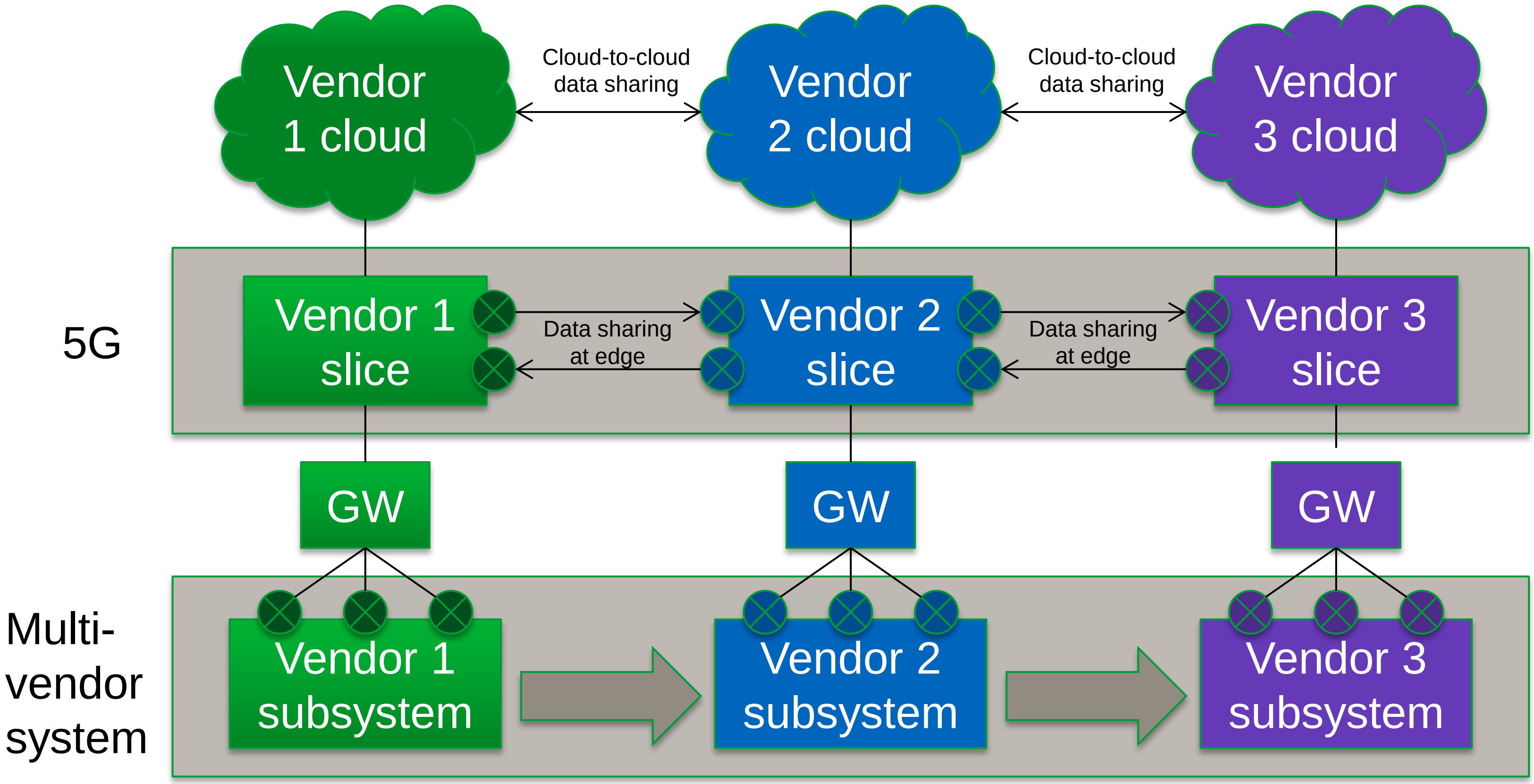
Present: Vertical silos



