Aalto University
School of Electrical
Engineering

OPC UA Field eXchange
Industrial Internet of Things

Information systems in industry
ELEC-E8113

Start at 12.15!

Contents

- **OPC UA Field eXchange**
- **Industrial Internet of Things (Industrial IoT, IIoT)**
- **OPC UA in Industrial IoT and Industry 4.0**
- **Example from research**

Rationale of the lecture:

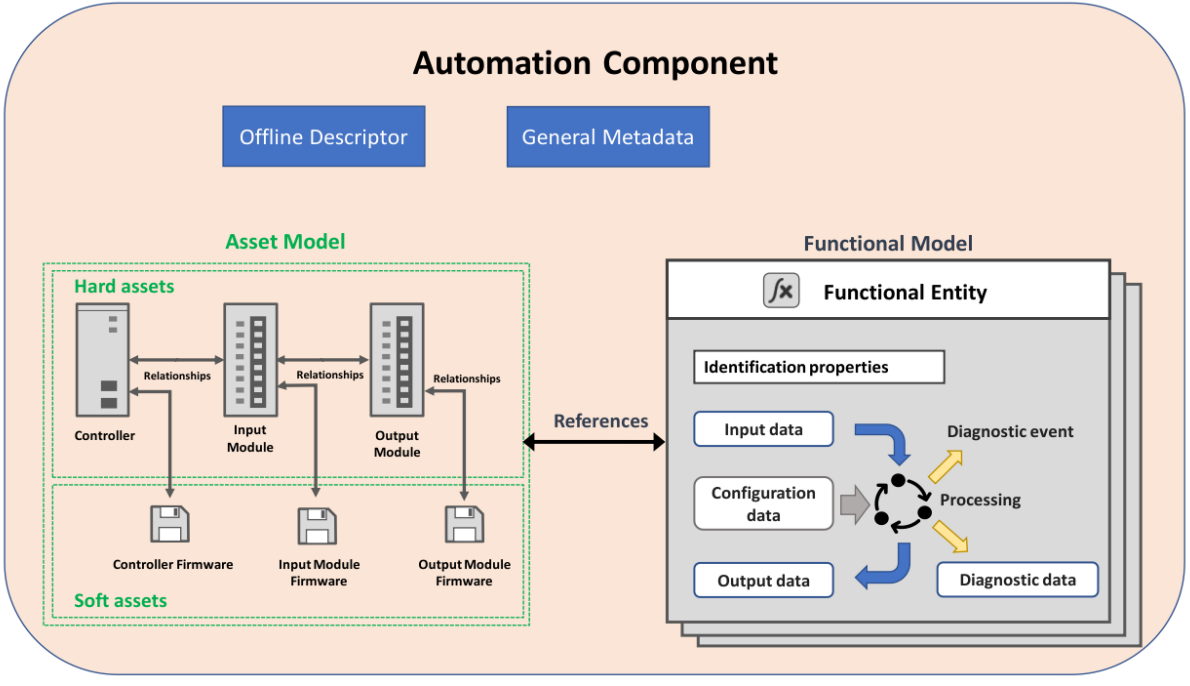
Industrial Internet of Things presents the idea that industrial things (devices, products, etc.) would be accessed through the Internet communication techniques. The idea is actually not new but the scale of this practice is expected to increase. Again, we might follow SOA and use OPC UA while doing this.

