From IoT to Digitised Production Automation

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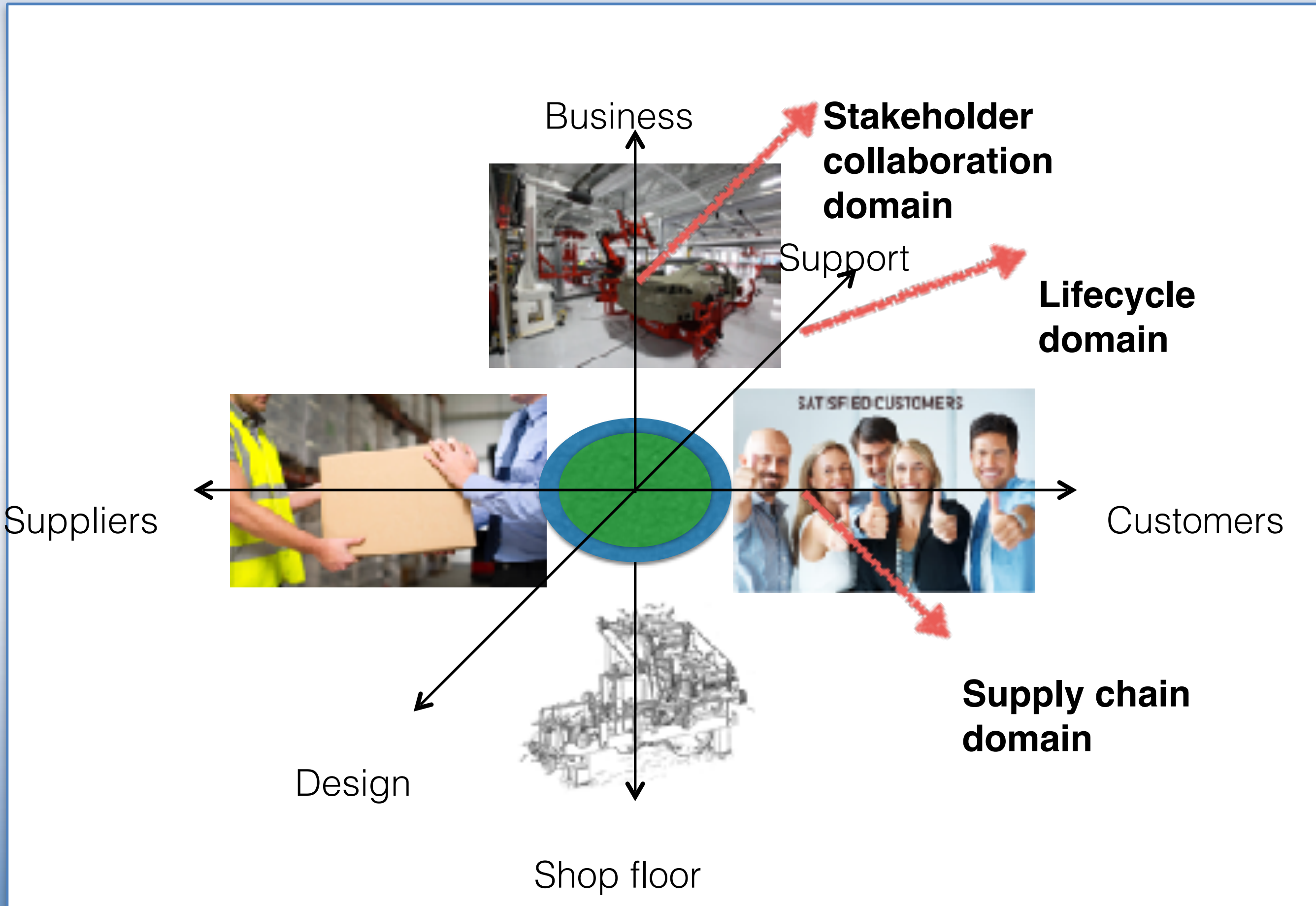
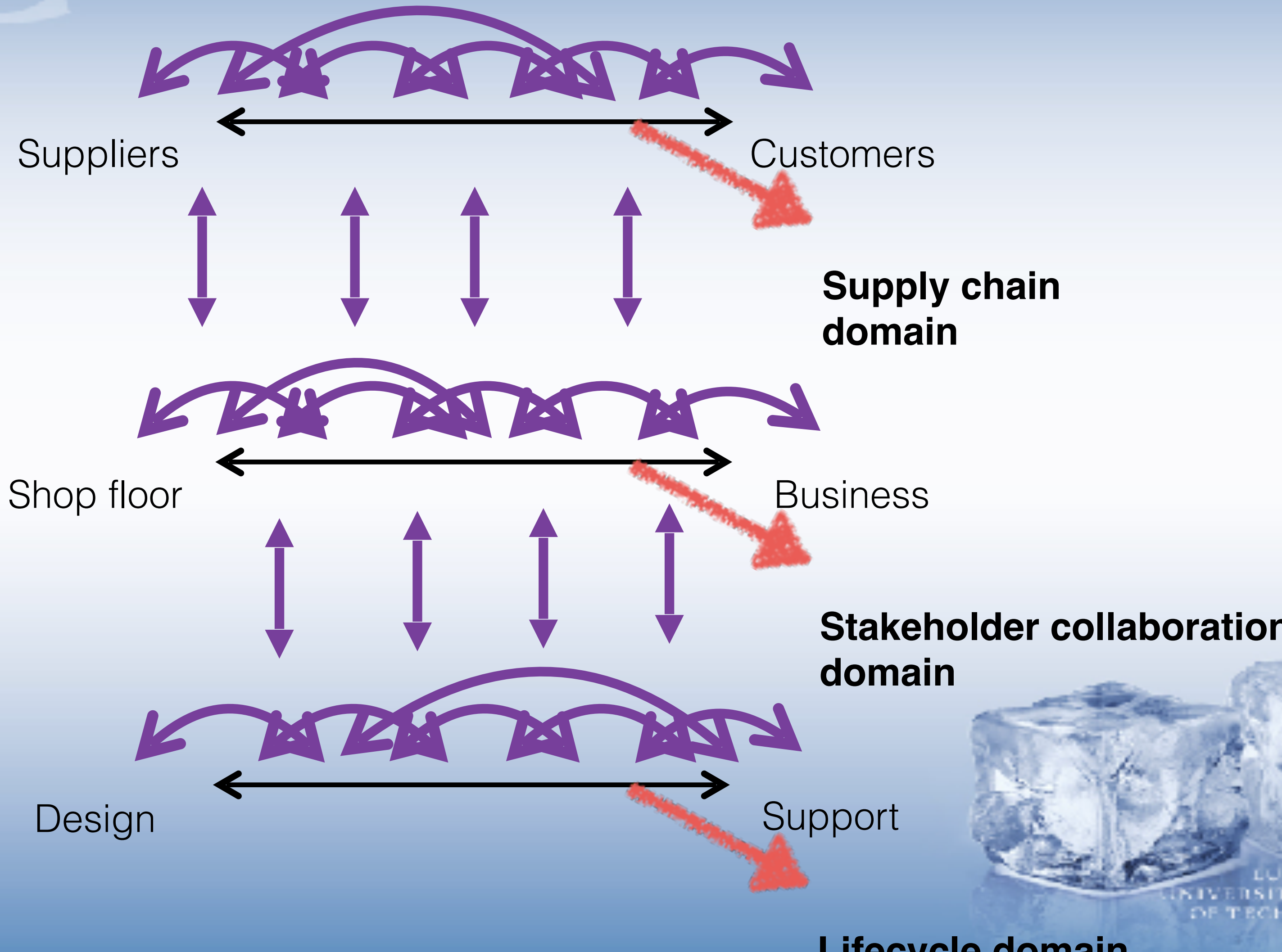
OF TECHNOLOGY

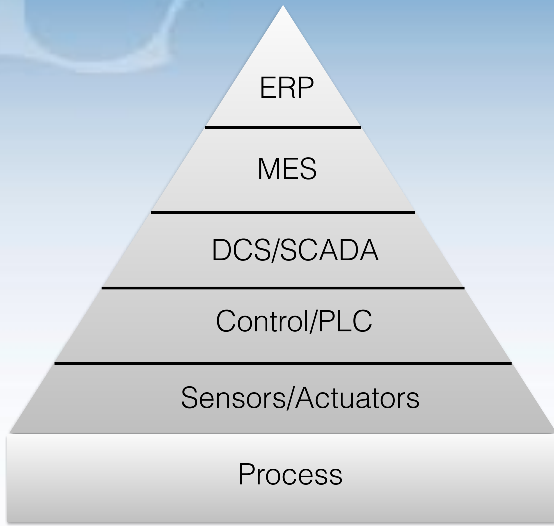
From enterprise to multi stakeholder operation



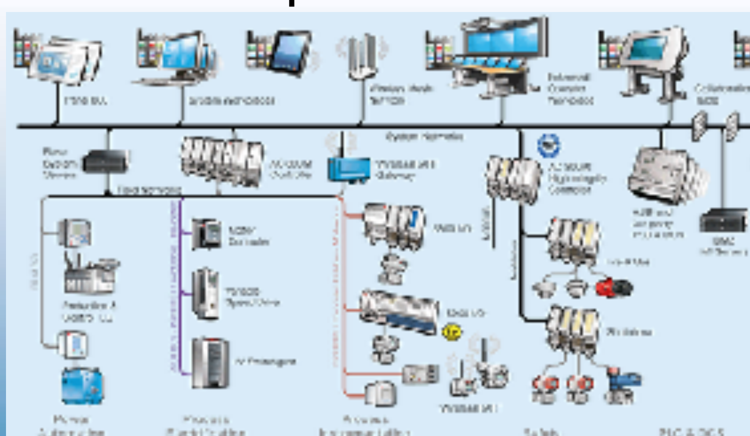
Information feedback enables improvements



ISA-95



Hierarchical system implementation



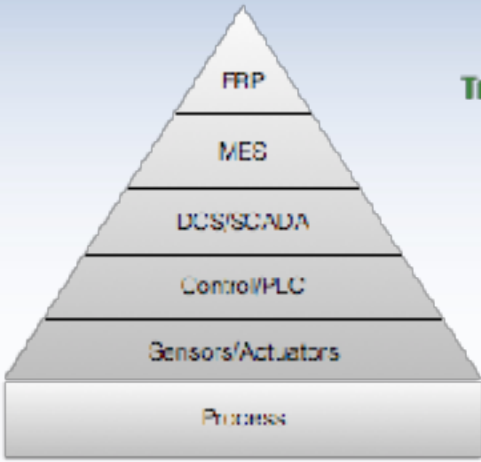
Current production automation

- Ridged pyramid
  - Inflexible automation
  - Cross layer dependencies
  - Low/No security