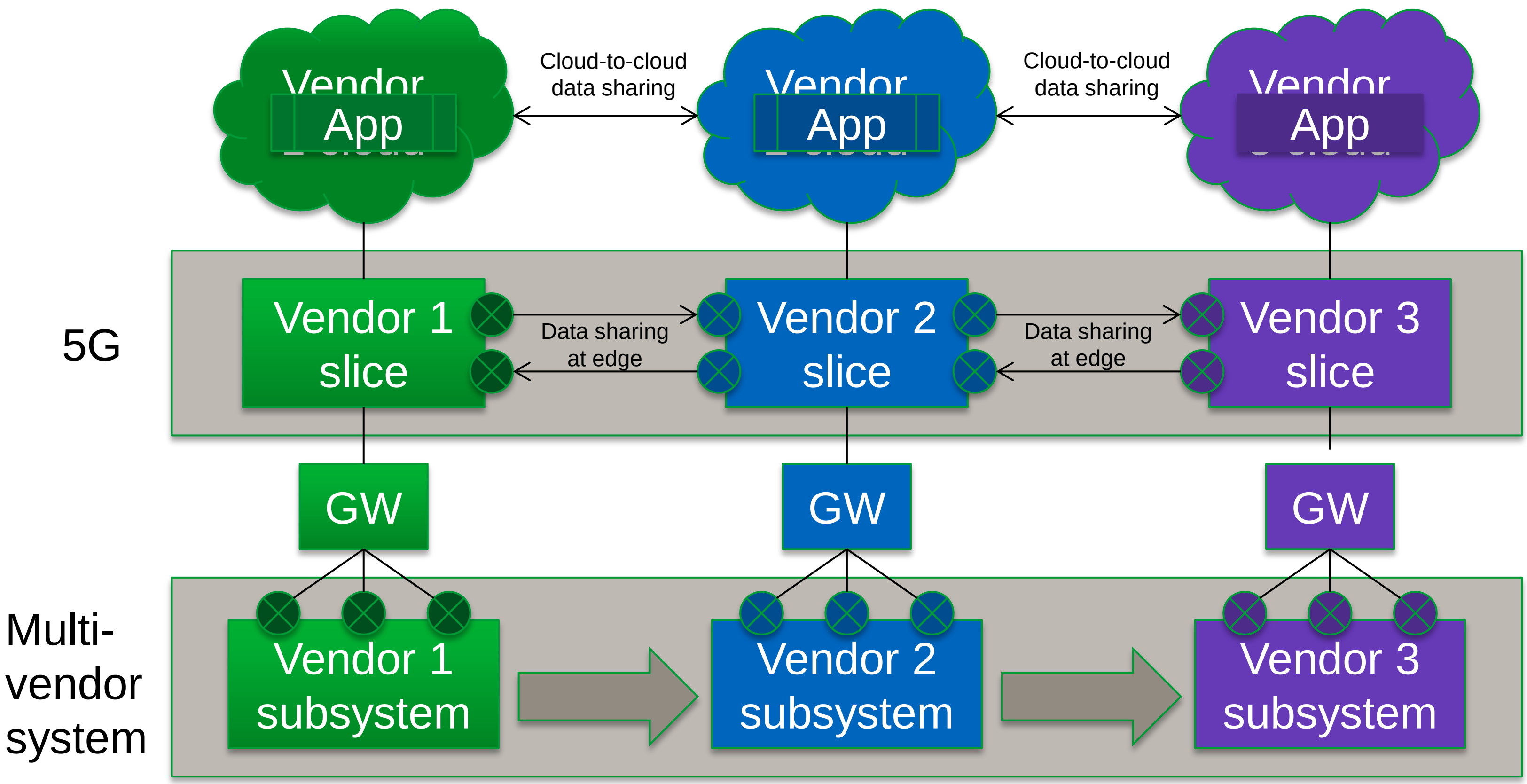
Future 1: Shared communications platform