OPC UA Field eXchange

- **Specifies OPC Foundation's optinion how OPC UA is intended to be used within automation**
  - NOT quite ready yet!
  - Now: Controller-to-controller
  - Later: Controller-to-device, device-to-device
  - FX Information Model
  - Communication within automation (PubSub)
  - Communication with offline enginering (Client-Server)

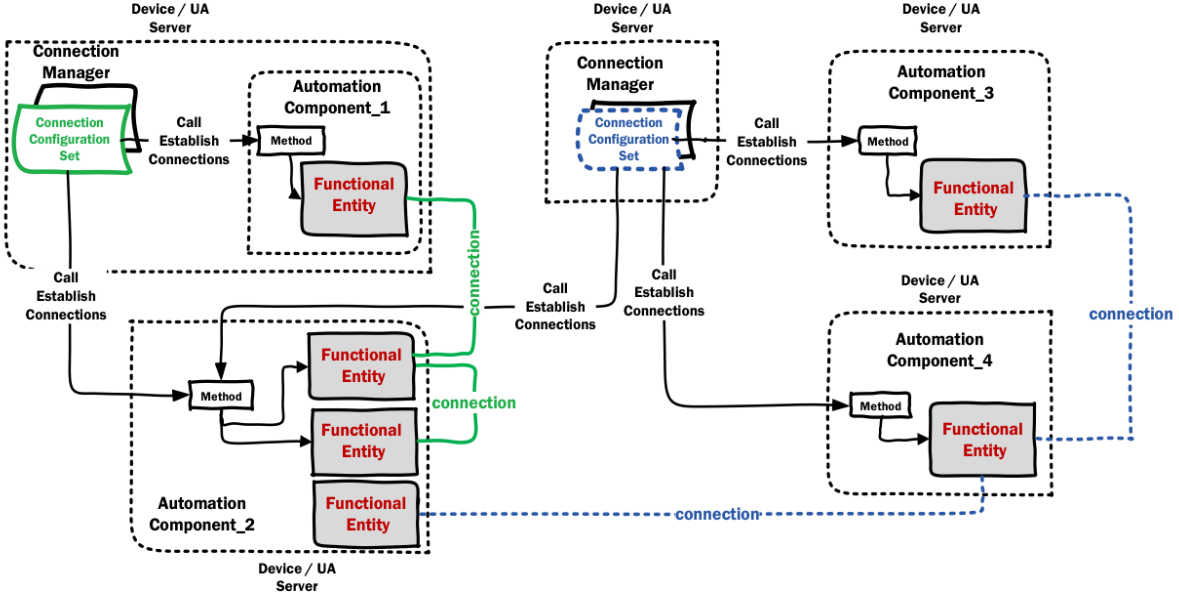
OPC UA FX Information Model

- **Automation component model**
  - Asset model
  - Functional entity model
  - And references between them
- **Detailed model of automation functions in other information models!**



