Arrowhead Framework
A Local Cloud Approach to Automation

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ARROWHEAD

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UNIVERSITY
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of Technology in Scandinavia

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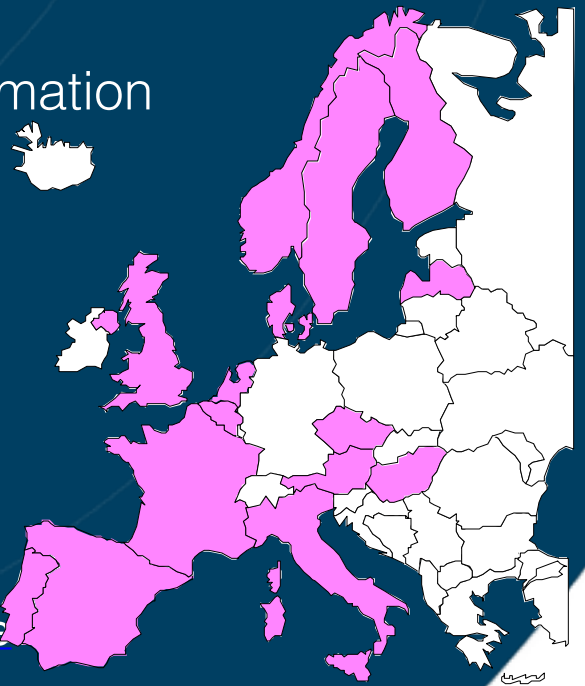
Arrowhead

Process and energy system automation



4 years project
68M€
79 partners
Coordinated by

processit.eu
Automation for process industries

an ARTEMIS CoIE

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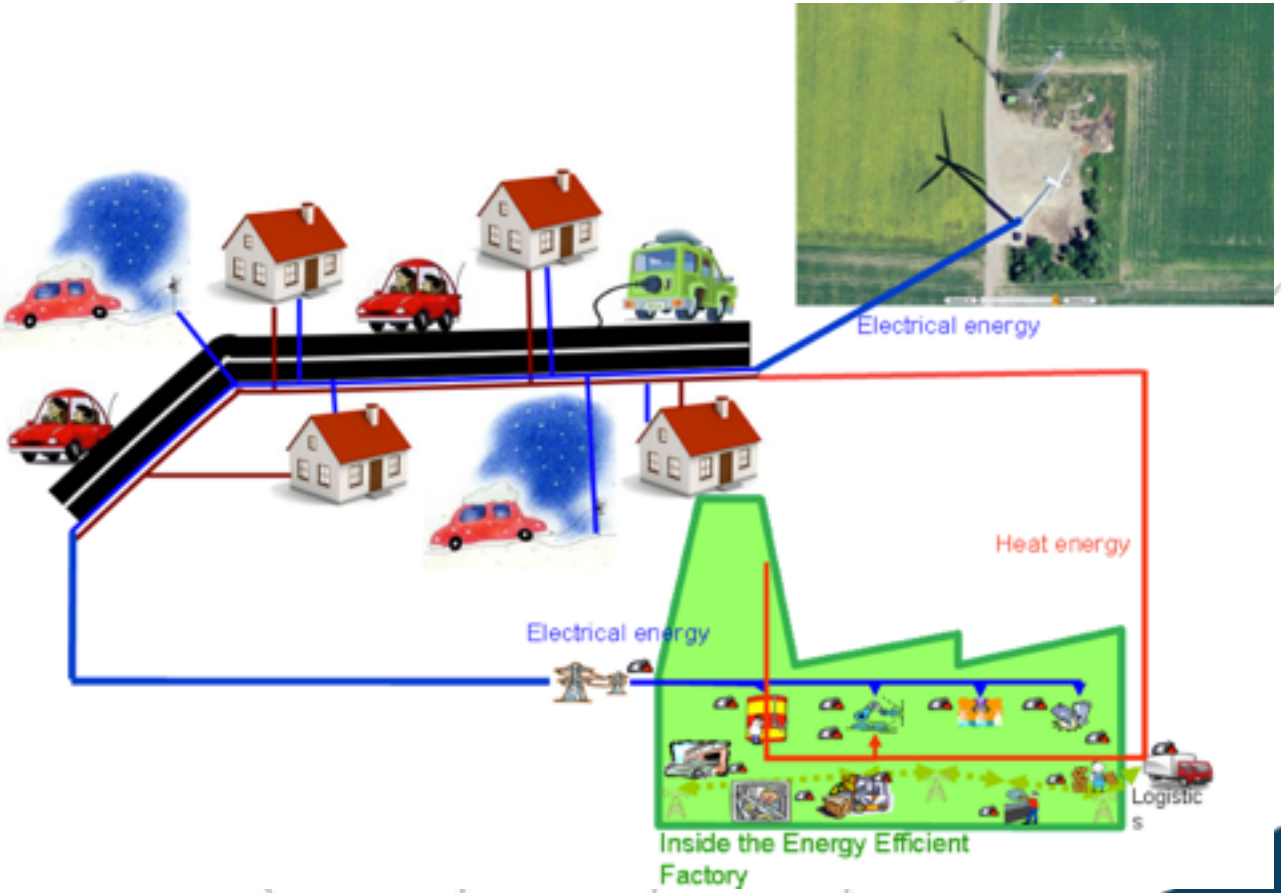
How to build **very** large complex automationssystem?



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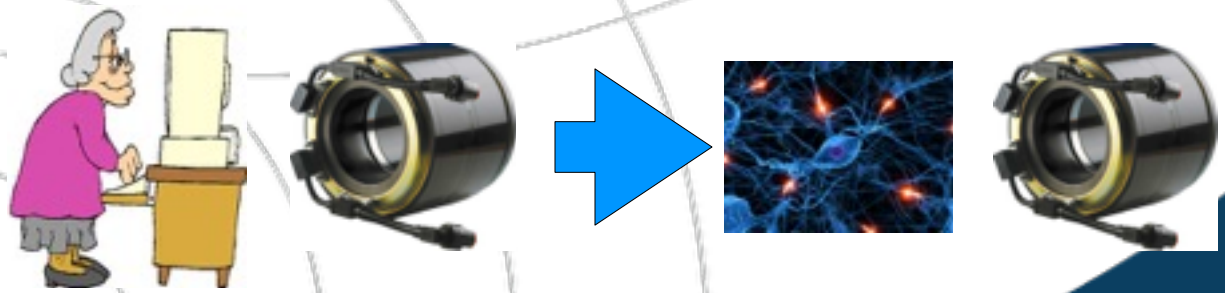
The automation challenge

- Annual growths more than 10% and over 500 billion connected devices are expected worldwide by 2025. - Cisco 2013
- Massive automation systems not possible with current technologies
- Not enough many engineers on the globe to do the job with current technology



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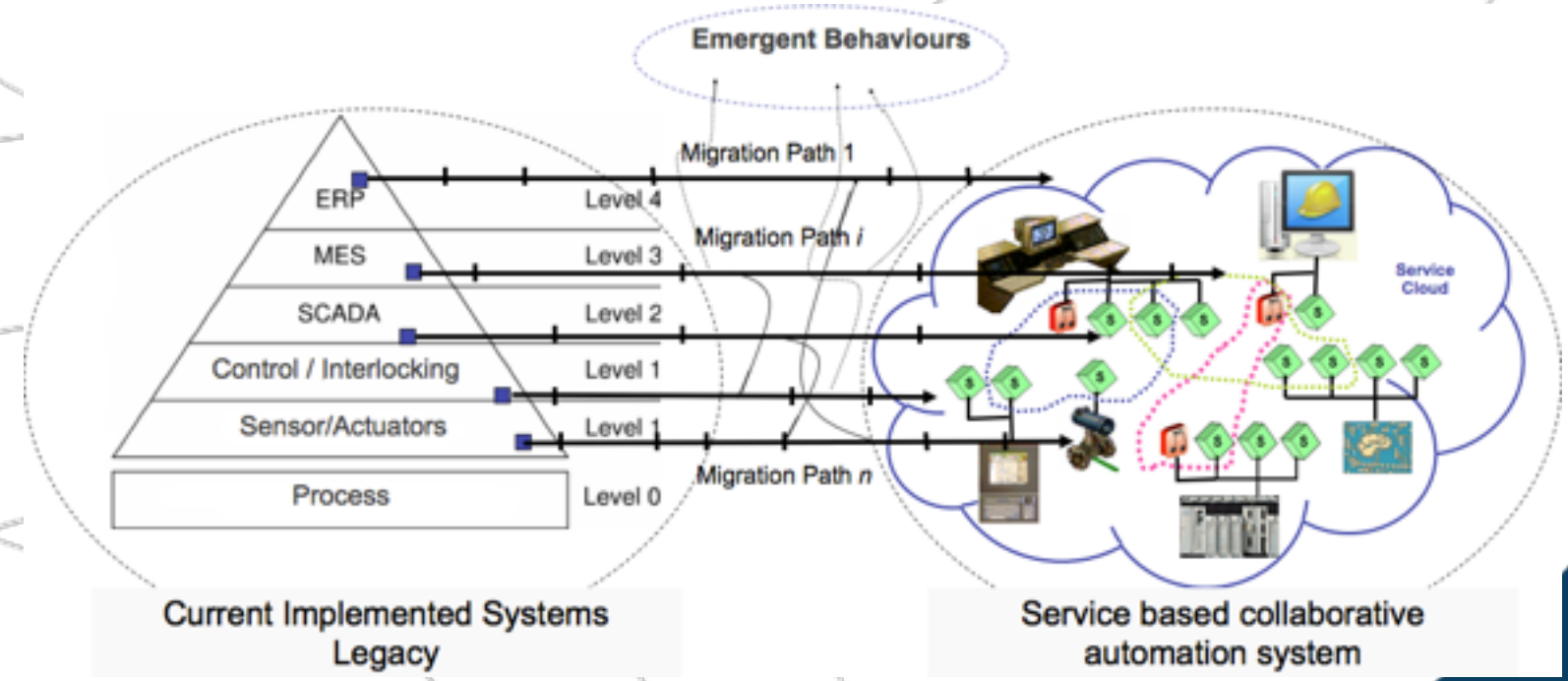
ISA-95 systems in to the cloud?