- Heterogeneous and incompatible networks
  - Industrial Ethernet
  - Fieldbus
  - Modbus
  - ASI bus
  - Hart/WirelessHart
  - 4-20 mA
  - ……

The automation technology transition

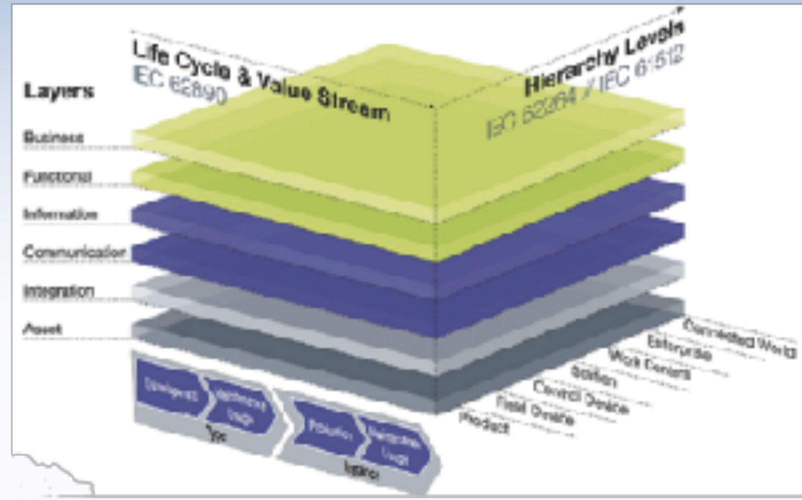
ISA 95



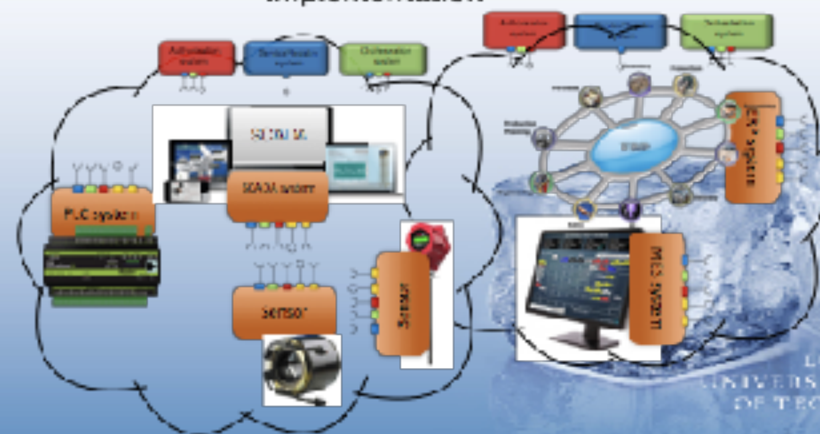
Hierarchical system implementation

Transition path

RAMI4.0



Local automation cloud implementation

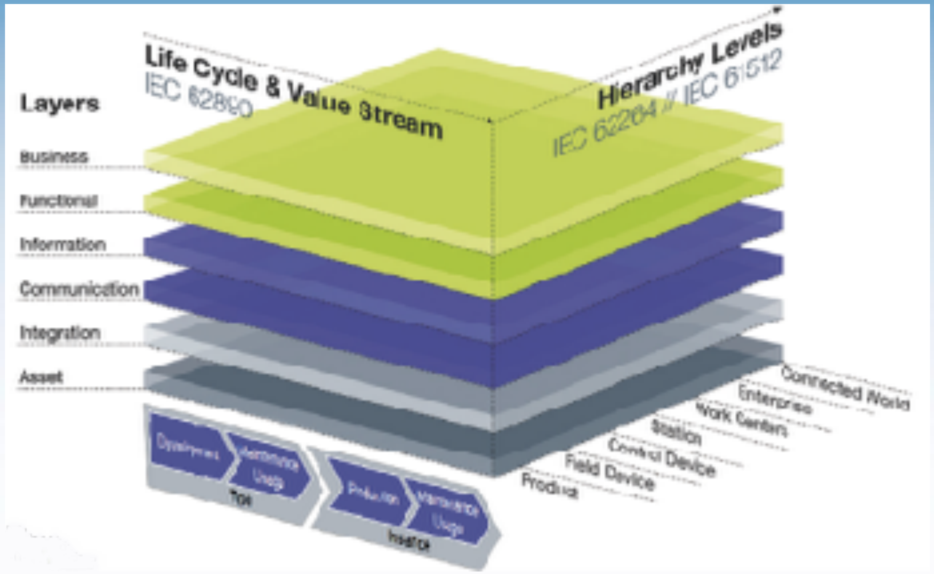


RAMI4.0

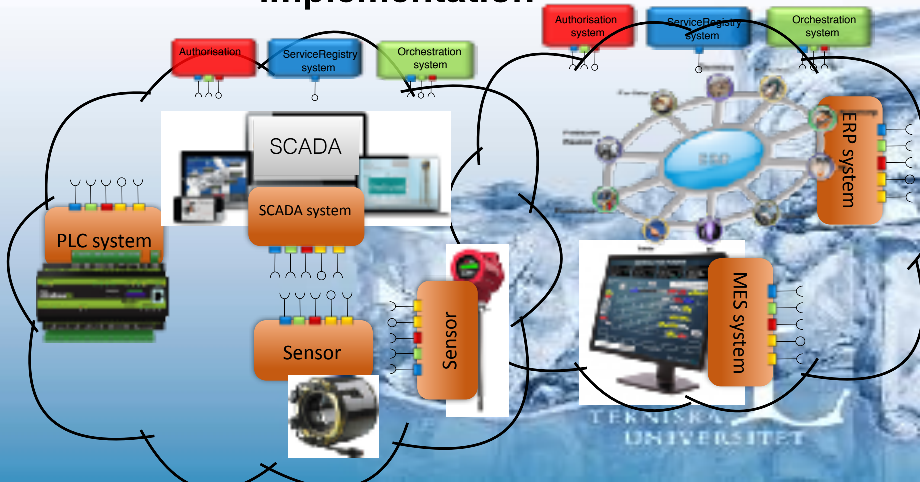
Digitised industry

- Dynamic digital industry
  - Changes in run-time
  - High security

- System of Systems - IoT based
  - Interoperable IoT's
  - Functionality management
  - Security management



Local automation cloud implementation



Digitalisation and Automation requirements

- Real time performance
- Engineering simplicity

- Interoperability
- Security and trust
- Safety
- Scalability
- System of Systems integration
- Flexibility

Real time IoT System of Systems

- Robust hard real time not possible over open Internet
- Need protection
  - Self contained networks/clouds
  - Firewalls
- Need real time capable physical and transport layer
  - Industrial ethernet
- QoS monitor and control

Engineering simplicity

- Application focused engineering

- Current engineering costs
  (based on data from the Arrowhead project)
  - Application ~20-35%
  - Connectivity ~65-80%

- Remove lower layer complexity from the engineering process
- Autonomous interoperability below application service level

Interoperability of IoT technology

- Device level?
  - 10+ physical layers
  - 10+ MAC protocols

Interoperability of IoT technology

- Device level?
  - 10+ physical layers
  - 10+ MAC protocols

- Products on the market to a large extent!

Interoperability of IoT technology

- Device level?
  - 10+ physical layers
  - 10+ MAC protocols

- Protocol level?
  - 10+ SOA protocols

Interoperability of IoT technology

- Device level?
  - 10+ physical layers
  - 10+ MAC protocols
- Protocol level?
  - 10+ SOA protocols, 3 encodings
- Protocol and encoding translation
  - XML, JSON, CBOR
  - REST, CoAP, MQTT, (OPC-UA), …

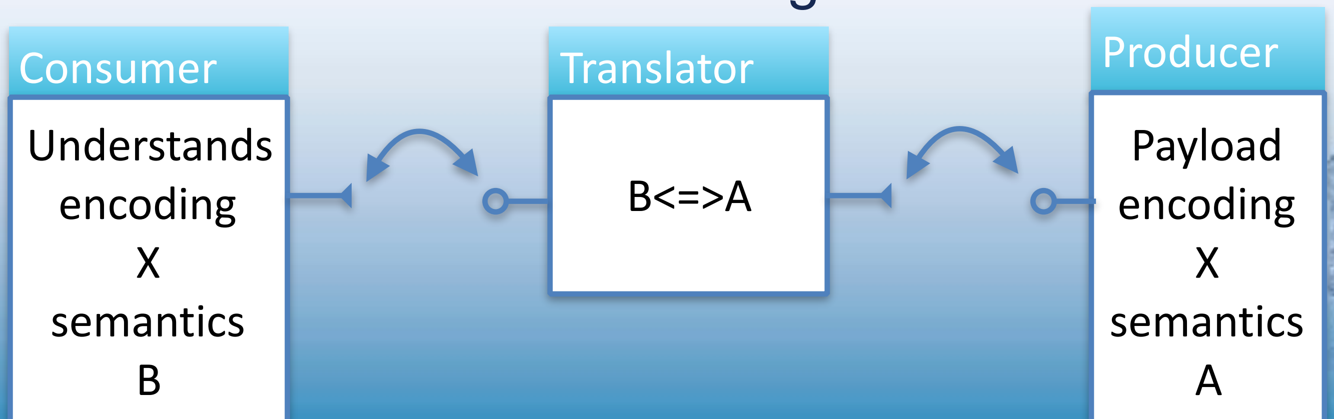
H Derhamy et.al, Interoperability for Low Latency IoT: On-demand Transparent Multi-protocol Translator, IEEE Internet of Things Journal, 2017

Interoperability of IoT technology

- Device level?
  - 10+ physical layers
  - 10+ MAC protocols
- Protocol level?
  - 10+ SOA protocols
- Service level?
  - 100+ data structures & semantics

Interoperability of IoT technology

- Service level?
  - 100+ data structures & semantics
- This is the **BIG** interoperability problem
- Research approaches in current literature
  - Ontologies
  - Natural langage
  - Machine learning