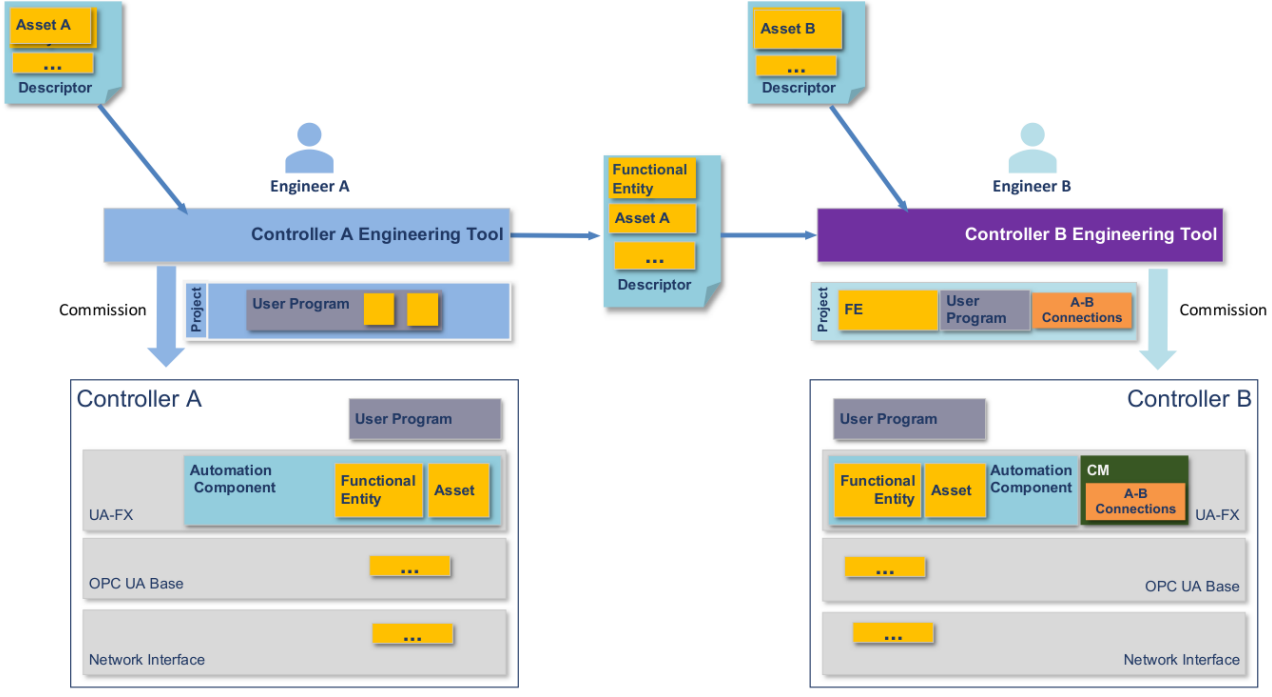
Logical connections

- Connection managers for configuring communication connections between devices / UA servers
- Connections are PubSub
- TSN or not