Future 2: Shared communications platform with data sharing at edge



Future 3: Client applications at edge



5G@ll Project

Aalto University

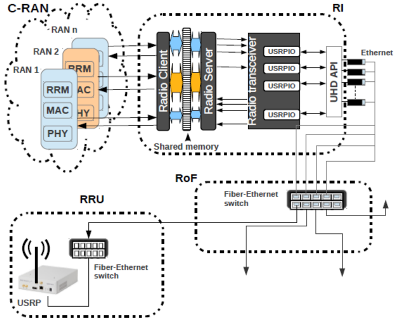
5G@II project

- Create a management system embedded in the 5G architecture that will support
  - secure management of the smart devices
  - scalable and secure data collection and storage on the basis of 5G network slicing
  - policy-based digital contracting, digital service creation and management
  - trustworthy data sharing using models rather than data itself.
- Pilot the system by combining the AIIC platform http://aiic.aalto.fi/en/ and TAKE-5 experimental 5G network (http://take-5g.org/) and running concrete experiments based on industrially relevant use cases.

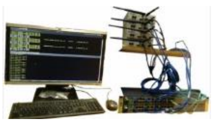
TAKE-5

5G research platform @Aalto

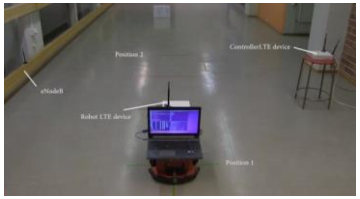
- Aalto TD-LTE testbed
  - Implementation of TD-LTE tesbed (Rel. 8) on general purpose processors and non-real-time operation system
    - Over 30 000 lines of C++ code
    - PHY and limited set of RRC and MAC functions
  - Cloud-RAN setup
    - Base station can run on virtual server
  - Flexible spectrum use
    - Can interact with Farispectrum geo-location data base
    - TVWS operation
  - DAS implementation
    - Antenna port selection
    - Open loop transmit diversity
  - D2D implementation
    - Network controlled D2D
    - Reliable D2D links
    - Underlay with IC
    - Mode selection
  - MTC MAC implementation
    - Compressive sensing based MAC with IC