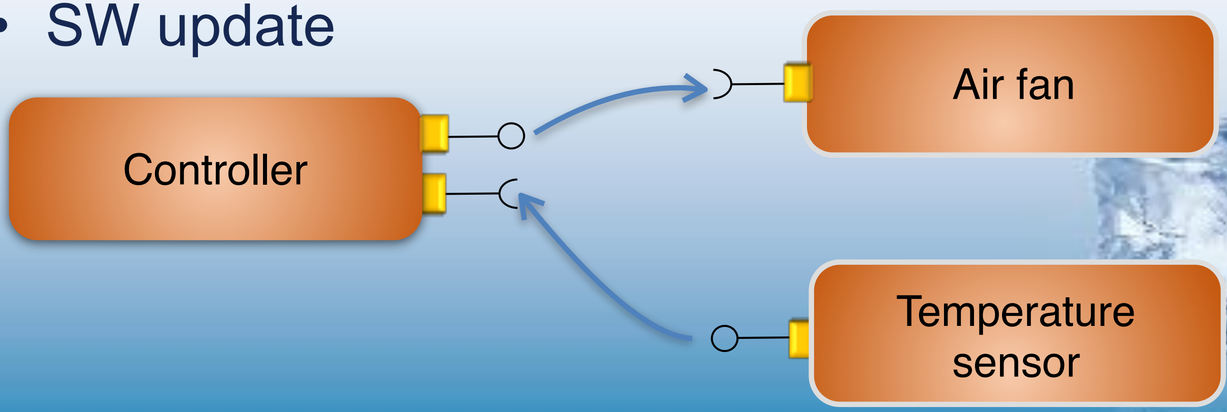


Security in distributed IoT systems

- Authentication
  - HW, SW, Service
- Authorisation
  - Granularity
- Accounting
  - #, time, value, ….
- On-boarding
- SW update

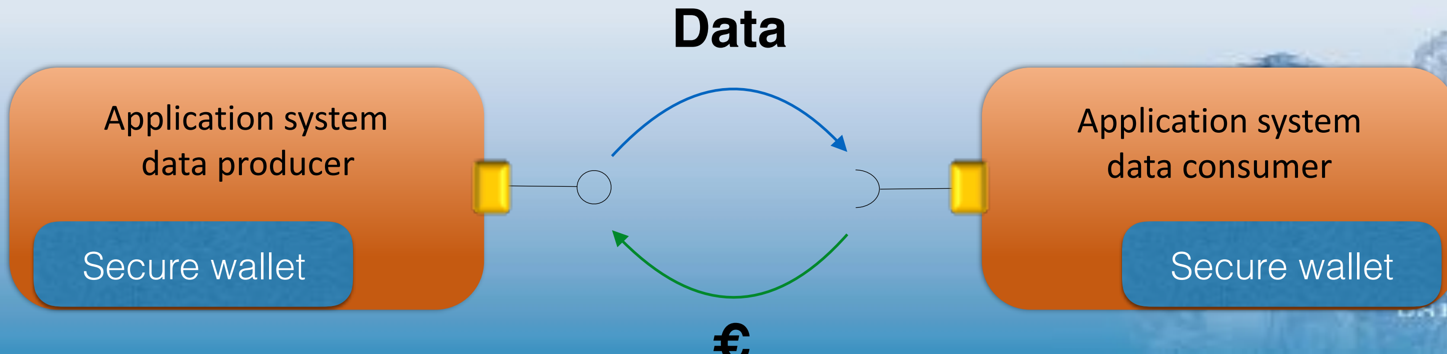
- Payload protection
  - Encryption
- Security management
- Assessment procedures
- Cost of security

- Heterogeneous IoT's



Security in distributed IoT systems

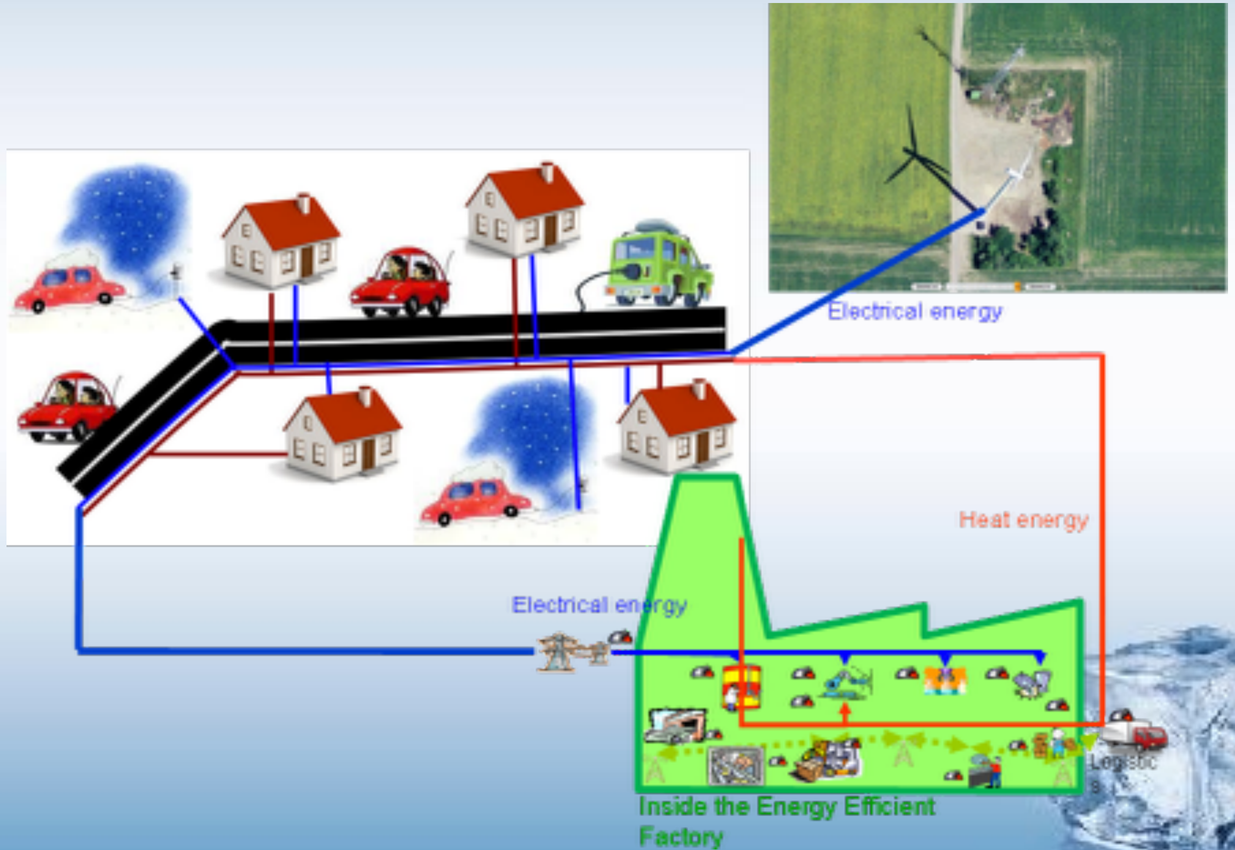
- Upcoming
  - Intrusion detection
  - Data ownership
  - Ownership management
  - Legal aspects - different in different countries
  - Nano payments
    - Wallet protection



Safety

- Assessment procedures
  - Compliance to safety standards
- Legal aspects
- Liability issues
  - Machine made decision

Scalability



Scalability

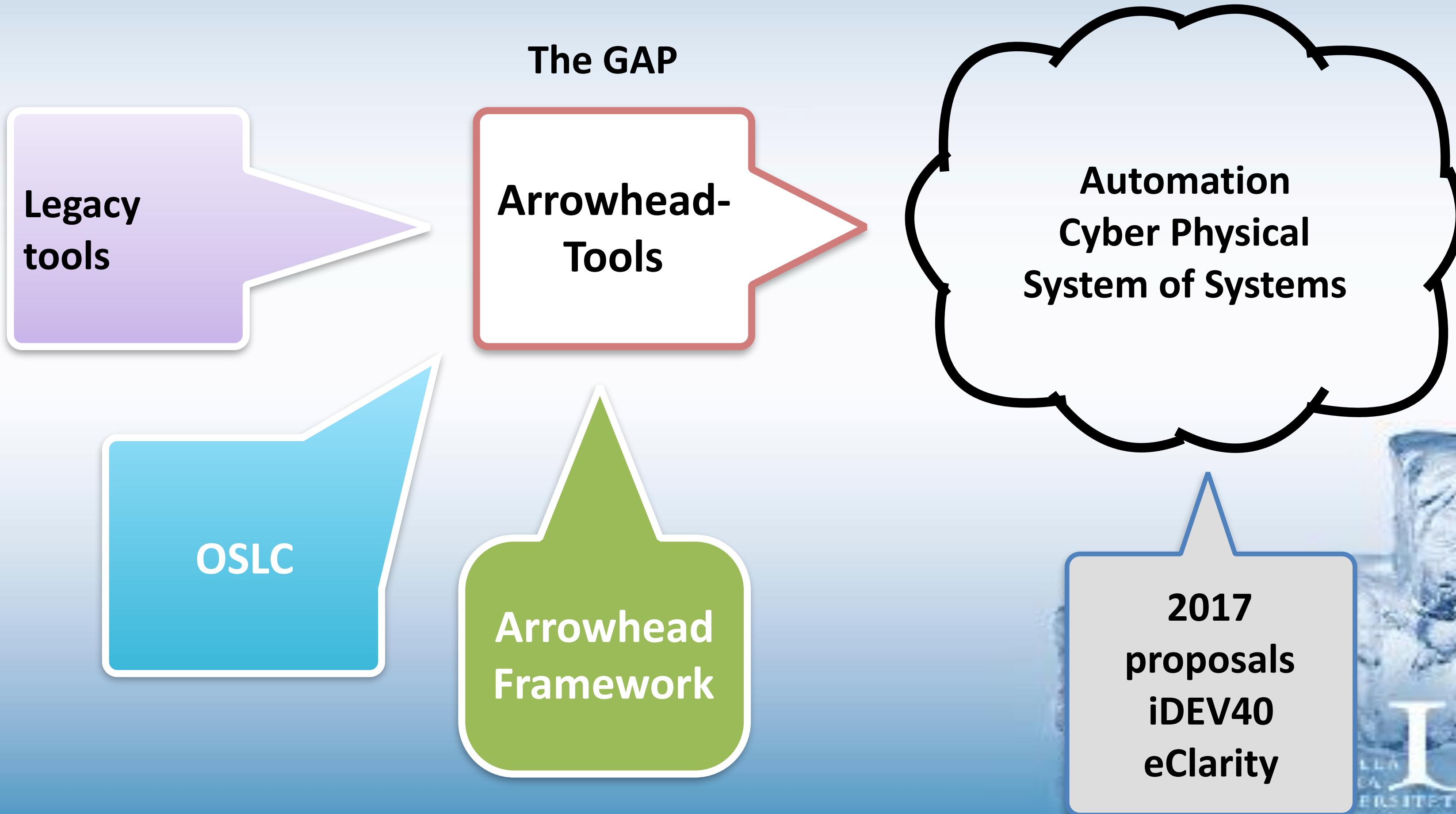
- Digitalisation is pushing for integration of more systems than today
  - Moving beyond 10^5 connected IoT's

- Integration of today isolated systems
  - Preserving
    - Functionality
    - Real time
    - Security
    - Interoperability
    - …..