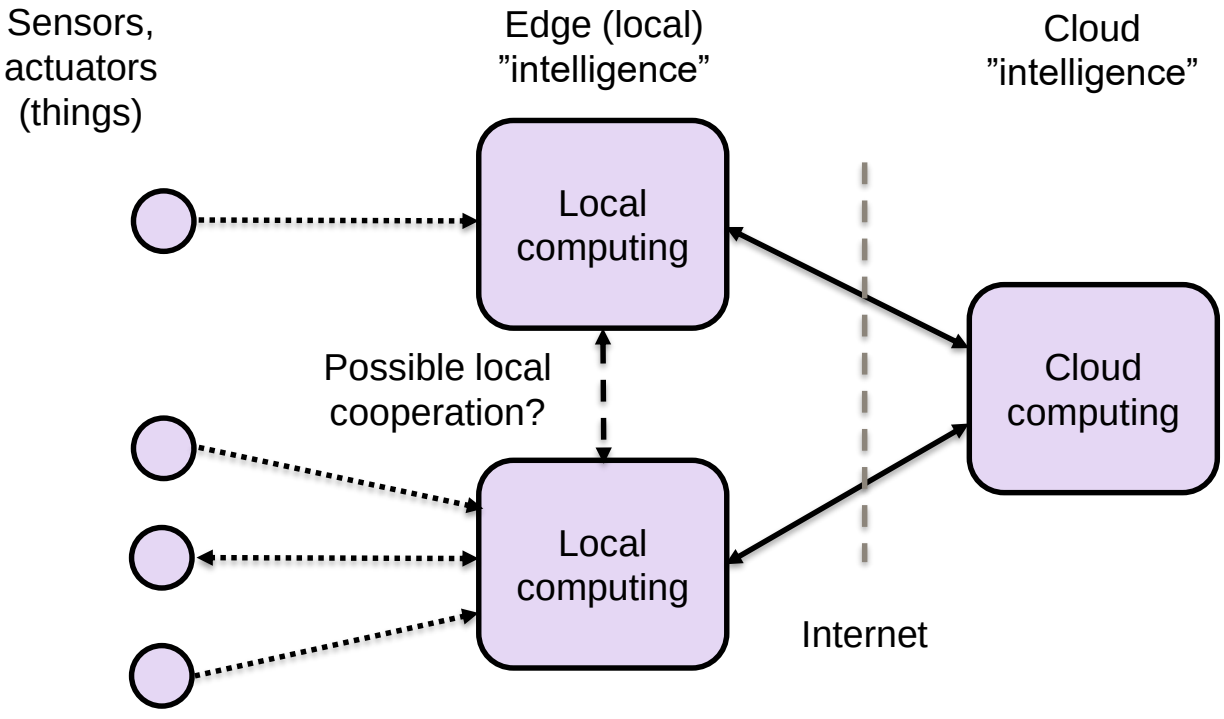


Offline engineering

- **Interoperability between different engineering tools through descriptors**
  - AutomationML
- **Deployment of automation applications through file upload**
  - AutomationML
  - OPC UA file transfer



Situation

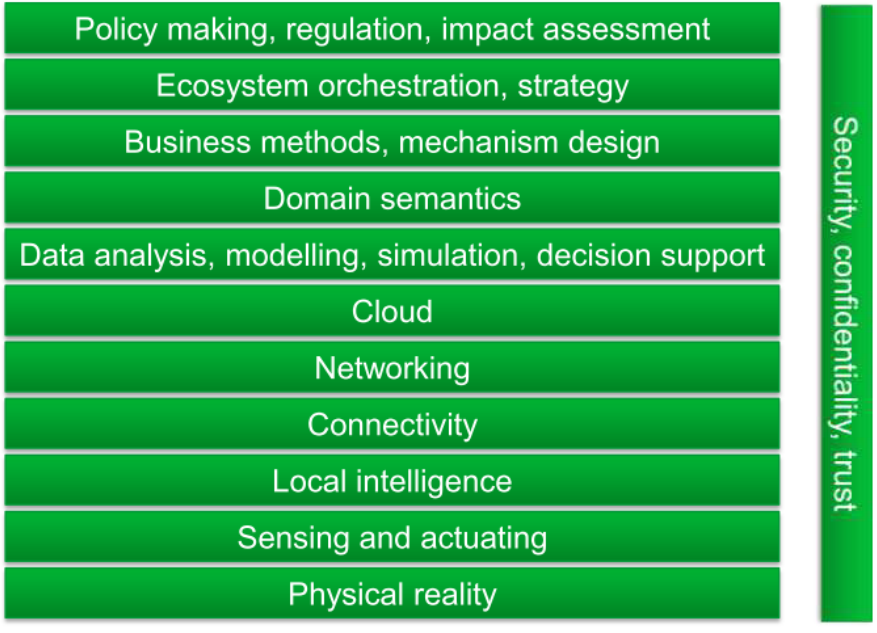

Sensors, actuators (things)
Edge (local) ”intelligence”
Cloud ”intelligence”
Local computing
Possible local cooperation?
Local computing
Cloud computing
Internet

Basic concepts

- **Internet of Things (IoT) refers to the idea of having physical things with sensing or actuating, computing and communication capabilities, which enable them to communicate with each other and with information systems using Internet protocols**
- **Industrial Internet (of Things) is a related and overlapping concept emphasized by industry in which the things that have a role in industrial business processes, e.g. sensor, product, part, device, machine, etc., are connected to the Internet**
- **Cyber-physical system (CPS) is a system containing interconnected cyber (IT) and physical parts**
- **Internet of Services is, again, a related concept that extends SOA to the IoT. Some of the services might then be provided by “things” or CPS.**