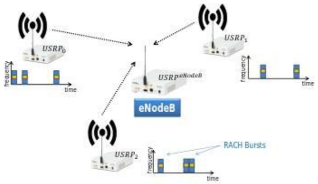
Cloud RAN architecture



eNodeB and RRU



D2D Robot control demo

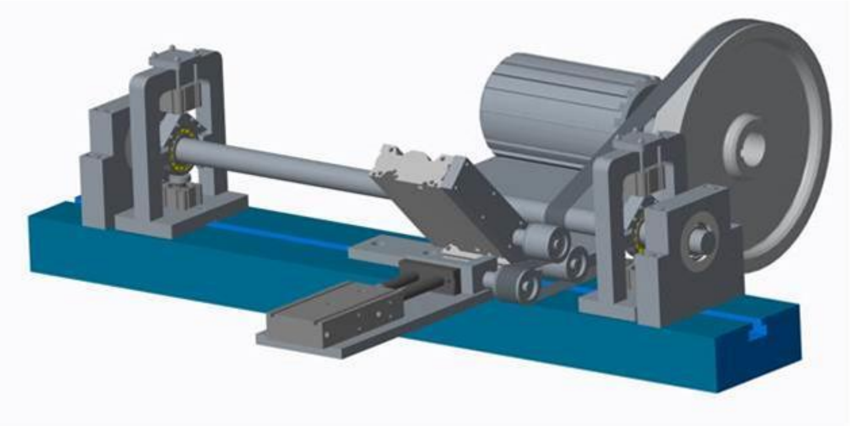


MTC MAC demo

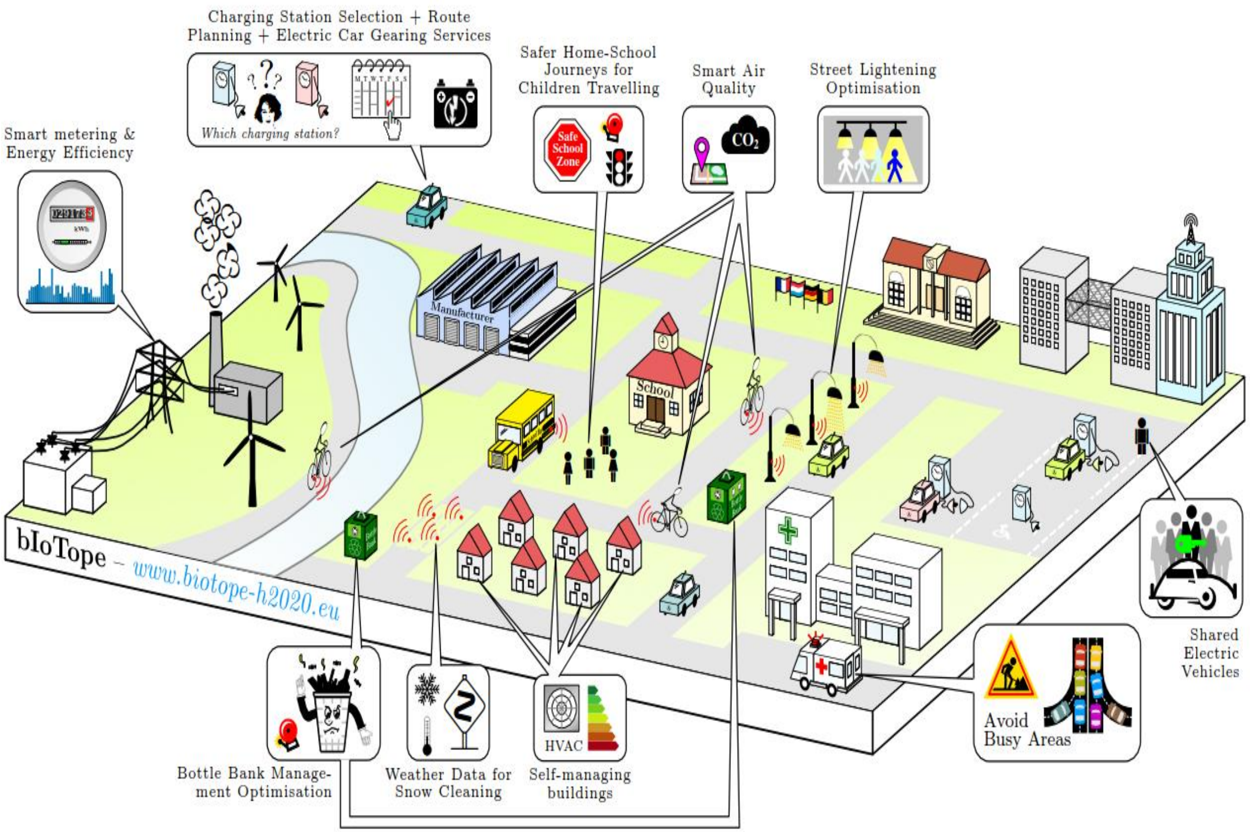
DAS demo

AIIC experimental platforms

- ABB: IoT instrumentation for a research apparatus for studying magnetic bearings
- Konecranes: Smart crane with extensive PLM models and IoT interfaces
- ABB et al.: Process control lab with several IoT-enabled unit processes
- ACRE: Digital campus