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Benefits to the production industry - Spire

- Better optimization and coordination of single processes or process chains and of complete plants and sites,
- Significantly improved resource efficiency.
- Better coordinated control loops in one process step and improved collaboration of control systems of different processes along a process chain give higher process yields which results in better material efficiency, waste reduction, less energy use and reduction of pollution.
- Improved product quality through better process control and smart quality control
- Higher utilization of equipment
- New collaborative solutions with integrated information management offer new possibilities for supply chain management including price-based coordination or optimised market mechanisms
- Safer operation of plants due to improved control and shut-down procedures.
- Possibilities to integrate multiple processes.
- Shorter delivery times and lower production cost.

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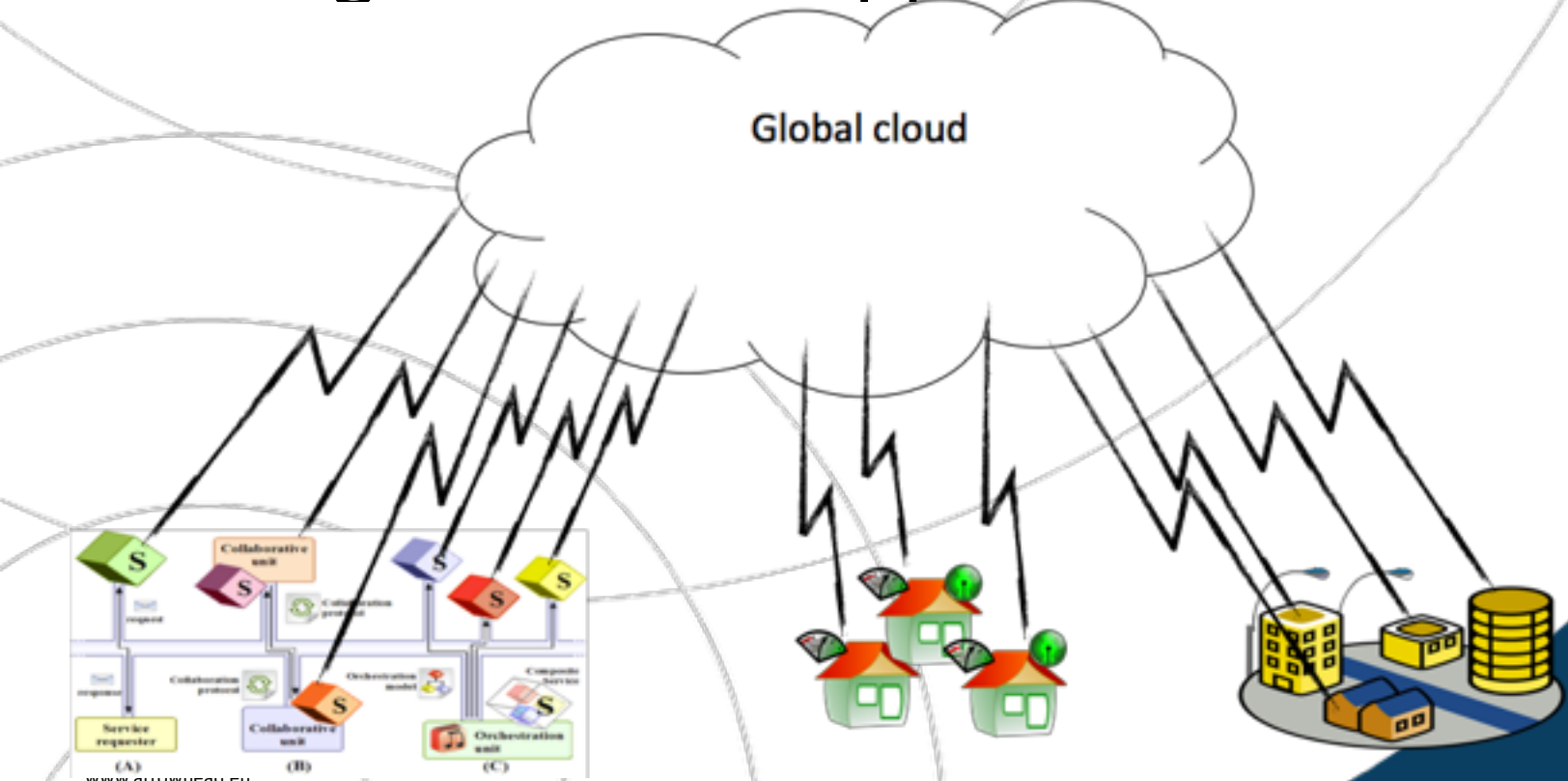
The global cloud approach



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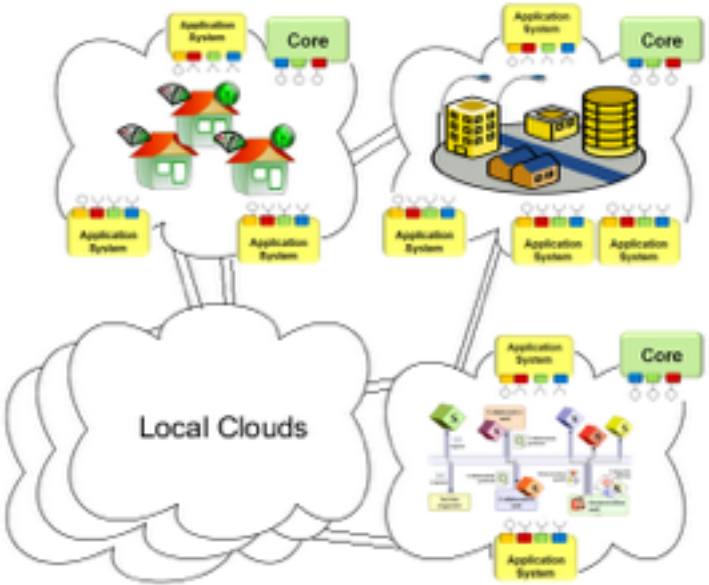
Collaborative automation in the cloud

- Automation is local - requirements on:
  - Real time
  - Security and safety
  - Continuous engineering

- Local clouds are beneficial to:
  - Latency - real time
  - Security - supporting safety
  - Less engineering dependencies