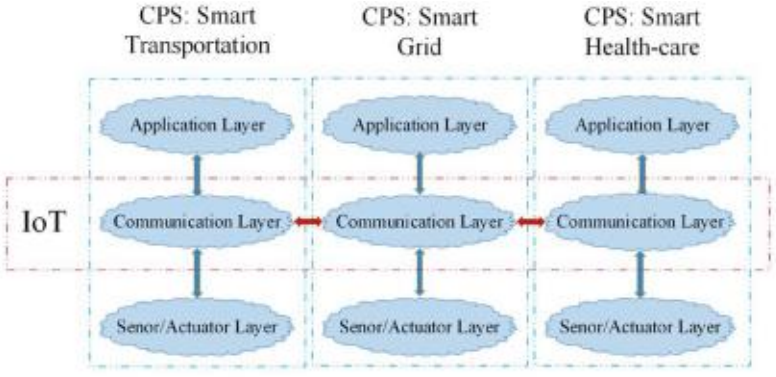
IoT digitalization stack

- At an abstract level IoT may be described with a digitalization stack, in which lower levels enable the higher ones
- IoT applications span to several layers
- Developments at the lower levels may introduce even radical changes at the upper levels
- Security, confidentiality and trust are present at all layers
- Scope is changed from companies and LANs to supply chains and the Internet



Three layer model of IoT

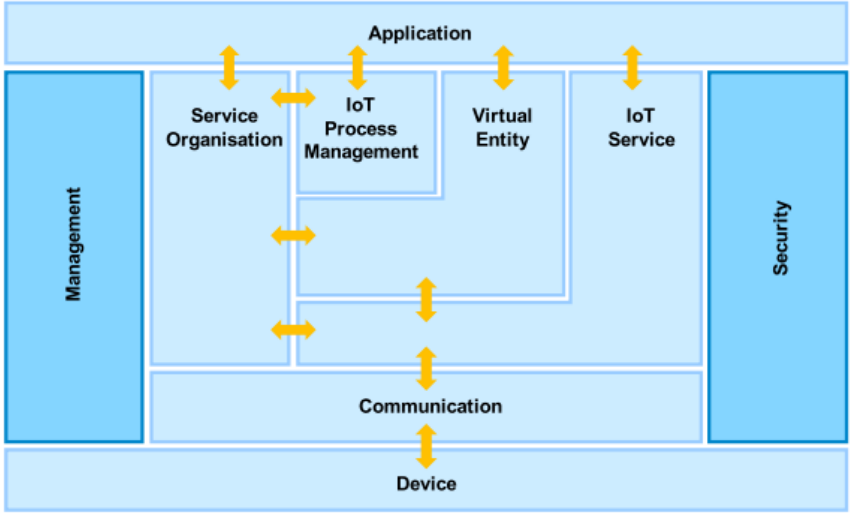
- **An even more coarse model of the architecture of the IoT consists of three (or four) layers:**
  - Perception (or sensor) layer provides access to the data of the things
  - Network (or communication) layer enables data transfer between the things and applications
  - Application (or business) layer provides applications utilizing data from things for business benefit



- Service layer can be added between the application and network layers providing applications access to the data from the things through services according to SOA