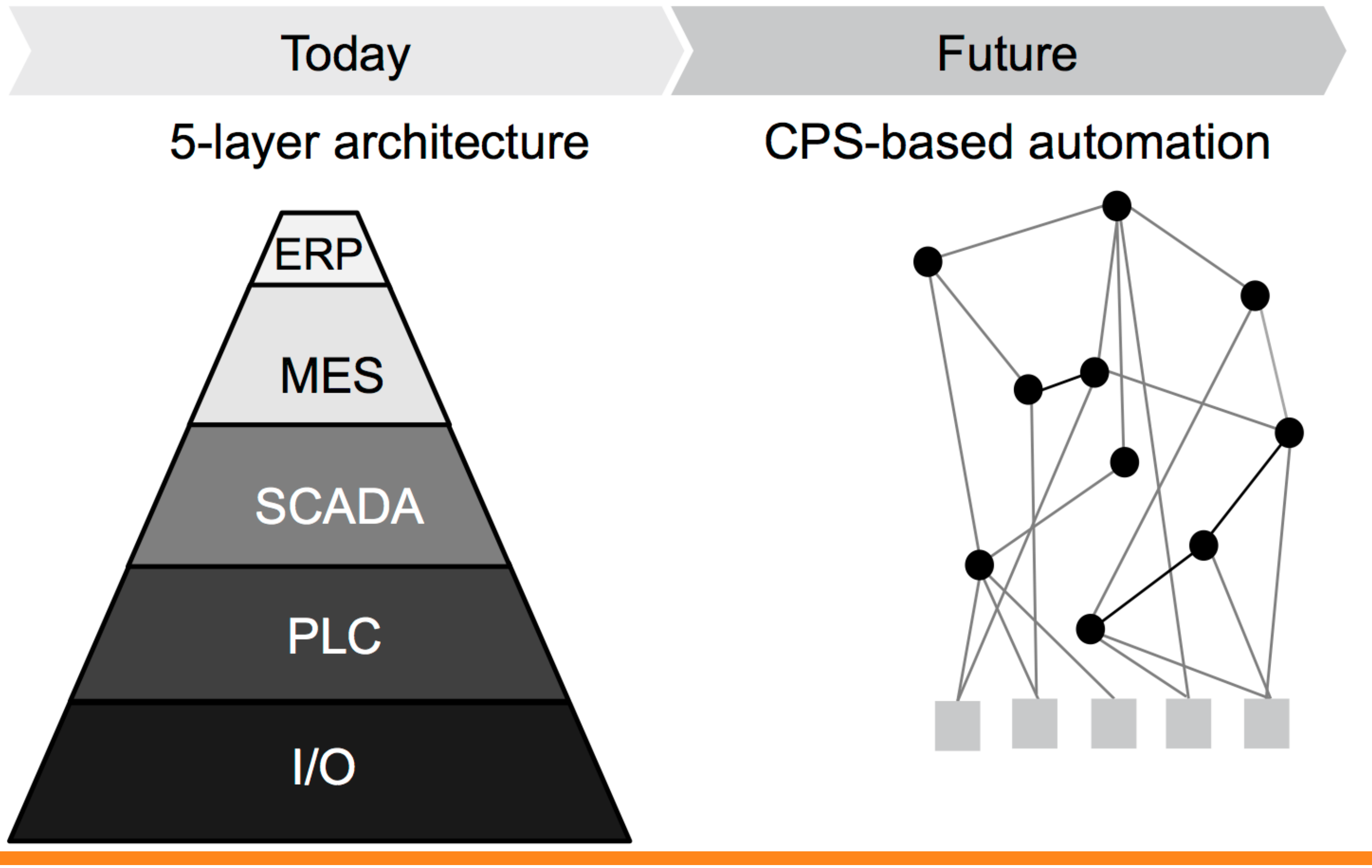
Digital campus: bIoTope project



Nomenclature

- “Factory”: shorthand for various kinds of production sites or pieces of physical infrastructure with a variety of equipment organised and managed as a whole
- “Equipment”: individual pieces of production equipment inside a factory, presently typically organised and managed with a hierarchical control structure (ERP, MES, SCADA, PLC)
  - With Industrie 4.0, the fixed hierarchical control may be replaced by a more flexible network of “components”
  - This opens the door for more flexible and agile control architecture (“control by cloud, and without ownership”)

From 5-layer architecture to autonomous cyber-physical systems



Data

- Production management data: Data on the material flow (inputs and outputs) through the factory and its equipment
- Control data: Used to control the direct operations of a factory and its equipment
- Diagnostic data: Used to monitor the performance of the operations of the factory and its equipment
- Engineering data: Lifecycle engineering data on the factory and its equipment (incl. design data, configuration data, maintenance histories, data on embedded software where relevant)
- Orthogonal categories of the above:
  - Personal data: Data related to persons operating the factory
  - Company data: Data related to the identity of the stakeholder(s)