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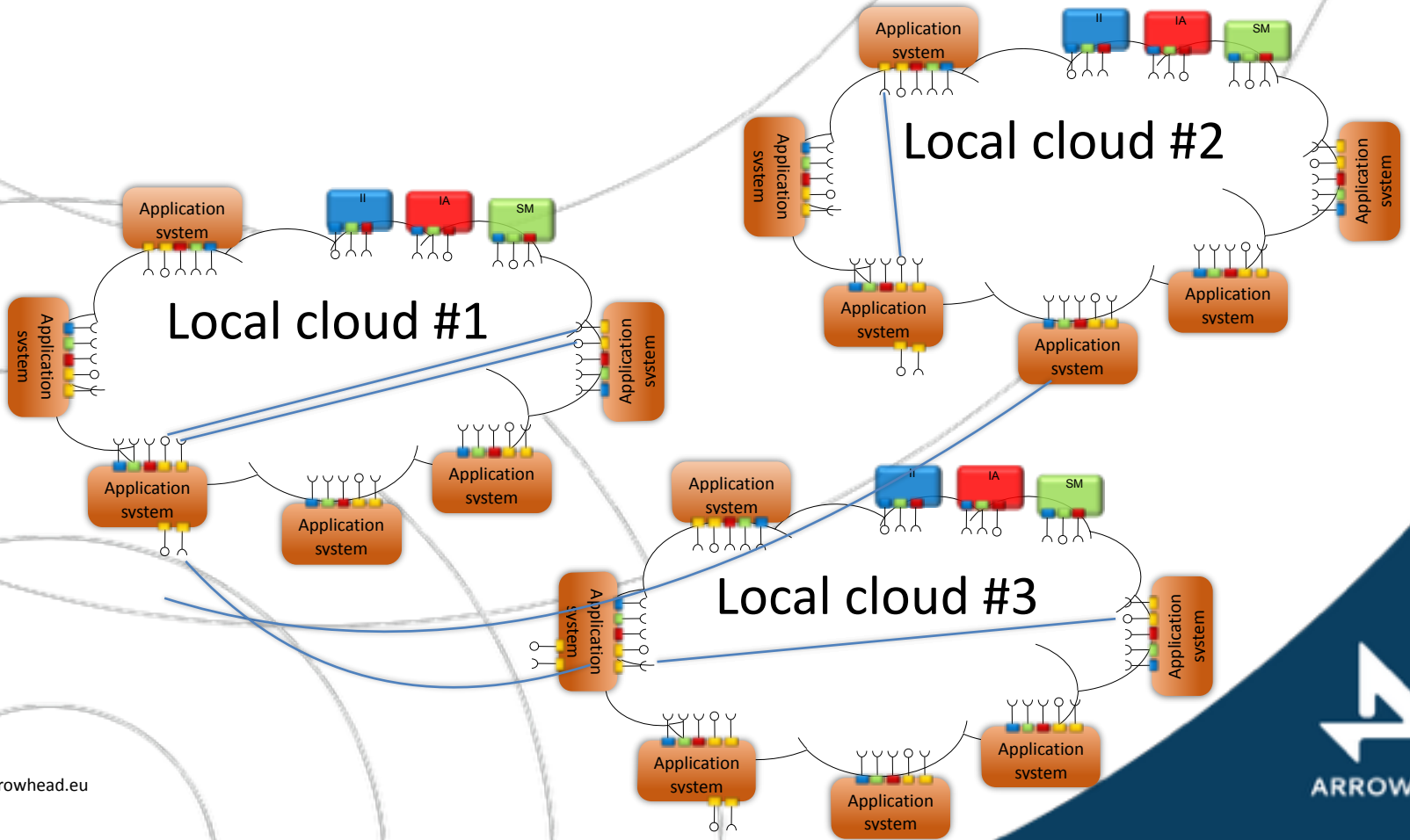
Collaborative automation - local clouds



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Arrowhead Vision

Enable collaborative automation by networked embedded devices.

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Arrowhead Grand challenges

- Enabling the interoperability of services provided by almost any device.

- Enabling the integrability of services provided by almost any device.

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Arrowhead approaches

- **TCP/IP** everywhere, middleware nowhere.
  - Internet of Things - IoT
  - System of systems - SoS
- The Integrating Technology
  - Service Oriented Architectures - SOA
    - Made possible by cheap silicon

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Collaborative automation

Made possible using SOA

Demonstrated in
Socrades and IMC-ASOP
projects

So whats the problems??

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Communication considerations

- Streaming of IoT data to cloud
  - Costly on communication
- IoT data/info. to consumer on configured event
  - Distributed data -> information computation
  - Subscription to distributed information based on events
  - Enabling consumer tailored information
  - Reduced communication to the expense of computation

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System of systems, SoS, approach

- Information provided as a configurable services
- Orchestration of services possible and feasible with complex event processing

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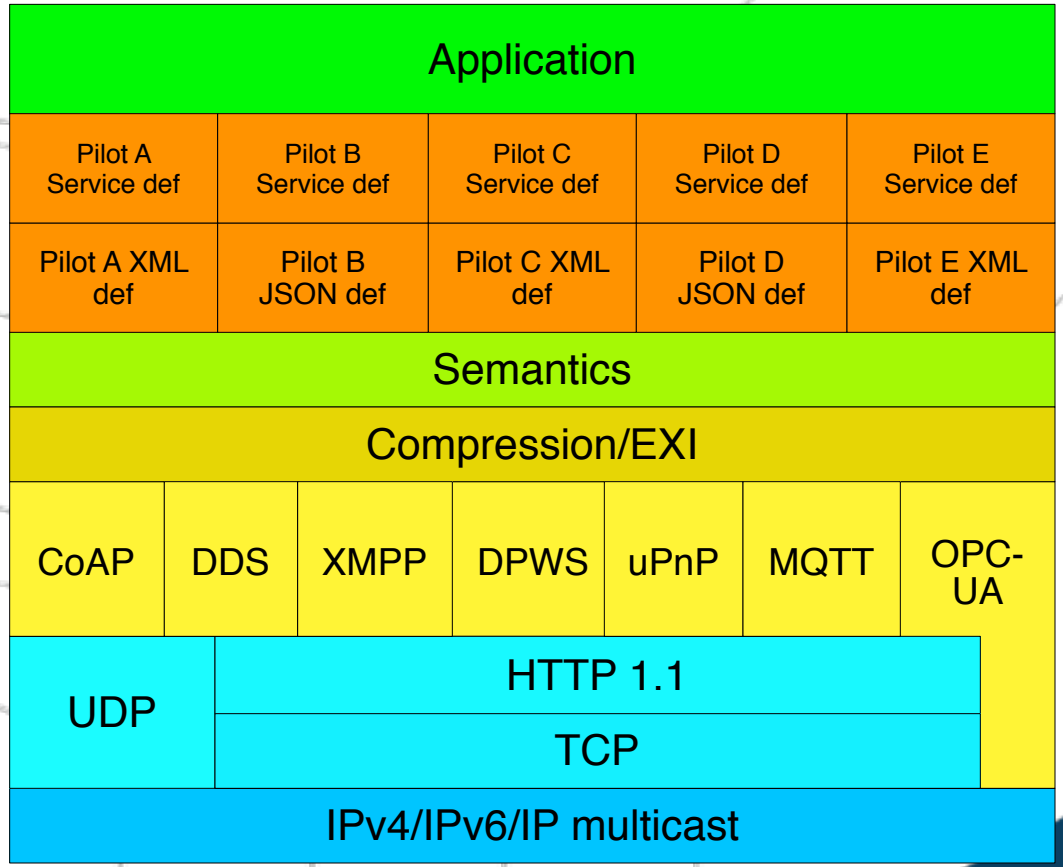
Service Oriented Protocols - The Challenge



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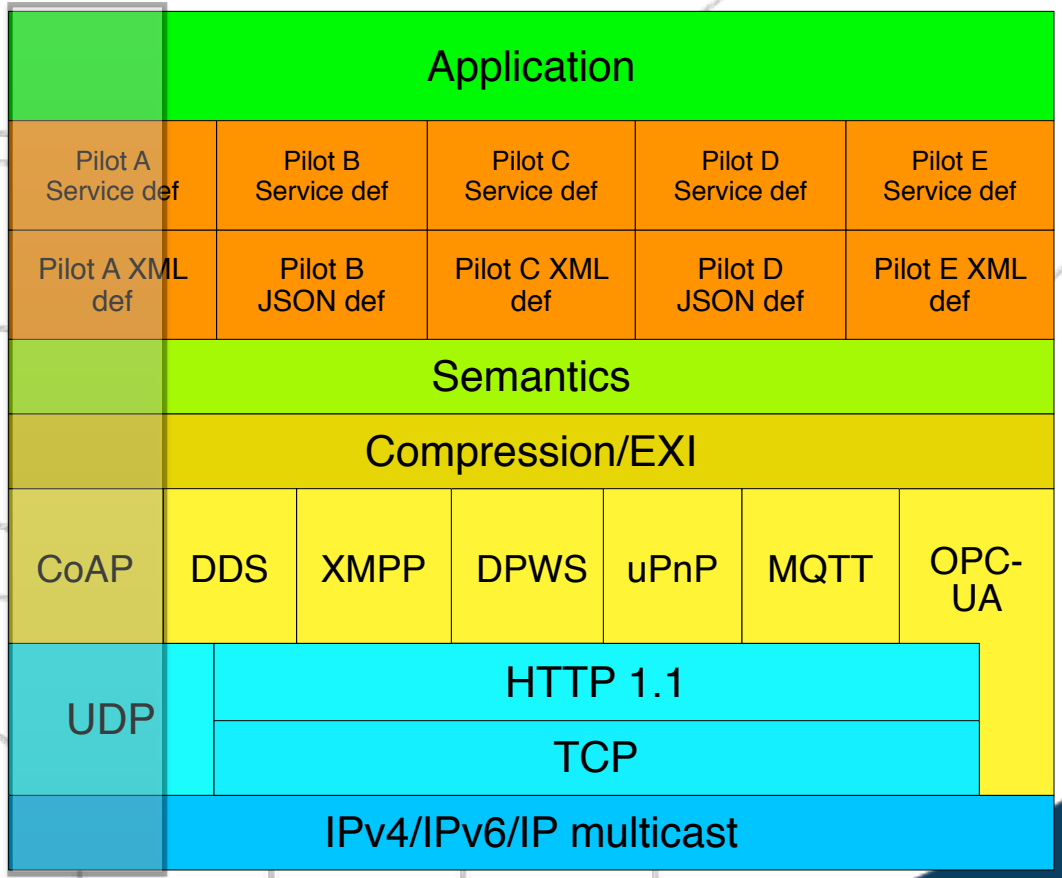
One Service Oriented Protocols - Works!