System of Systems integration to Cyber Physical Systems

- Service level integration
  - Descriptions of a plant
    - Physical functions
      - PI&D, ….
      - Control, ….
    - Electrical
      - Topology, logical
    - Communication, computation
      - Topology, Logical
    - Wiring
    - Layout

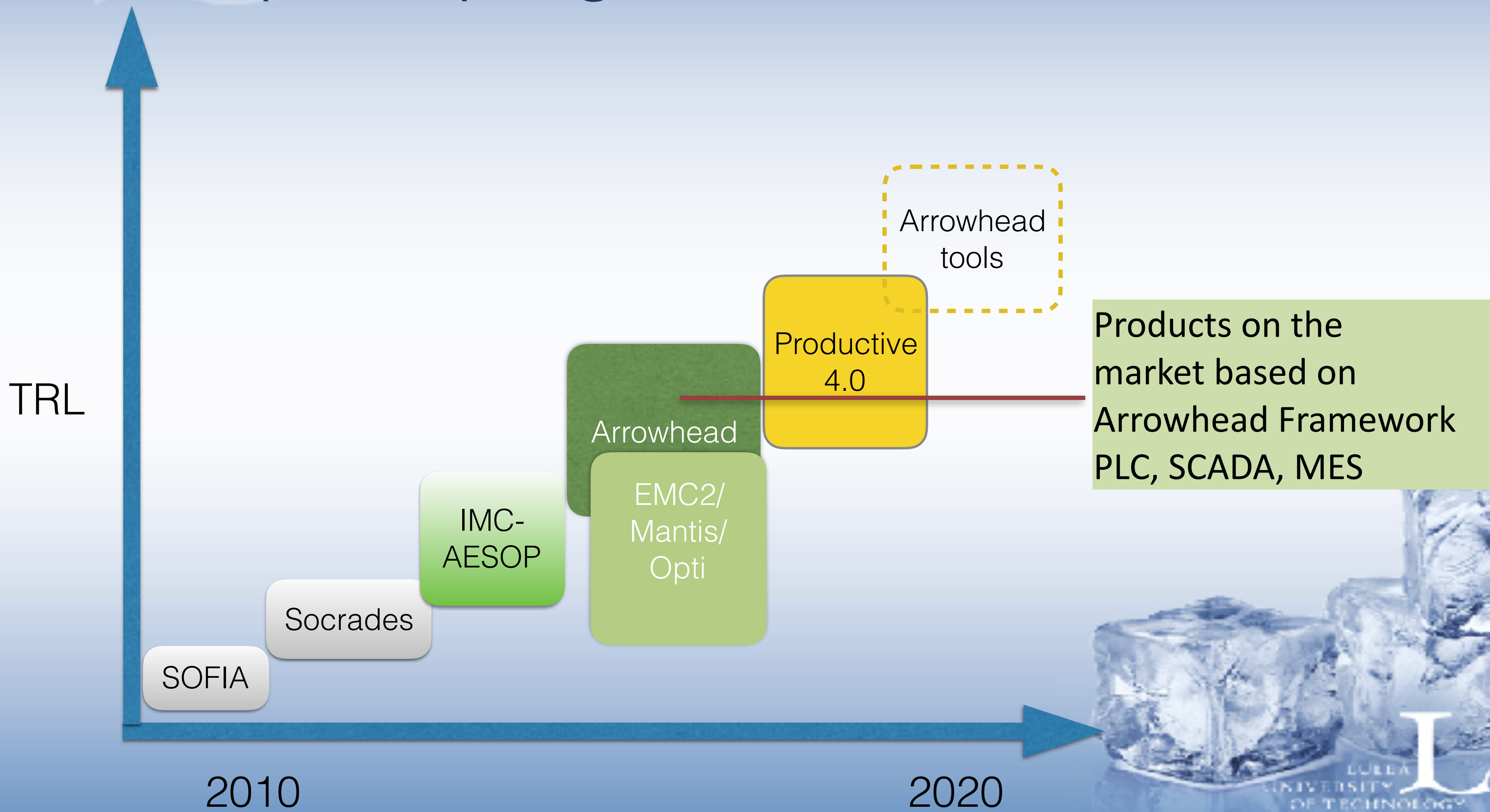
System of Systems tool gap



Progress since 2000

- Sofia
  - SOA usage in control
- Socrades
  - SOA for automation
- IMC-AESOP
  - SOA for large automation systems
- Arrowhead
  - IoT Interoperability and integrability
- EMC^2
  - Safety critical and multi core IoT SOA
- Productive4.0
  - IoT production automation
- Opti, Mantis, Desire, Flexoffer, …….

European progression of IoT automation



Current state of the art

- Arrowhead Framework
  - IoT interoperability at service level
  - SoS integration
  - Automation support services

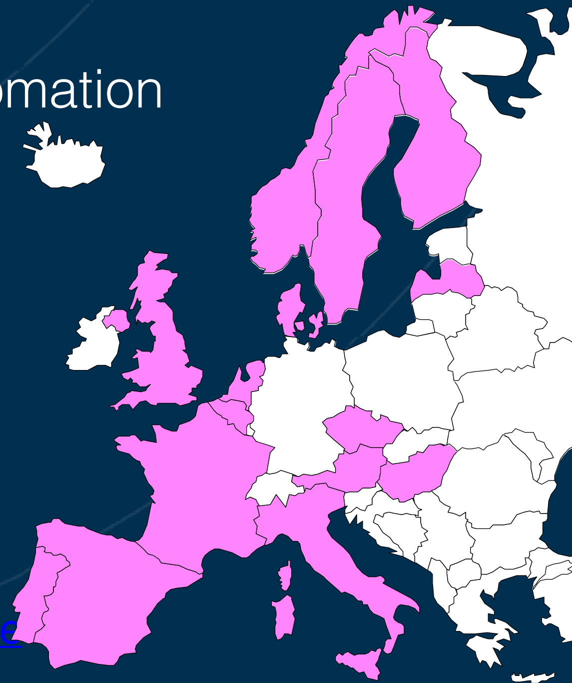
- **The need of new communication technology is high up in the ISO communication stack**

Arrowhead

Process and energy system automation

4 years project
68M€
78 partners
Coordinated by
processit.eu
Automation for process industries
an ARTEMIS CoIE

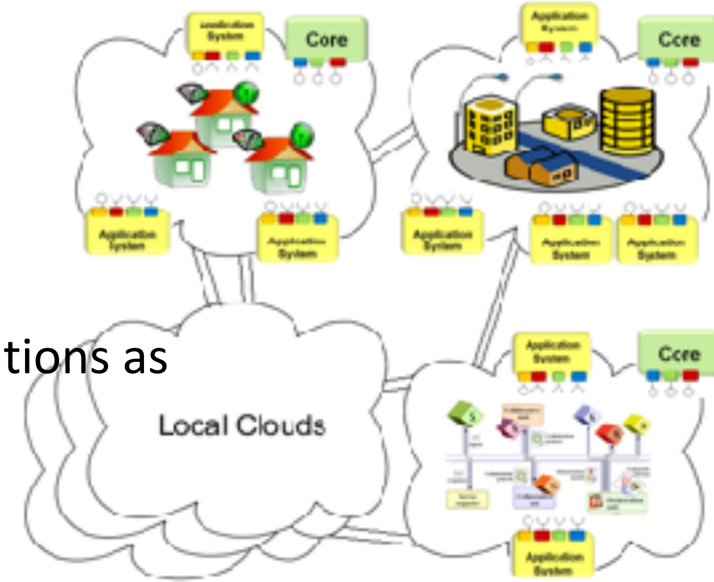
www.arrowhead.eu - jerker.delsing@ltu.se