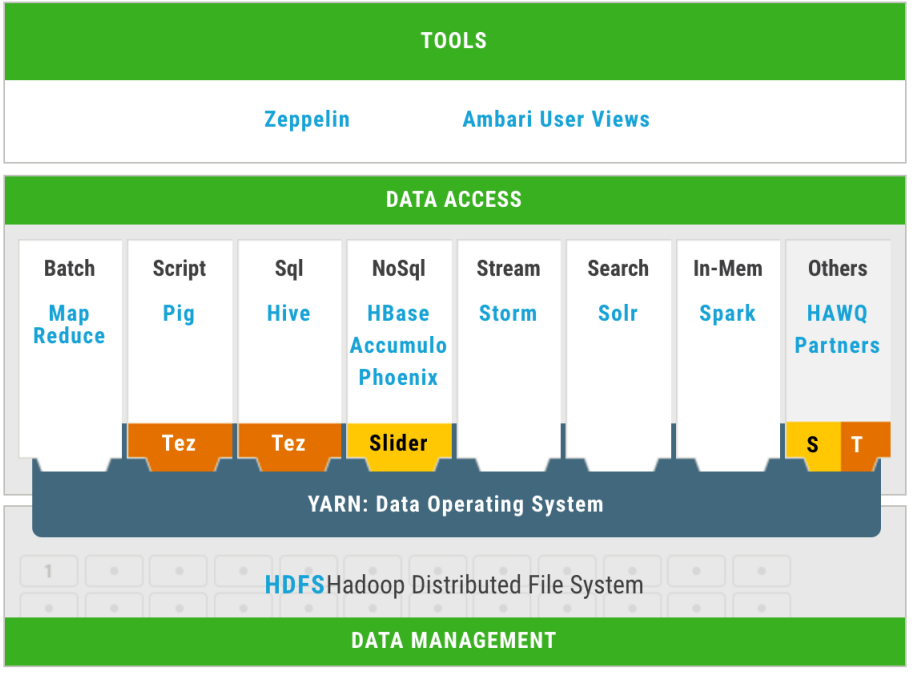
Service layer: SOA for IoT

- **Essential parts of SOA for IoT are IoT Service and Virtual Entity**
- **IoT Service enables discovery, management and communication with things.**
  - Interface to IoT middleware.
  - Vs. OPC UA Server
- **Virtual Entity is a service interface of a thing and enable other services to interact with it.**
  - Id, type, attributes, services
  - Vs. OPC UA objects and types



IoT technology: cloud platform and IoT middleware

- IoT applications often are run on cloud platforms providing PaaS services, particularly data storages
- Data is collected through IoT middleware with possibly multiple messaging services
- Historian in the cloud is a typical application (public, private, in between)
- Integration from things to cloud and potentially between cloud applications



Network layer: Messaging

Protocol	Transport	Conversation	QoS	Security
REST	HTTP	R/R	No	HTTPS
CoAP	UDP	R/R	Yes	DTLS
XMPP	TCP	R/R, P/S	No	TLS/SSL
MQTT	TCP	P/S	Yes	TLS/SSL
AMQP	TCP	P/S	Yes	TLS/SSL
WebSocket	TCP	R/R, P/S	No	TLS/SSL
DDS	UDP, TCP	P/S	Yes	DTLS

R/R = request/response, P/S= publish/subscribe

Big data

- Volume of data is very large. No single hard drive is enough.
- Velocity of data updates is fast due to large volume. Something is updated all the time.
- Variety of data refers to large number of different data types.
- Veracity which means the unknown trustworthiness of data
- Value (importance) of data is not necessarily known when it is observed

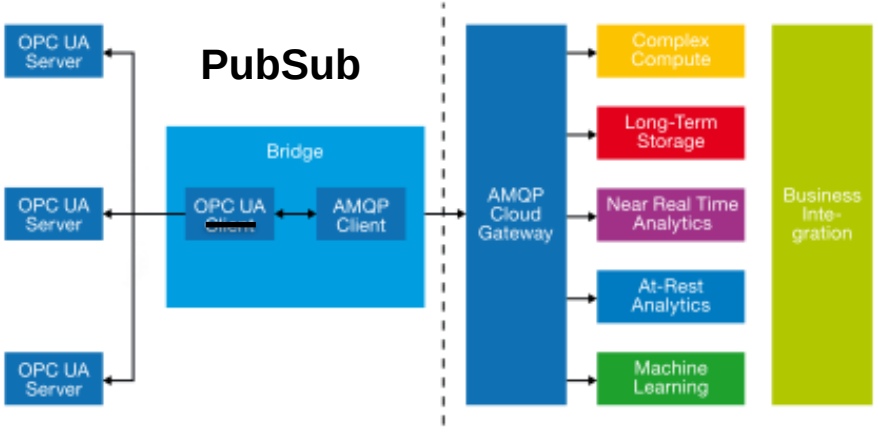
- Data collection defines what data is collected, from where, when, in which form and where it is saved.
- Data storage defines how data is stored for analysis. SQL is a common query interface.
- Data analysis defines how new data is created from collected data. Faster analysis require immediate response. Slower analysis is looking for longer term trends.
- Visualization for human users in an easily understandable form.