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What about service protocol interoperability

Is it possible to make machine assisted translation like

- CoAP -> XMPP
- CoAP -> MQTT
- CoAP -> DPWS
- CoAP -> OPC-UA
- OPC-UA -> CoAP
- OPC-UA -> DPWS
- and so on.

Necessary semantics translation
Necessary data structure translations

Service integrity over protocols, data structures, semantics etc.

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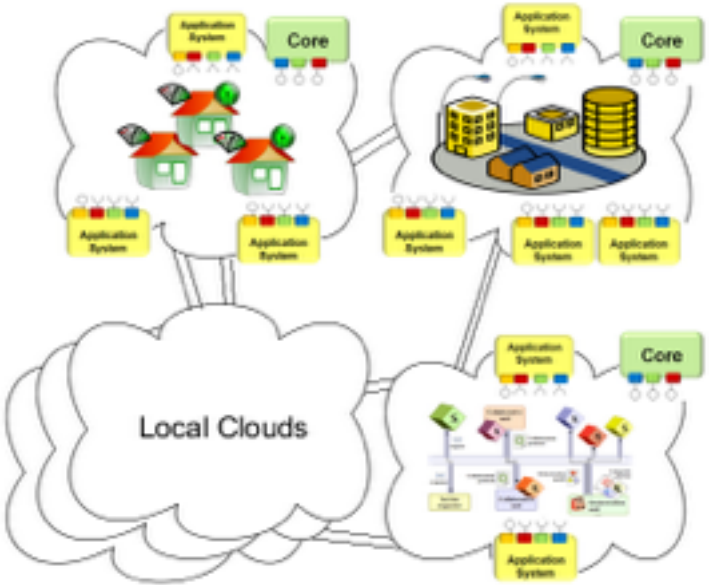

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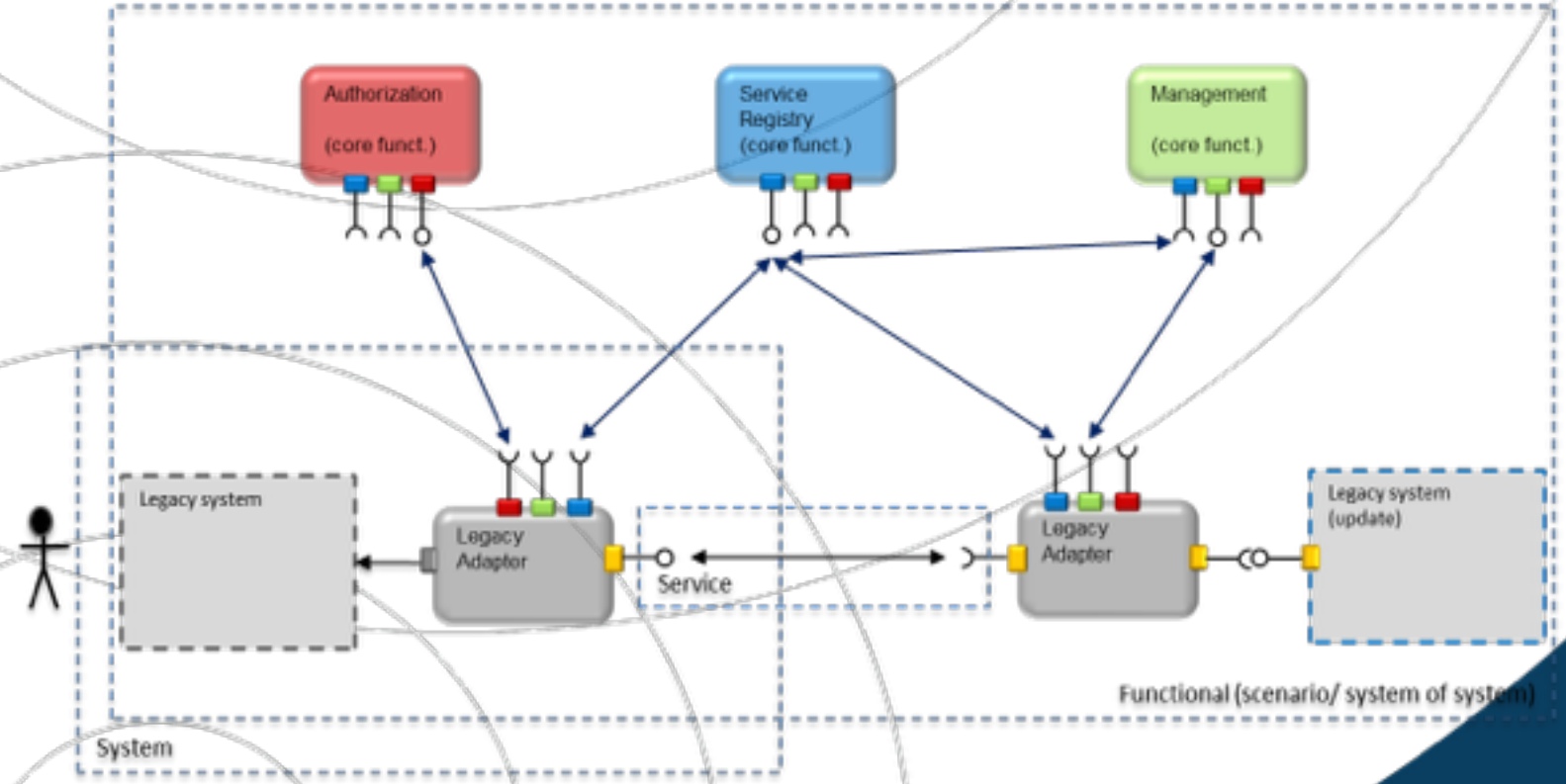
How to build local cloud?
Conceptual overview



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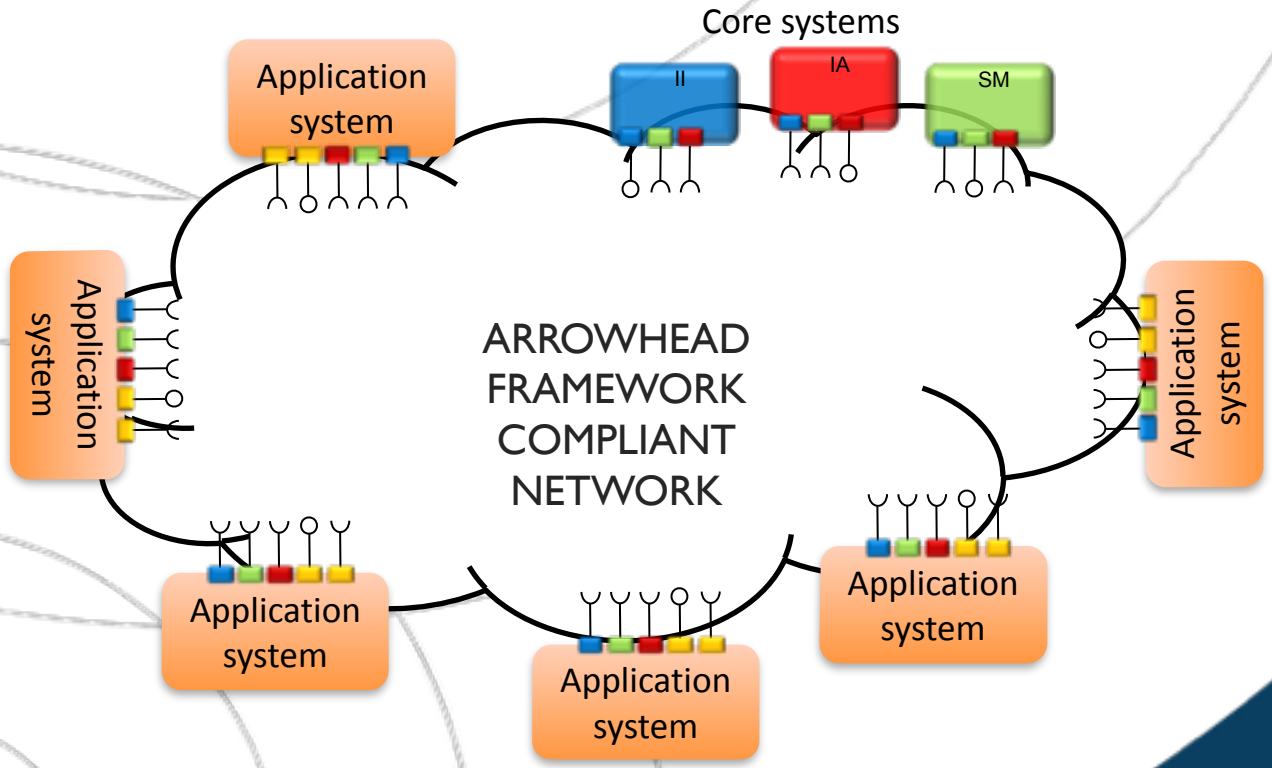
Core Functionalities serving System-of-Systems