ARROWHEAD

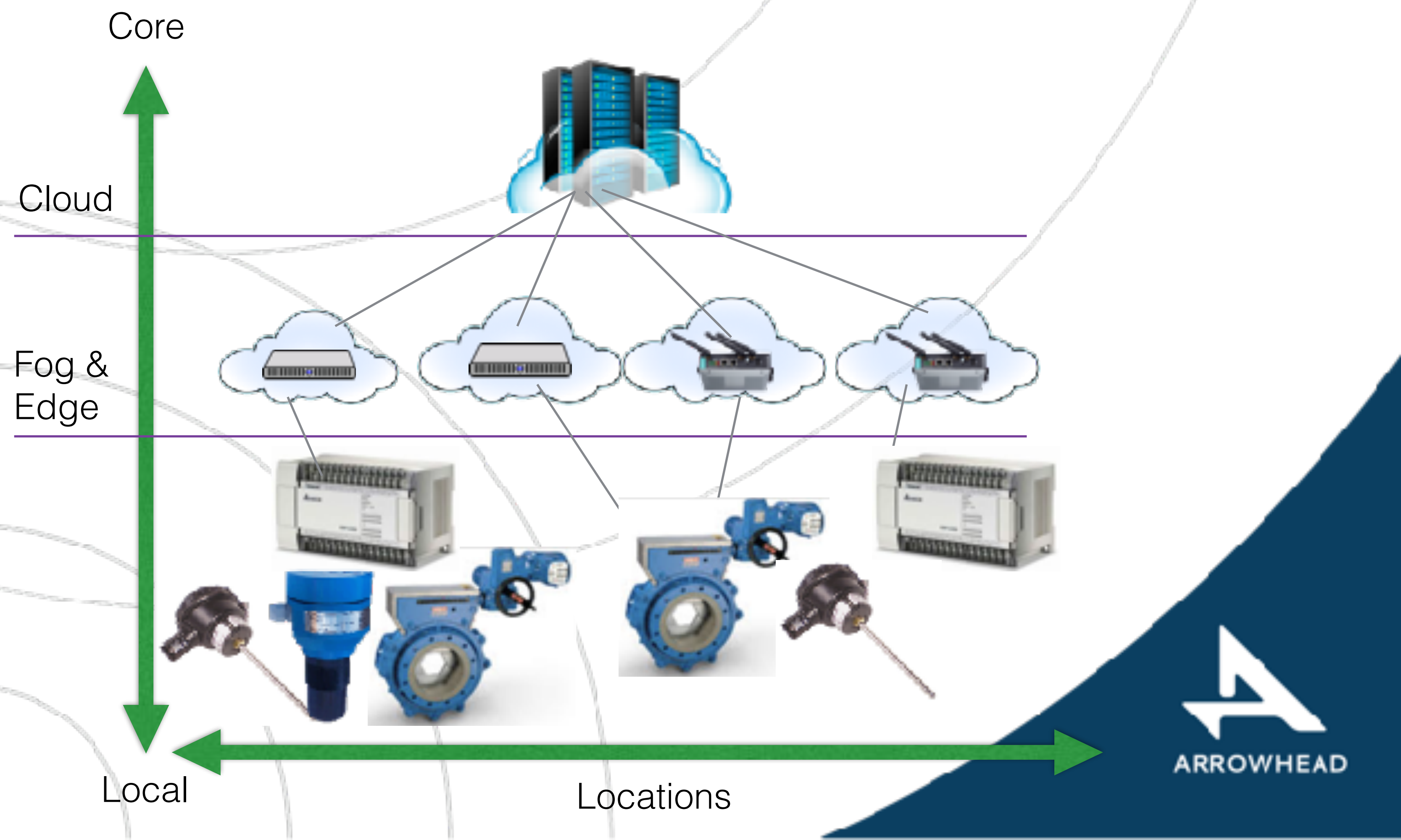
Local cloud meeting automation requirements

- Automation is local
- Local clouds provides
  - A protective security fence
  - Inter cloud service exchange
- Thus protecting sensitive automation operations as
  - Real time closed control loops
  - Safety critical operations
- Reducing engineering efforts on
  - Interoperability - semantics
  - Real time
  - Security

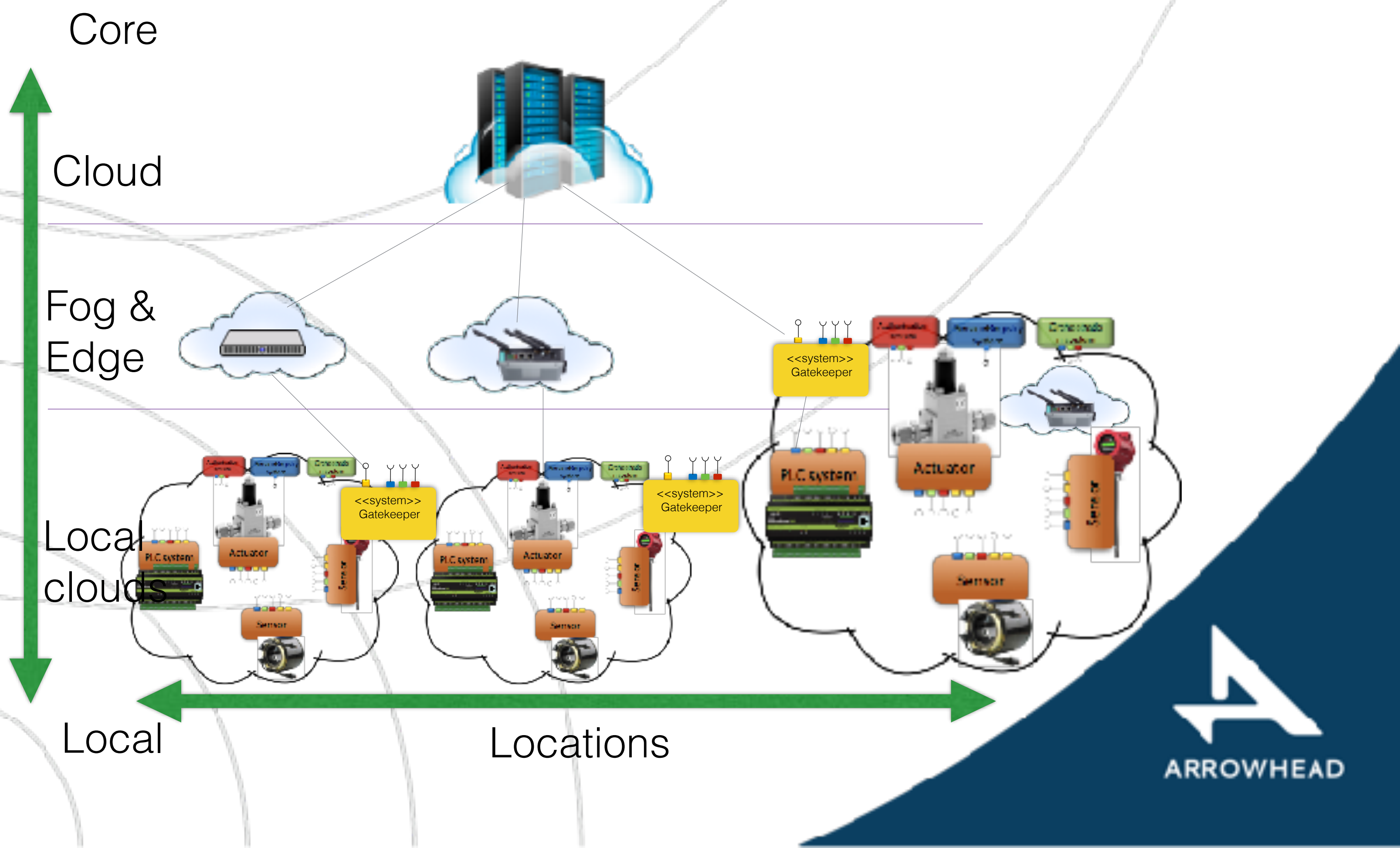


ARROWHEAD

Cloud - Fog/Edge - Local



Cloud - Fog/Edge - Local



How to build a local automation cloud? Arrowhead technology approach

- **Self contained local clouds, supporting**
  - **Loosely coupling, Late binding, Look-up**
- **Security**
- **Autonomy**
- **Pull and push behaviour,**
- **Interoperability**
  - **Translation between SOA protocols, encodings, ….**

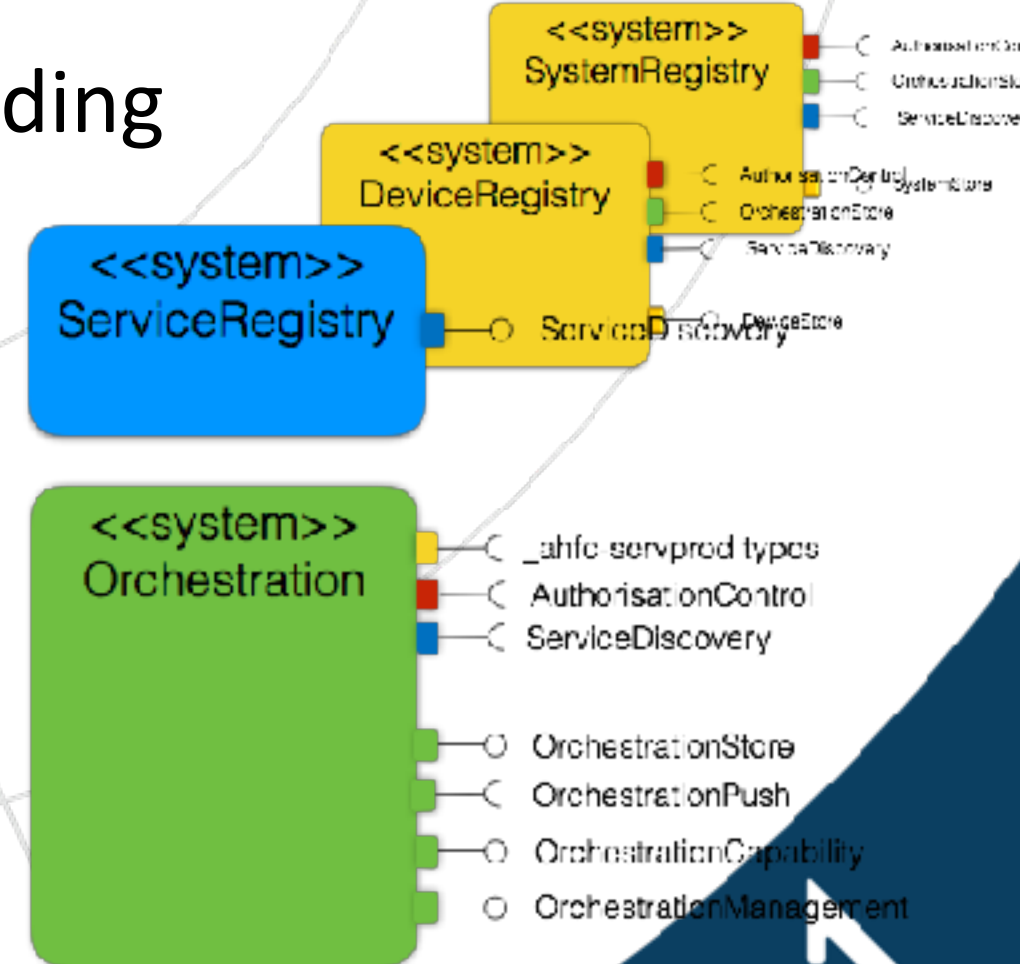
ARROWHEAD

Interoperability

Look-up and late binding

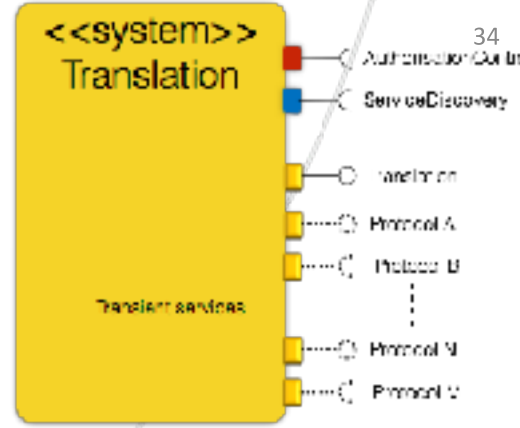
- Service/System/Device look-up
- DNS-SD based