Stakeholders / domains of governance

- Factory “owner”
- Factory operator (if distinct from owner)
- Shop floor operator
- Equipment provider
- Supplier(s) and customers
- Service providers
  - Incl. maintenance, engineering services
- Regulators, certification authorities
- Financial institutions
- Public domain

Use cases

- Factory control
  - Local / remote
- Factory monitoring
- Fleet management
- Digital twin
- Intelligent mobility

Factory control

- Enable control of factory equipment for industrial process optimization
- Local: E.g., private 5G network inside factory site
- Remote: E.g., network slice for data transmission between different production sites and other parties
- Stakeholders:
  - Factory owner: needs full access
  - Equipment providers: must grant access to the control features

Factory control

- 5G issues
  - Spectrum management
  - Latency (Especially to enable “remote control” by leveraging cloud-based approach)
    - On-demand provisioning of some "control" features at the edge of the network
  - Dynamic network and service chaining
  - Robustness and availability
  - Cyber security
  - Lifecycle management
    - New equipment, new control software versions, …
    - Esp. scenarios where equipment from many vendors needs to be managed and controlled in a single system

Factory monitoring

- Provide data for monitoring the performance of the factory and its equipment
  - (Some) control data, diagnostic data
  - Collect historical performance data for analysis and assessment
- Stakeholders:
  - Factory owner: full view
  - Equipment provider: partial view related to the specific piece of equipment (plus potentially relevant other data related to the use context) -> **fleet management**
  - Other stakeholders: e.g., regulative body, financial institution, factory supplier, factory customer, factory service provider