Utilization of data

- **IoT offers a possibility to develop new services utilizing the data about observations from anywhere in a supply chain, provided one can access and trust the observations, e.g.**
  - Observe, forecast and classify status of products, parts, materials in a supply chain during deliveries
  - Traceability of products in a supply chain after deliveries
  - Observe, forecast and classify status and condition of machines and devices
  - Observe, forecast and classify activities of customers, workers and partners
  - Analyzing a potentially very large set of observations
  - Observe, identify and communicate with other things
- **The question is how to create business value from the observations?!**

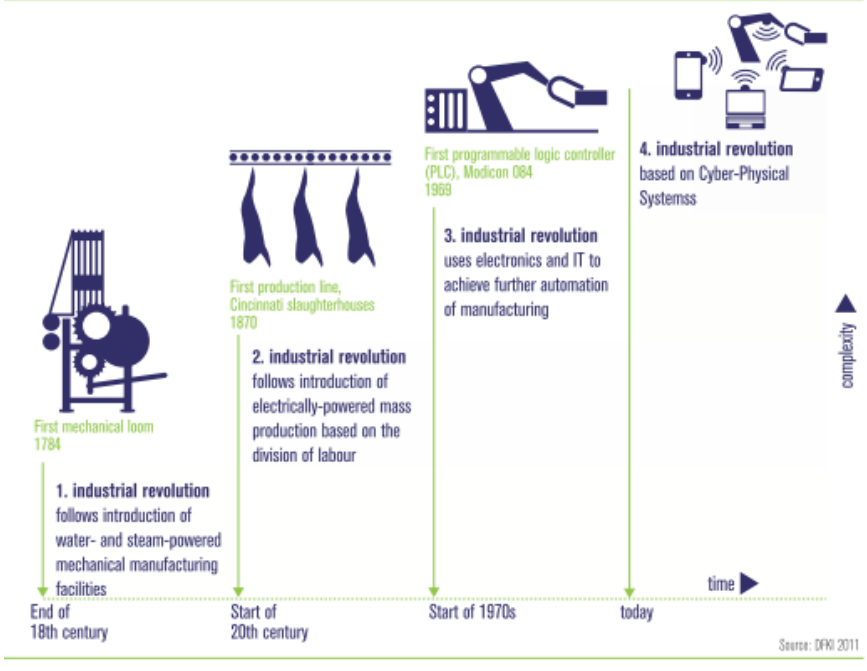
IoT and OPC UA

- OPC UA is a natural choice for a data service at an industrial plant (IoT for manufacturing)
- A combination of OPC UA and a message queue broker following the PubSub communication model can be used for data transfer between manufacturing sites and cloud services
- Configure what attributes of variables are in messages
- Bring the server information model to the cloud with OPC UA Cloud Library