- Run-time binding
- Push or pull of orchestration rules
- Associated Management tool
- Integration to Engineering tools through PlantDescription



ARROWHEAD

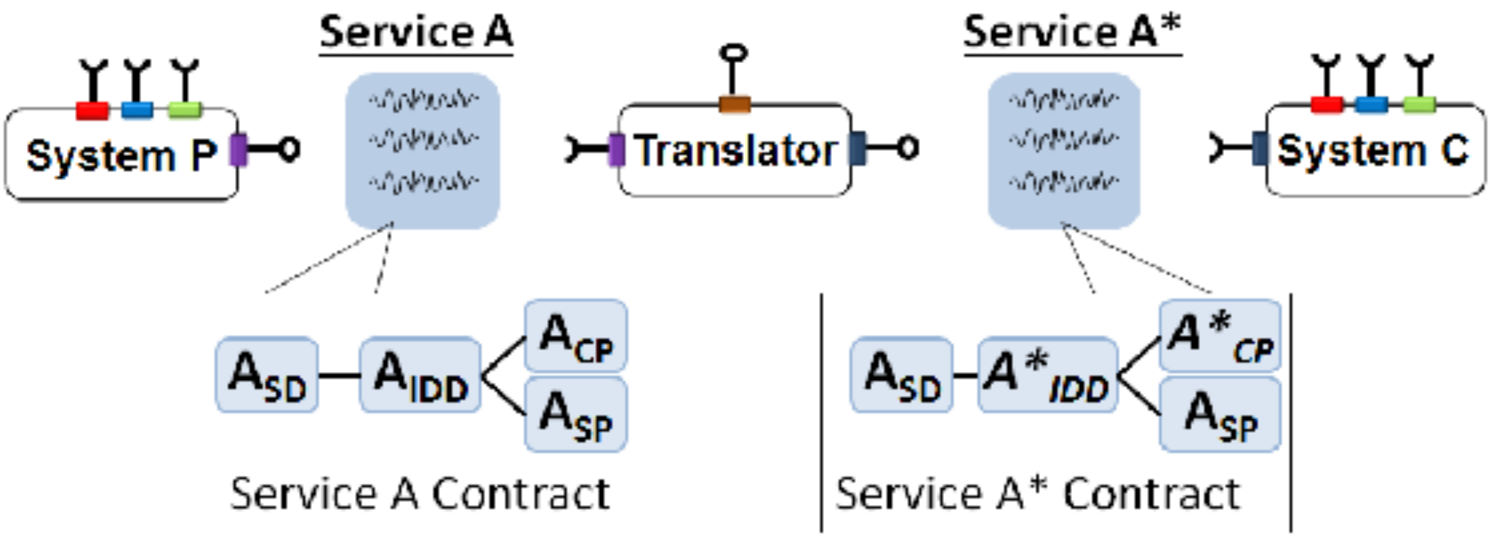
Interoperability



Is it possible to make machine assisted translation like

- CoAP <-> XMPP <-> MQTT <-> OPC-UA <-> REST……………….
- Service integrity over protocols, data structures, semantics etc.

- Current status: REST - CoAP - MQTT - (OPC-UA)



Hasan Derhamy, Pal Varga, Jens Eliasson, Jerker Delsing and Pablo Punal Pereira
Translation Error Handling for Multi-Protocol SOA Systems, ETFA 2015, Luxembourg

Security

Security

Authorisation of service exchange

Authentication of service consumer

X.509 certificates or

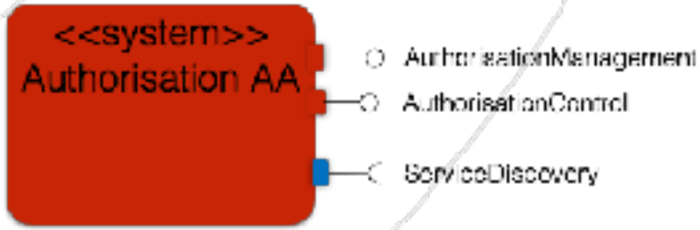
Radius ticket

Payload encryption

IPsec - IP layer

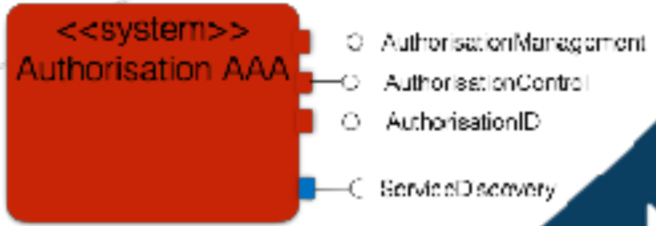
Protocol level e.g. DTLS

X.509 certificates - AA



Resource constrained devices

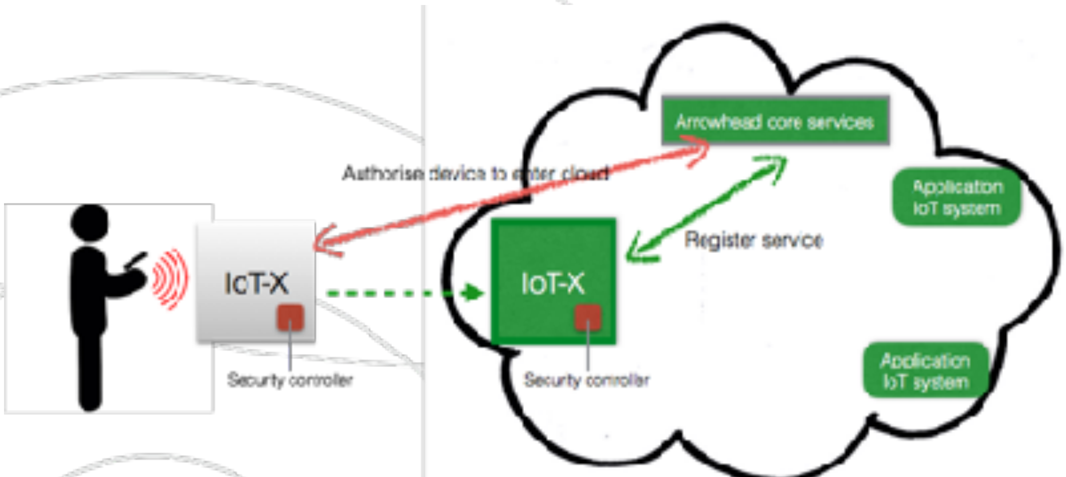
Radius tickets - AAA

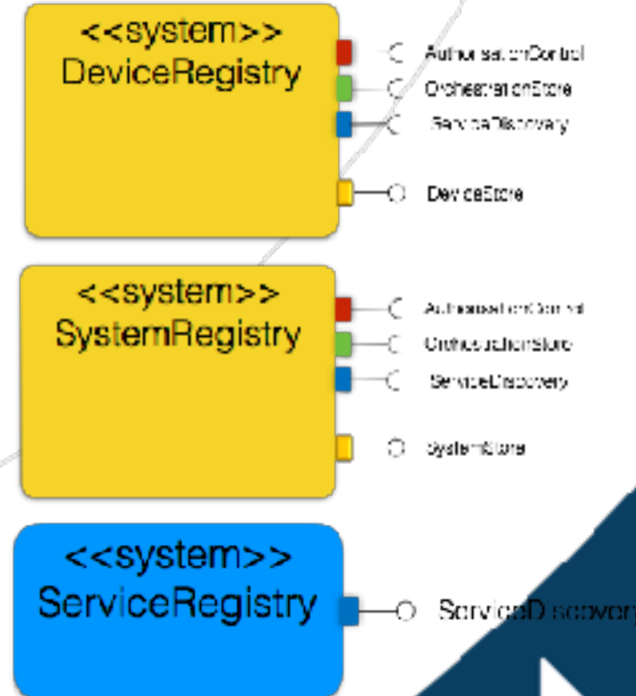


ARROWHEAD

Secure local cloud deployment

- Procedures to securely identify and deploy
  - Device hardware
  - System software
  - System services

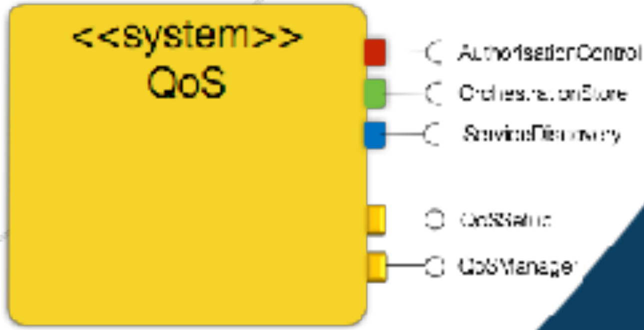




Real time

Hard real time IoT local cloud

- Hard real time dependent on underlaying communication capabilities
  - Local hard real time cloud to prescribe communication technology
  - e.g. Industrial ethernet, TTTech, time slotted 802.15.4
- SOA overhead eats bandwidth
  - Use compression
  - EXI
- QoS Manager system
  - End-to-end delay – hard/soft real-time guarantees;
  - Data bandwidth;
  - Communication semantics – delivery guarantees, and message ordering
  - Message prioritization
  - Local device parameters – on device application scheduling
  - Service configuration parameters – buffer size, middleware parameters and prioritization of requests.