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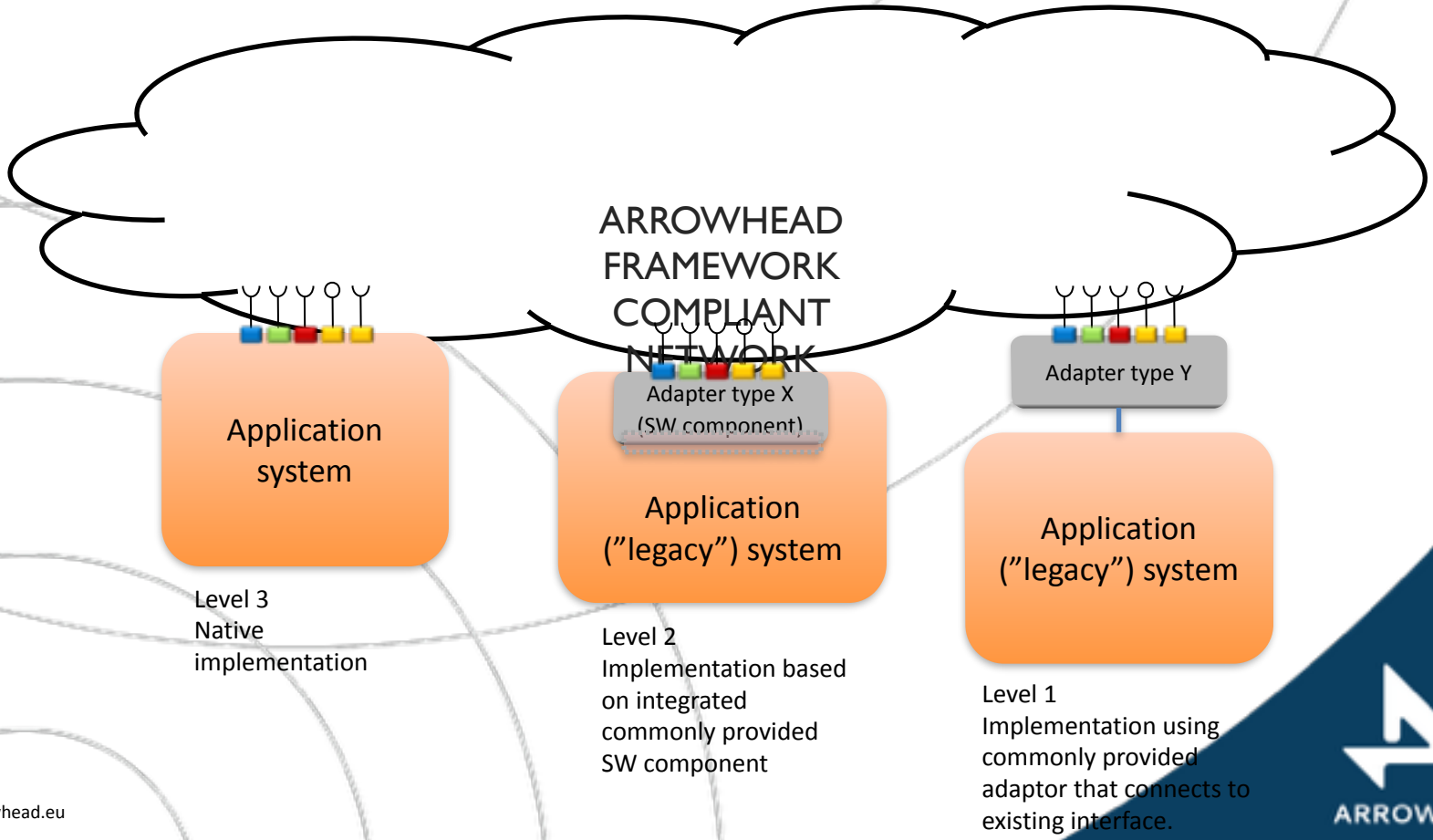
Maturity levels



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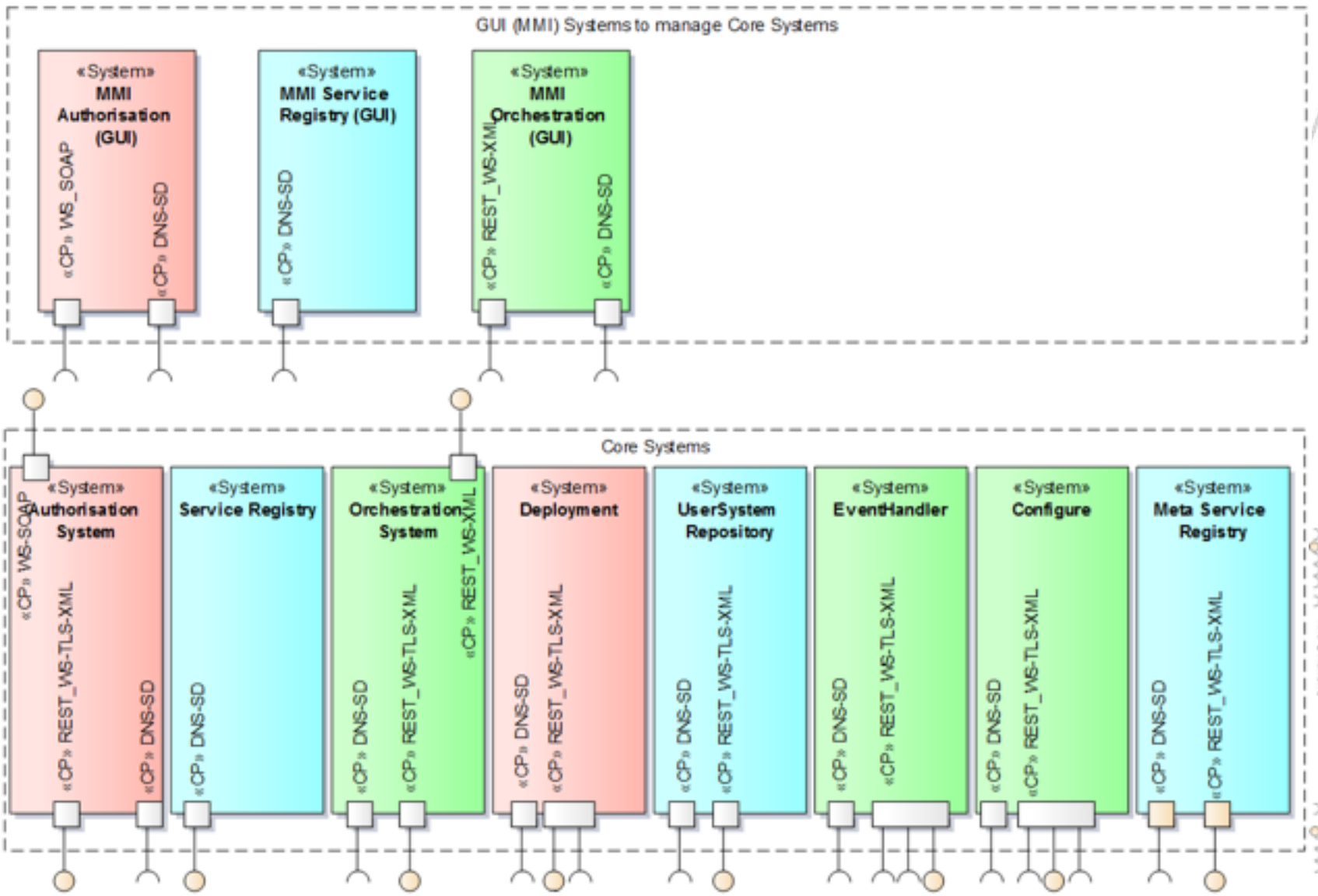

Application Systems

Three mandatory local cloud services

- Service registry system
- Authorisation system
- Orchestration system

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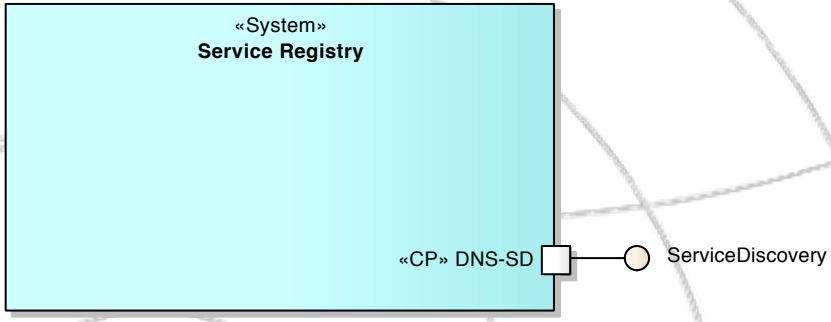
Service Registry

• supports a service registry functionality based on DNS and DNS-SD.