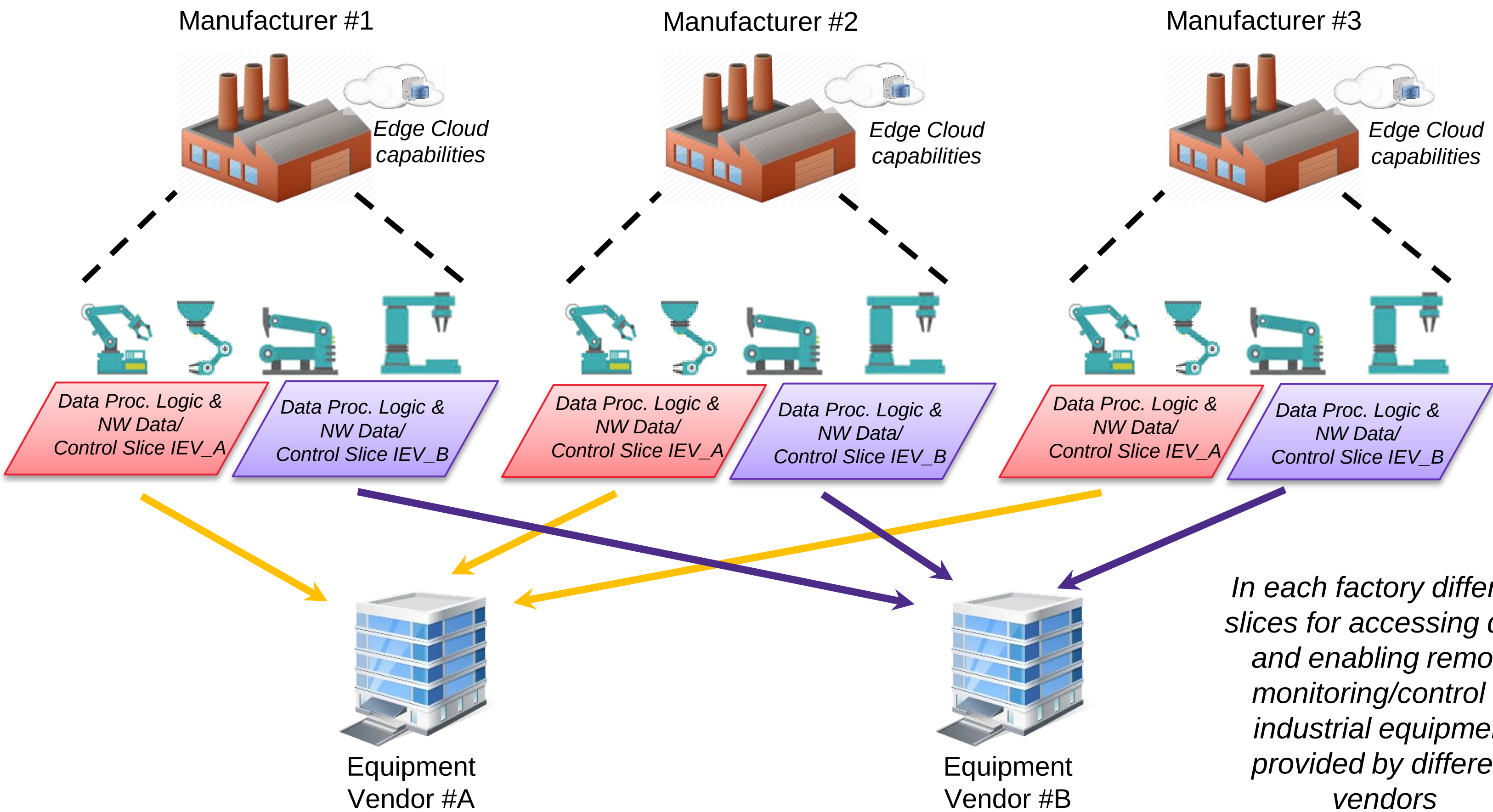
Factory monitoring

- 5G issues
  - How to provide several parallel views to the underlying factory data flows corresponding to the needs of various stakeholders and respecting the confidentiality requirements of each?

Fleet management

- Remote management of equipment by its provider
  - Diagnostics / predictive maintenance: Collect diagnostic data for fault prediction and assessment, guide maintenance operations
  - Life-cycle engineering: Collect diagnostic data to study how the operations can be improved by better design, optimising the control, improving the product configuration via some update, etc.), design and deploy updates
- Stakeholders:
  - Equipment providers: access to relevant data from installed base
  - Customers: need to grant access to relevant data
- 5G issues
  - How to provide access to all installed equipment on the field while respecting the confidentiality requirements of the customers?