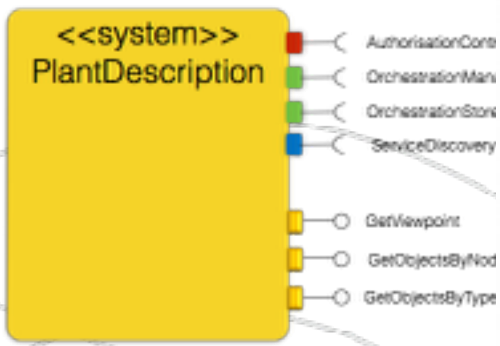


EXIP: A Framework for Embedded Web Development
Kyusakov, R., Punal, P., Eliasson, J. & Delsing, J. Oct 2014
In : ACM Transactions on the Web. 8, 4, 29 p.23

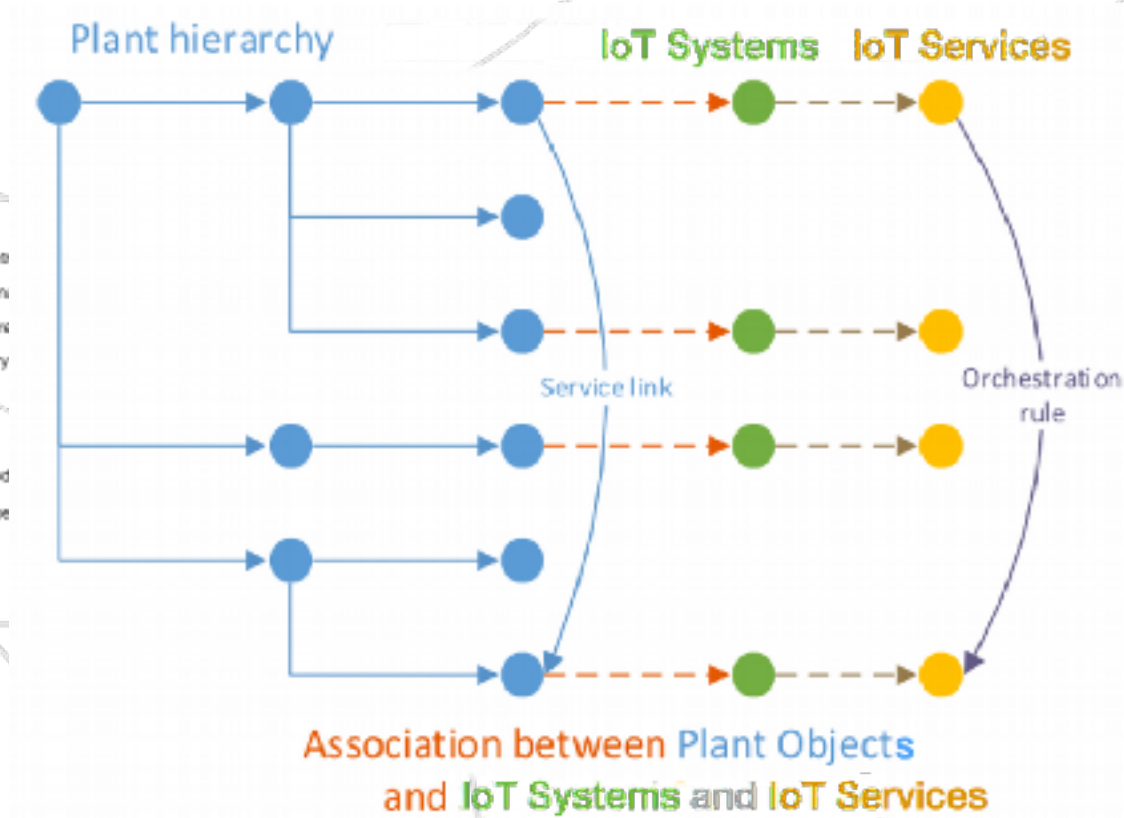
ARROWHEAD

Engineering support

PlantDescription to IoT service Orchestration

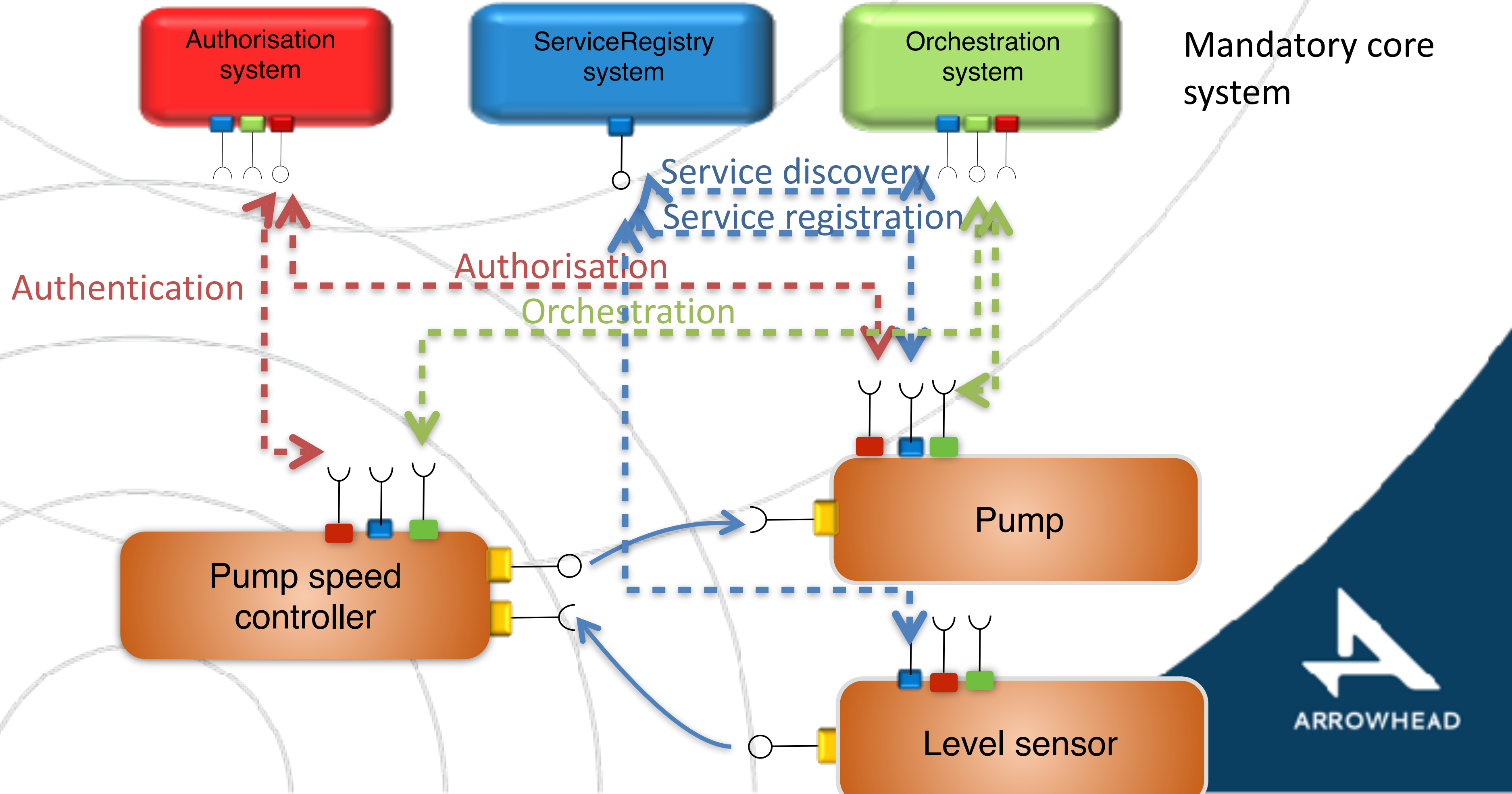


Based on IEC 81346 ,CAEX/IEC62424, …



ARROWHEAD

Local automation cloud - functionality
Autonomous behaviour



Mandatory core system

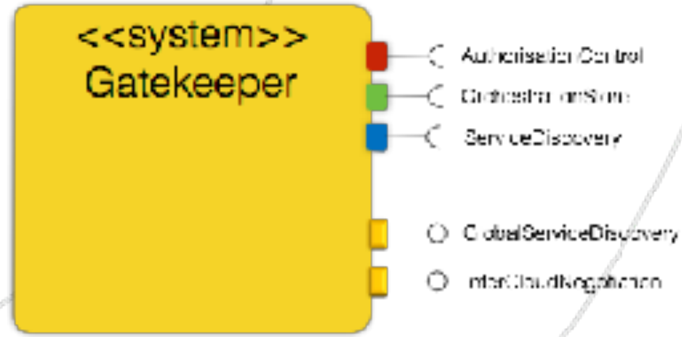
Scalability

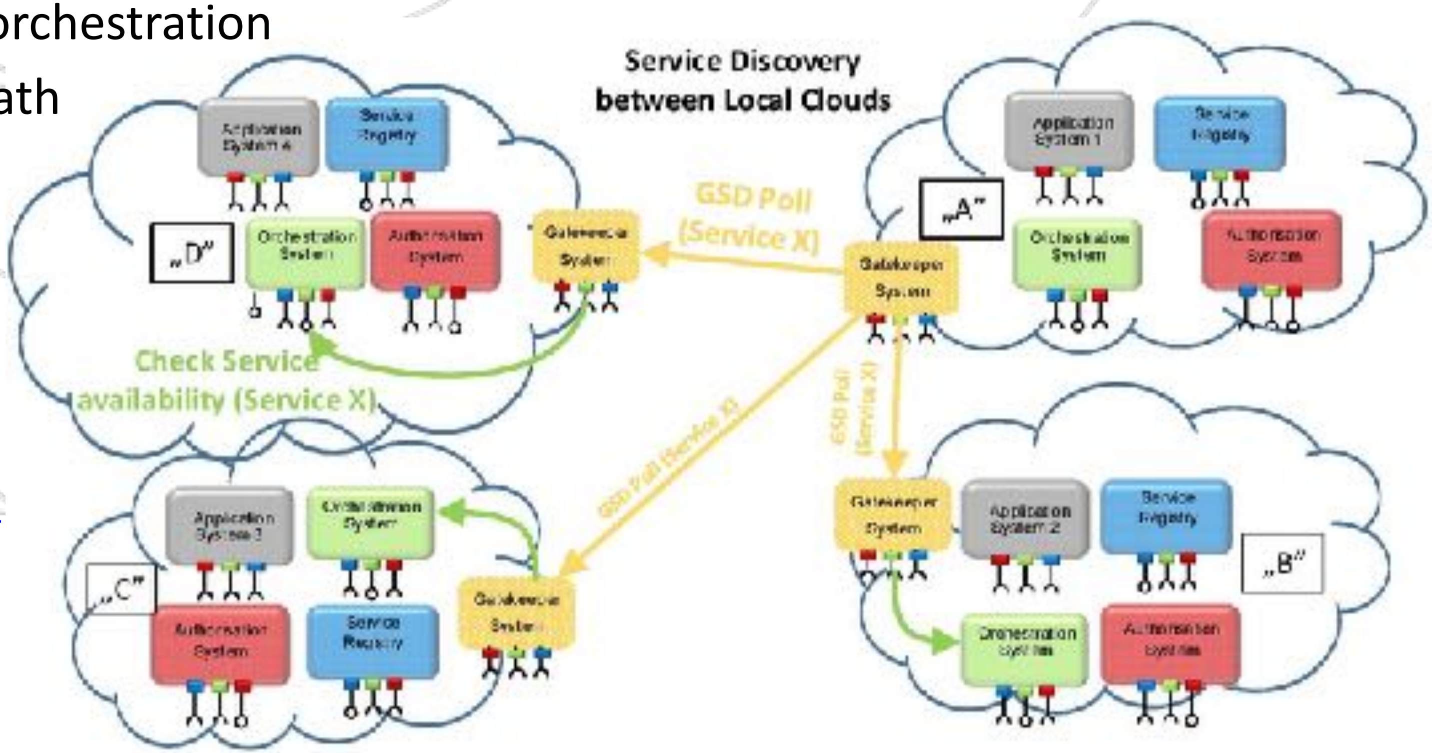
Scalability

Service exchange administration

- Inter cloud discovery
- Inter cloud authorisation
- Inter cloud orchestration

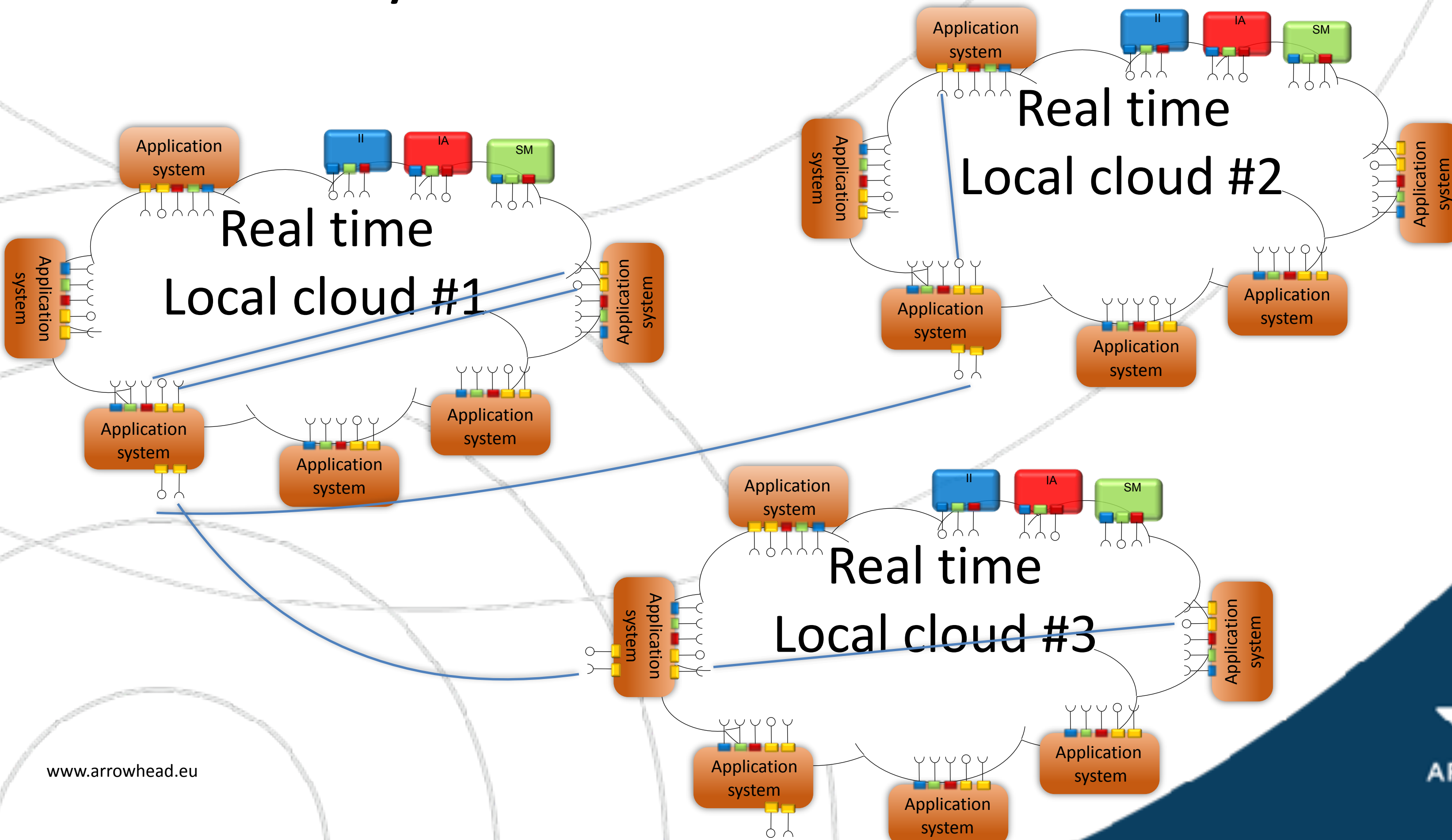
Secure data path





[Service Interaction through Gateways for Inter-Cloud Collaboration within the Arrowhead Framework](#)
P Varga, C Hegedus - 5th IEEE WirelessVitae, Hyderabad, India, 2015

Real time local cloud automation
Scalability - inter cloud interaction



ARROWHEAD

Automation engineering time

- Simplicity of automation service engineering is market key

- Arrowhead Framework reduces engineering time
    - **From 5-6 days -> 6-8 hours (Abelko; building energy automation)**
    - **From 4-5 weeks to 1 week (BnearIT; airport logistics)**