• all Systems within the network shall publish its producing service within the Service Registry by using the Service Discovery service



The Service Registry system consist of all active producing services within the network.

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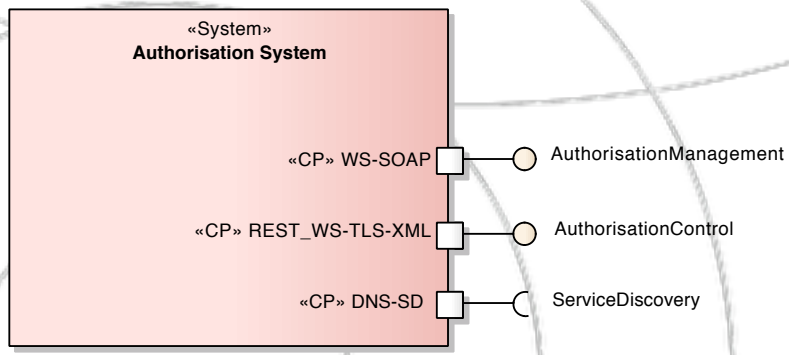
Authorisation System

- Authorisation Management service provides the possibility to manage the access rules for specific resources.
- Authorisation Control service provides the possibility to control the access for an external service to a specific resource.
- Service Discovery service uses the Service Discovery to publish the Authorisation Systems producing services within the Service Registry System.



The Authorisation System consists of access rules to system resources (i.e. services).

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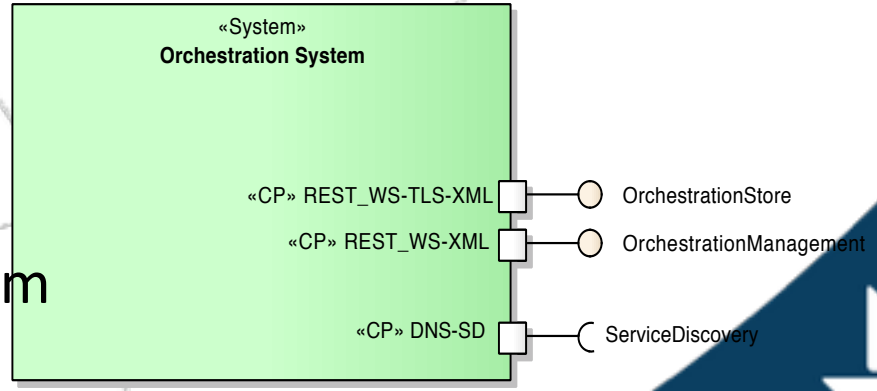
Orchestration System

- Orchestration Management service provides the possibility to manage the connection rules for specific services.
- Orchestration Store service provides the possibility to fetch configuration for a system.
- Service Discovery supports the publishing of the Orchestration Systems producing services within the Service Registry System.

The Orhestration System provides the functionality of manage connection rules (i.e. orchestration of the system of system composition).



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Arrowhead core systems

- Factory description system
- Deployment system
- Configuration system
- Event handler system
- Historian system
- Meta service registry system
- User registry system
- Quality of Service system

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Factory description system

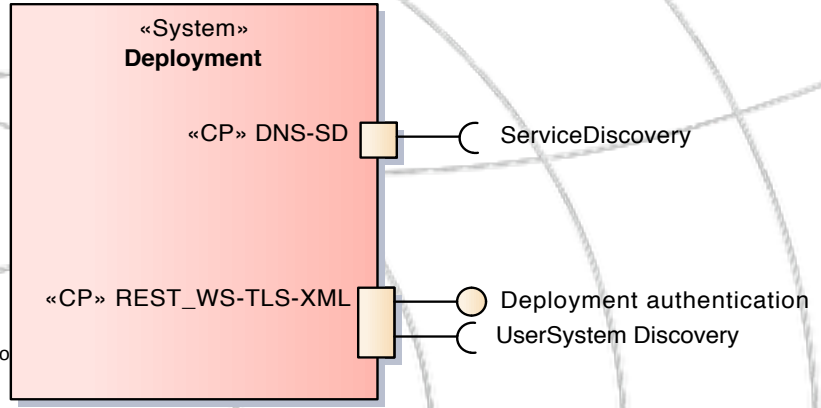
The purpose of the Plant description system is to provide a way to find Arrowhead devices and systems through browsable structures based on the physical systems the Arrowhead devices are connected to.

The first specification of this system is intended as a basic interface to present hierarchies and basic information about each object. It is intended to allow a user to find objects, physical or Arrowhead systems, based on either their physical location or based on their place in a functional context.

Deployment System

The purpose of the Deployment system is to automatically join pre-assigned new devices to a specific Arrowhead Framework enabled cloud and save installation/engineering time.

The idea is to allow an administrator of the local cloud to set conditions under which a factory issued identification key can be used to authenticate certain systems to allow distribution of more specific keys which then allows a system to connect to the Arrowhead framework without any detailed administration of the specific system.

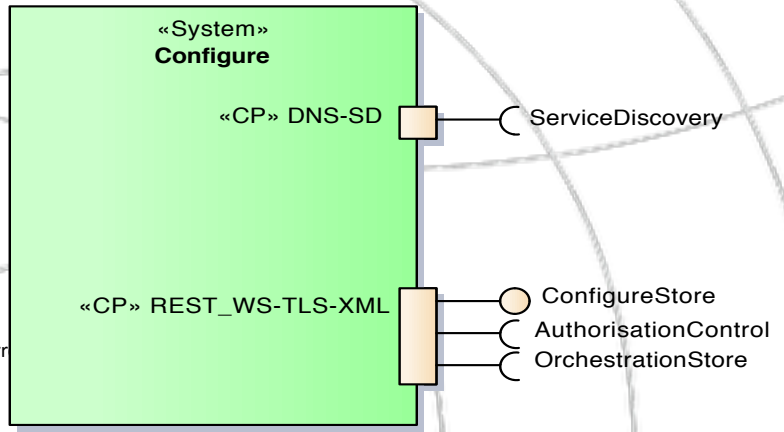


ARROWHEAD

Configure system

As the devices running Arrowhead compliant systems are loosely coupled and provided by different suppliers the engineering is expected to move to open or independent engineering platforms rather than those provided by hardware manufacturers. The Configuration system allows the configuration of systems from different system suppliers through a uniform service interface.

The Configuration system is designed so that the configuration possibilities are not limited by the service interface but allows all configurations that the configurable system is set to allow.



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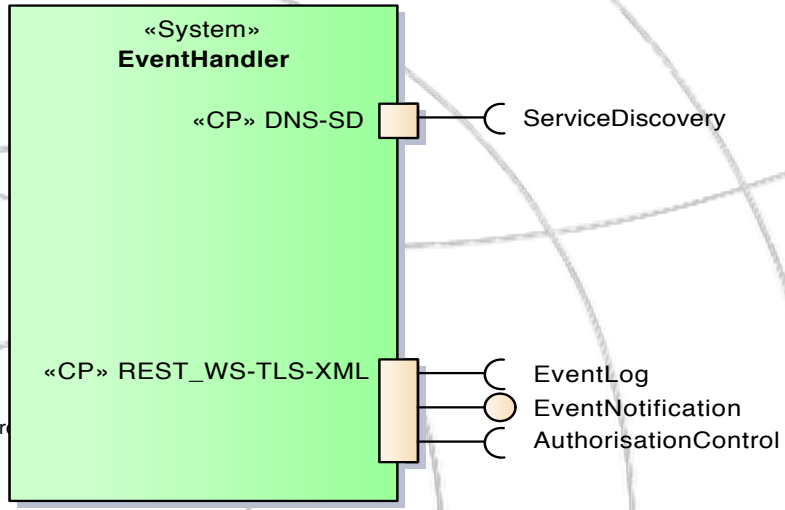
Event Handler

The Event Handler system searches and connects to published services of the type EventLog in the ServiceRegistry.

If a system have registered, by use of the EventNofication service, to listen on some specific type of event or system that log events, it will be notified of the specific event when it arrives at the EventLog service interface.