Remote monitoring / fleet management



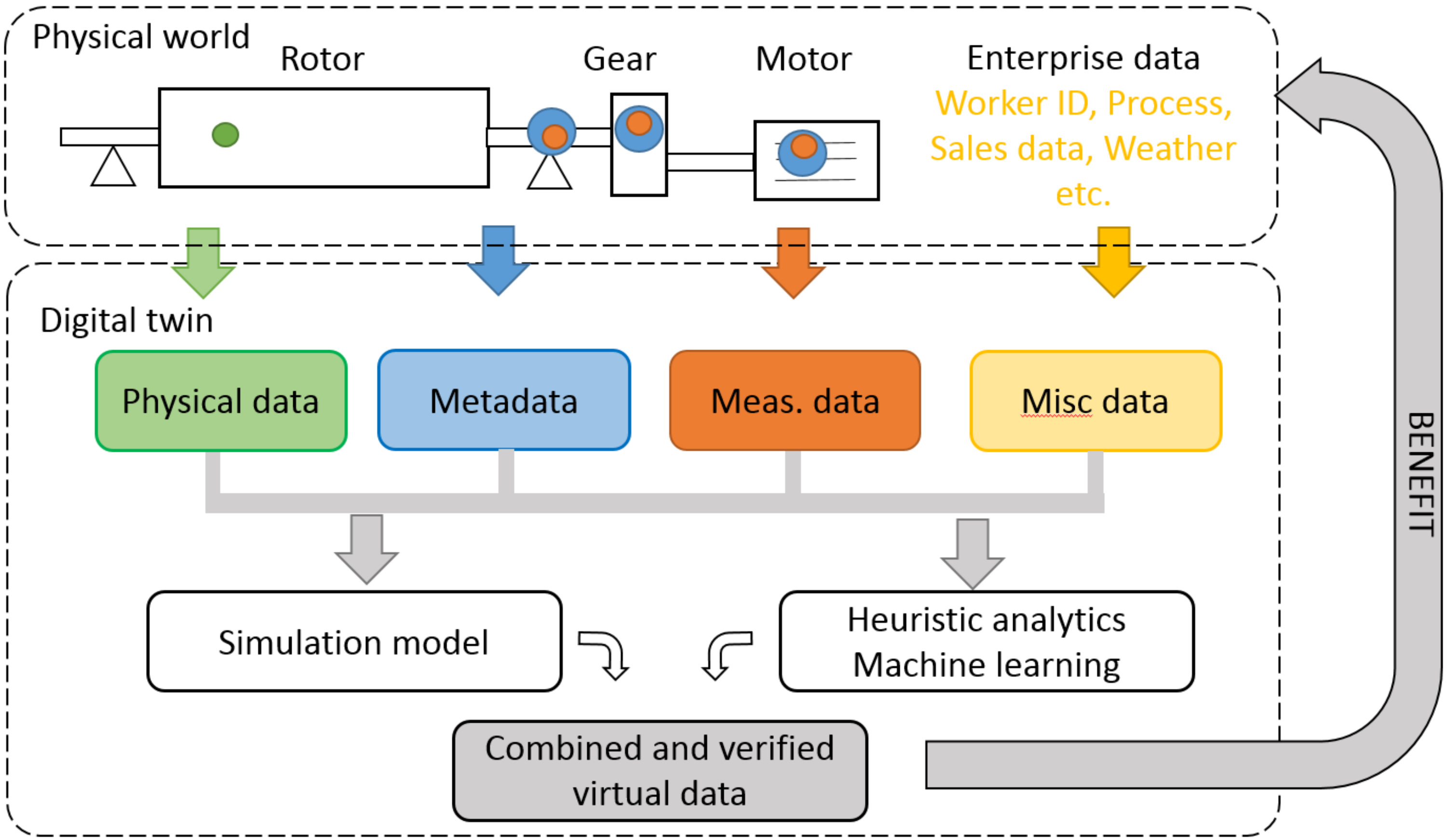
In each factory different slices for accessing data and enabling remote monitoring/control of industrial equipment provided by different vendors

Picture credit: Ivan Ferris & Tarik Taleb

Digital twin

- Build and maintain a comprehensive data repository representing a specific product instance across its whole lifecycle (design, manufacturing, installation, use, demolishing/reuse), e.g.
  - Rich design/engineering data such as simulation models and design rationales
  - Maintenance history
  - Time-series data of embedded sensor readings

Digital twin



Intelligent mobility

News & Events

Henry Ford Trust and Aalto University to cooperate on smart traffic research

LISTEN

02.06.2017

A networked traffic system offers possibilities to streamline traffic safety, mobility services, and traffic, especially in urban environments.

Henry Ford Trust will support Aalto University's research project on smart traffic with a four-year funding. The extent of the whole project is about 700 000 euros, of which the trust will now fund the first year and the purchase of a research car. When realised in its entirety, the trust's funding enables three four-year doctoral theses on the field of smart traffic.

The trust also annually awards grants for several Master's and other theses.

"Aalto University's interdisciplinarity is a strength in researching future technologies and their applications. The study of smart traffic and mobility is closely tied to digitalisation, new energy solutions, and built environment, which are our strengths", says Dean **Gary Marquis**.

"Committed research, building networks, international cooperation, and systematic utilisation of information multiply the effectiveness of the investment", states **Hannu Pärssinen**, the chair of the board of Henry Ford Trust.

Use cases vs. AIIC experimental platforms

	Smart crane	Process plant	Building mgt
Factory control	M2M scenarios with strict latency requirements	Remote control scenarios with strict latency requirements	System-level control of devices from multiple vendors Equipment life-cycle management
Factory monitoring /fleet management	Managed access to relevant data to the equipment provider Partial access to relevant data to other stakeholders	Managed access to relevant data to the equipment providers	Managed access to relevant data to the equipment providers
Digital twin	Data integration scenarios including sensor data	On-line simulation & control scenarios	On/off-line simulation and control scenarios

Comments and questions welcome!