    - **From 6-7 week to 2 weeks (BnearIT; recycling logistics)**

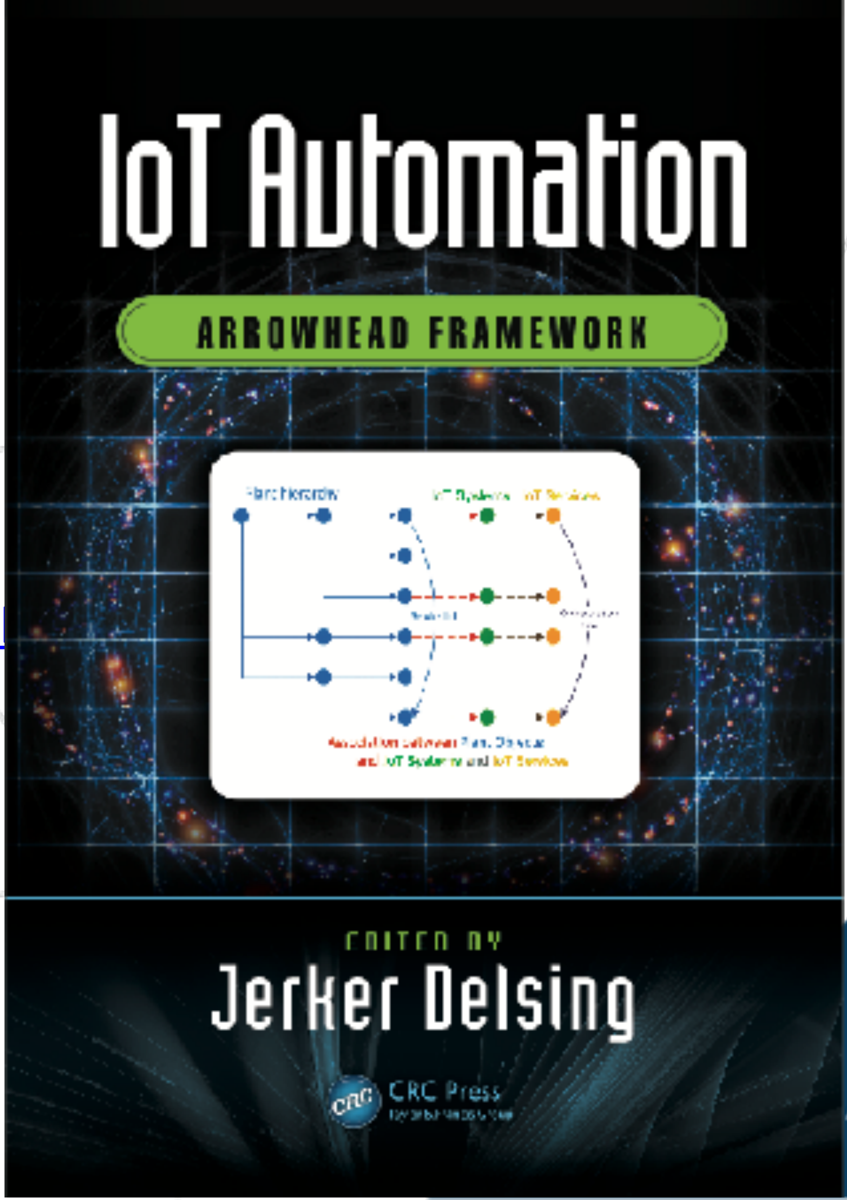
ARROWHEAD

Arrowhead Framework wiki

Arrowhead book

CRCPress

https://www.crcpress.com/Arrowhead-Framework-IoT-Automation-Devices-and-Maintenance/Delsing/p/boo
9781498756754



Can we build Arrowhead automation systems today?

Robust communication	➡**Products on the market**
IoT sensors, actuators, PLC:s, etc.	➡**Some products on the market**
DCS and SCADA functionality	➡**First products on the market**
MES and ERP functionality	➡**First product on the market**
Cloud integration technology	➡**Some products on the market**
Engineering tools cloud automation	➡Demonstrated in industrial env.
Test tools and simulators	➡**First products on the market**
Migration to cloud automation	➡Demonstrated in industrial env.
Suitable security	➡**Some products on the market**

ARROWHEAD

Conclusions

- Digitalisation in production automation expands the automation scope
- Expected benefits are substantial and drives the change
- Advancement beyond ISA-95 is maturing
  - Arrowhead Framework
    - Supports implementation of digitalisation models like
      - IIRA, RAMI4.0, ….
    - Open source technology
- Industrial understanding of digitalisation and IoT and SoS automation is in early stage

Thanks for listening

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