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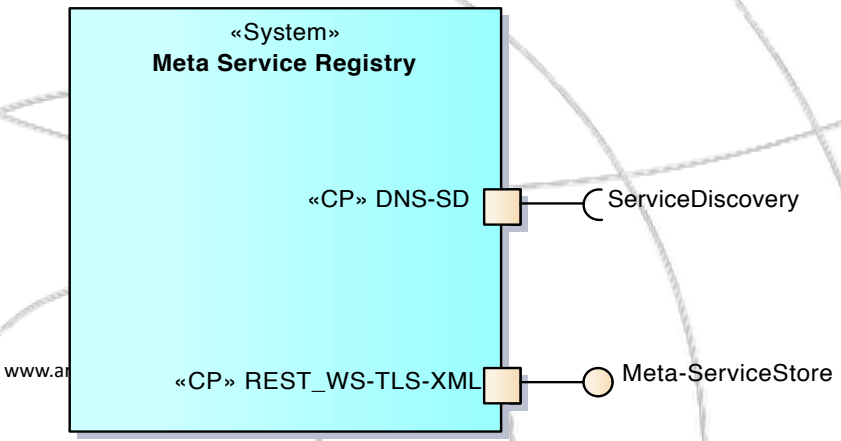
Historian

The Historian is used for storing large amounts of sensor data, as well as distributing messages from resource constrained devices to a large number of clients. The built-in support for Arrowhead Events enables the Historian service to log events and act as an intermediated event cache for device to device or service to service interaction. Thus the Historian behaves like a network cash for data from resource constrained devices.

Meta Service Registry

The Meta-Service system stores additional information about a service for offline/later access.

This system is a support system for the service registry for store additional information such as constraint information, up-time, or other specific information that can be valuable for the usage.



Arrowhead Meta Service registry

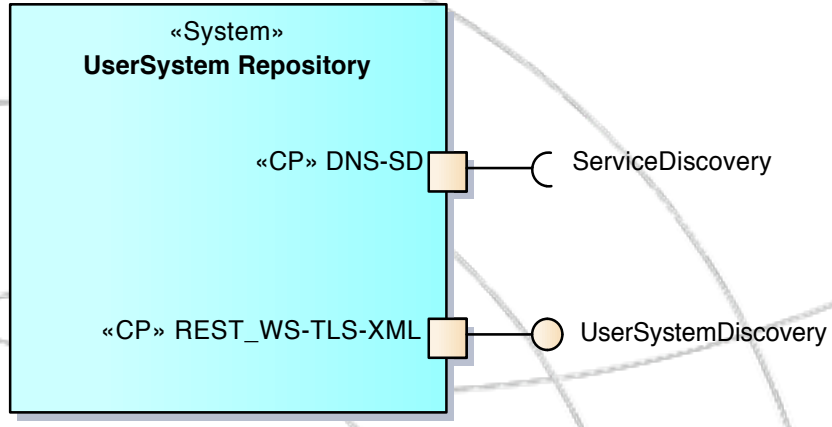
The Arrowhead MSR is primarily designed to work with resource-constrained and battery powered wireless devices, and contains metadata about services and devices, such as:

- Battery level, renewable energy sources
- Signal strength, network topology, current access point
- Bandwidth requirements and low-latency real-time communication using QoS
- Uptime, no reboots,
- Software and hardware revision, manufacturer
- etc.

ARROWHEAD

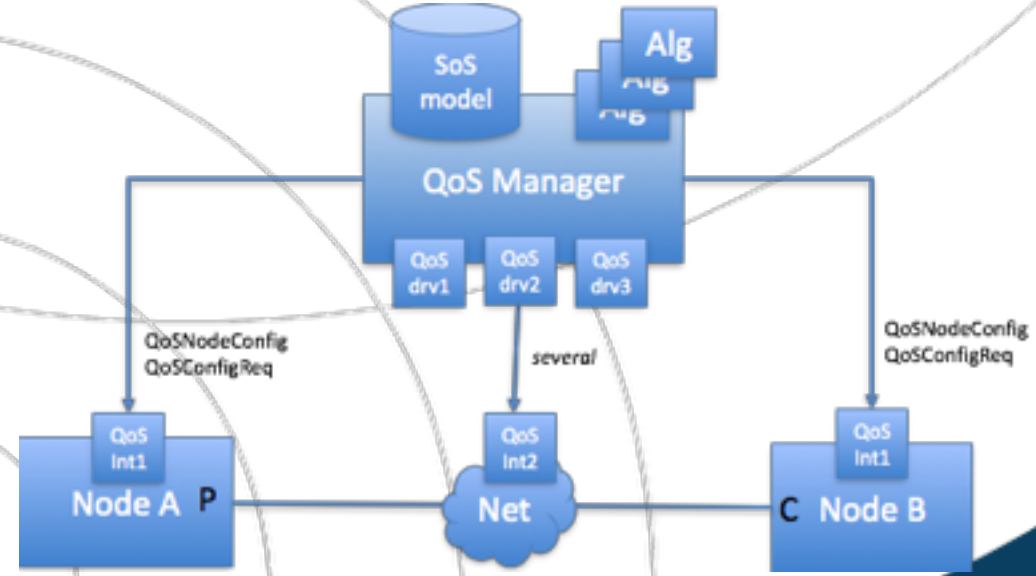
User / System Registry system

The User-System Registry system holds unique system identities for deployed systems within the Arrowhead network.



Quality of Service

The Quality of Service (QoS) approach takes care of handling requests from Service Consumers in order to guarantee the reservation of the network and/or computational resources and to give delivery guarantees to the communications with Service Producers.



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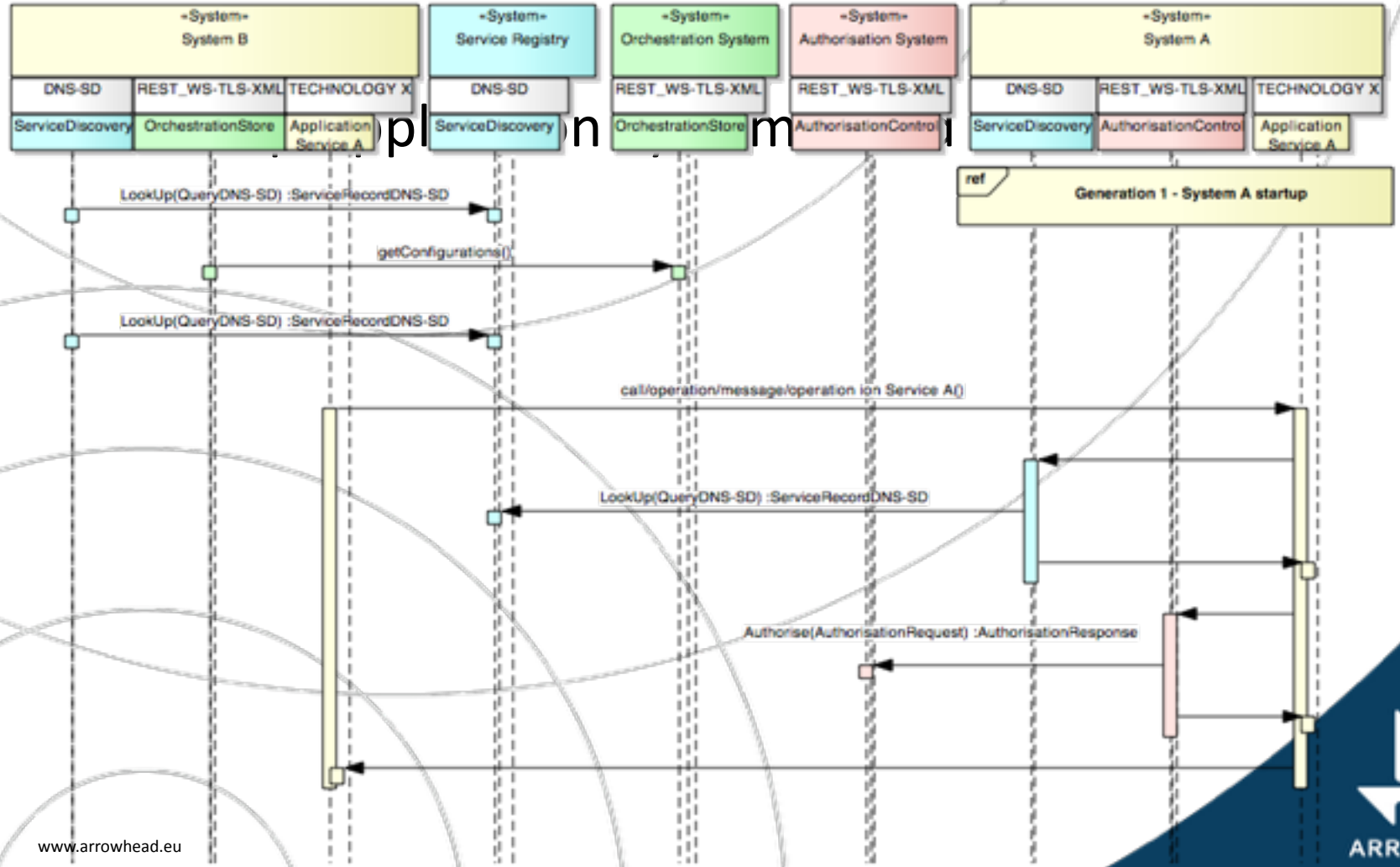
«System»
System B
DNS-SD
REST_WS-TLS-XML
TECHNOLOGY X
ServiceDiscovery
OrchestrationStore
Application Service A
«System»
Service Registry
DNS-SD
ServiceDiscovery
«System»
Orchestration System
REST_WS-TLS-XML
OrchestrationStore
«System»
Authorisation System
REST_WS-TLS-XML
AuthorisationControl
«System»
System A
DNS-SD
REST_WS-TLS-XML
TECHNOLOGY X
ServiceDiscovery
AuthorisationControl
Application Service A
ref
Generation 1 - System A startup
LookUp(QueryDNS-SD) :ServiceRecordDNS-SD
getConfigurations()
LookUp(QueryDNS-SD) :ServiceRecordDNS-SD
call/operation/message/operation ion Service A()
LookUp(QueryDNS-SD) :ServiceRecordDNS-SD
Authorise(AuthorisationRequest) :AuthorisationResponse