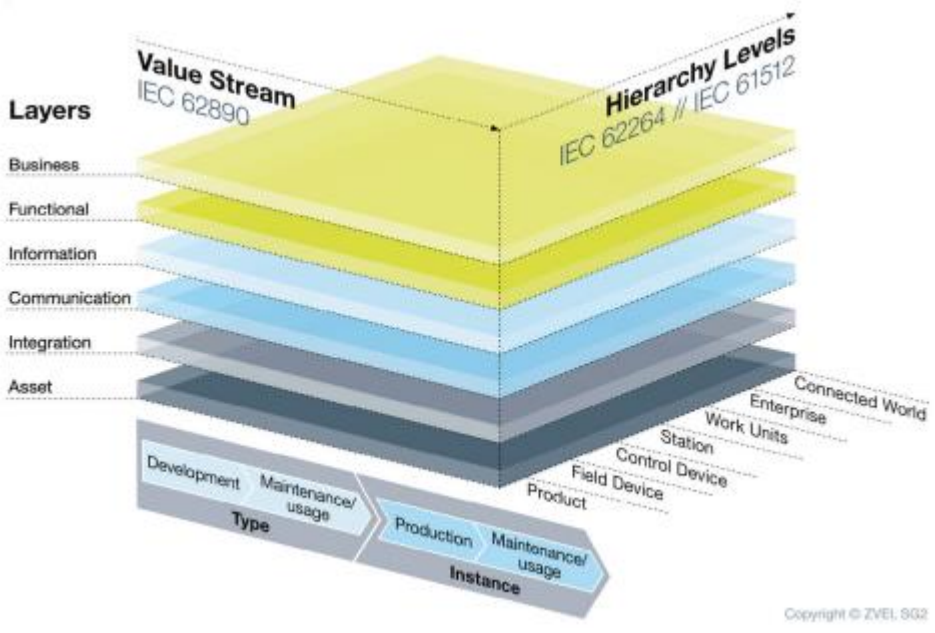
Industry 4.0

- **German research initiative that has influenced R&D elsewhere in Europe as well**
- **Priority areas of Industry 4.0:**
  - Communication infrastructure
  - Open standards
  - Management of complex systems
  - Safety and security
  - Work organization
  - Training and continuous development
  - Resource efficiency
  - Regulatory framework



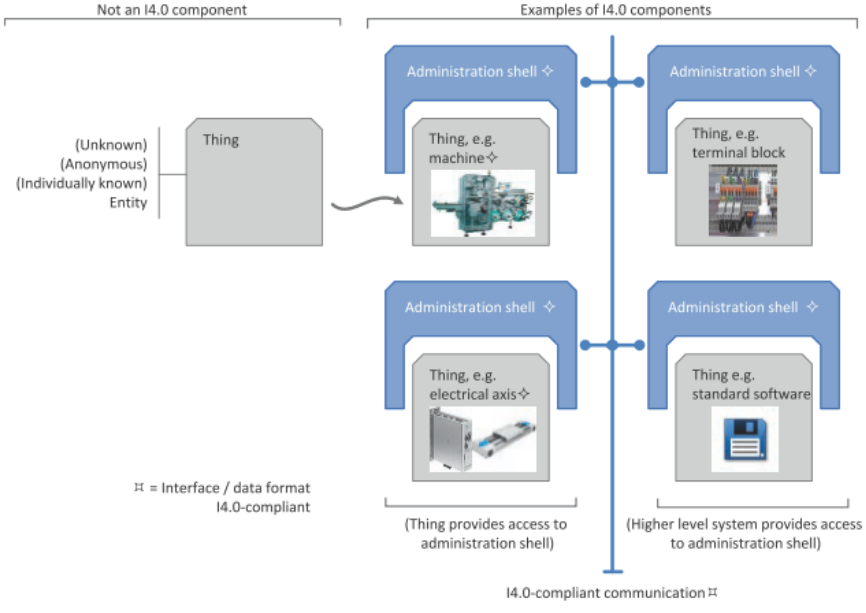
RAMI 4.0

- A reference architecture model of Industry 4.0 has been developed
- Integration of cyber-physical I4.0 components is being defined according to the reference model
- Standardized communication infrastructure
- Interfaces with formal definitions
- SOA, OPC UA and a few other standards are being adopted (work in progress?)



I4.0 components

- I4.0 components contain an Administration shell that turn industrial things into components of cyber-physical systems
- I4.0 components communicate according to SOA, through OPC UA and something else
- I4.0 components provide a virtual description
- I4.0 components follow I4.0 compliant standardized semantics (work in progress)



Example application: Mobile work machines

- Research project at Aalto EEA and partners
- Monitoring of the operation and condition of agricultural work machines
- Discovery of machines and communication to a cloud data storage
- OPC UA and REST as alternatives, message queues maybe in future
- Standardized semantics from ISO 11783 (ISOBUS)