Necessary technology for large automation systems in the cloud

Robust communication, wired or wireless

IoT sensors, actuators, PLC:s, etc.

DCS and SCADA functionality’

MES and ERP functionality

Cloud integration technology

Engineering tools for cloud automation systems

Test tools and simulators for debugging

Migration of cloud automation into legacy production system

Suitable security

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Experiments made

Boliden 2011

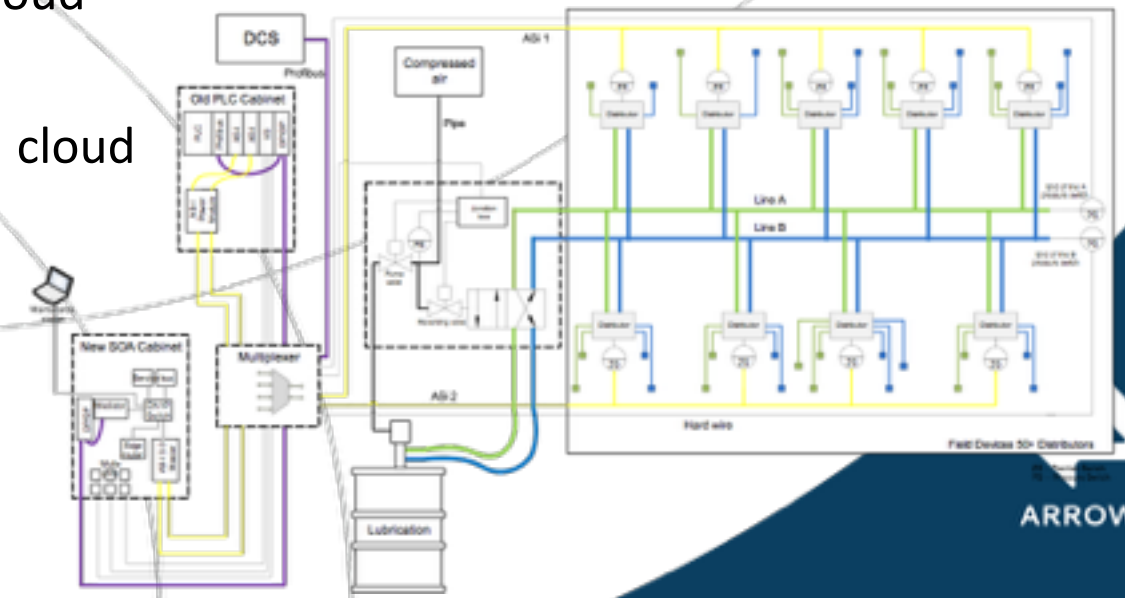
- Control over wireless link

Hydraulic control at damm in Tampere 2013

- PLC in a global cloud

LKAB 2013

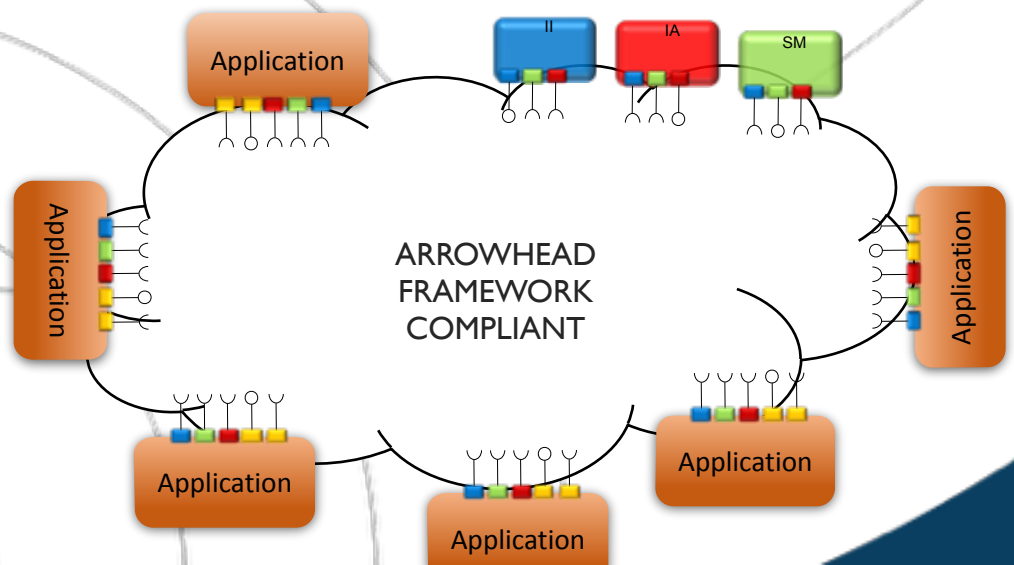
- SCADA in a local cloud



ARROWHEAD

Whats in the works Arrowhead

- Automation cloud integration technology - SOA based
  - Interoperability at service level across suppliers and technologies
  - Technology translation
  - Integration to legacy technology



ARROWHEAD

Whats in the works Arrowhead

- Automation cloud integration technology - SOA based
  - Interoperability at service level across suppliers and technologies
  - Technology translation
  - Integration to legacy technology
  - Development support, documentation, training
  - Development tools
  - Test tools
  - Open source working examples
  - Commercial actors offering products

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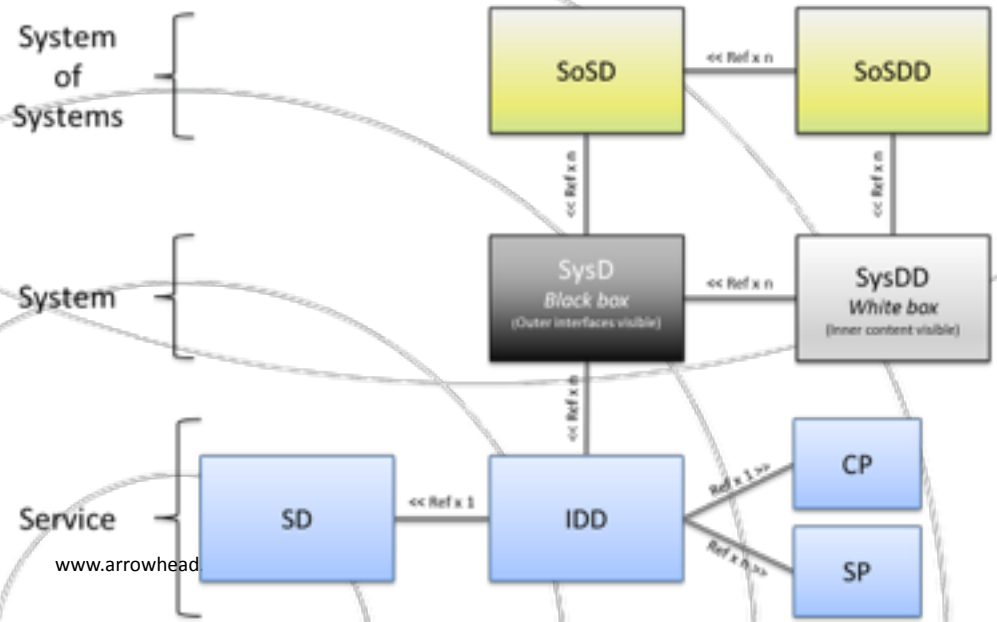
Whats in the works Arrowhead

Engineering tools for cloud automation systems

Development support, documentation.

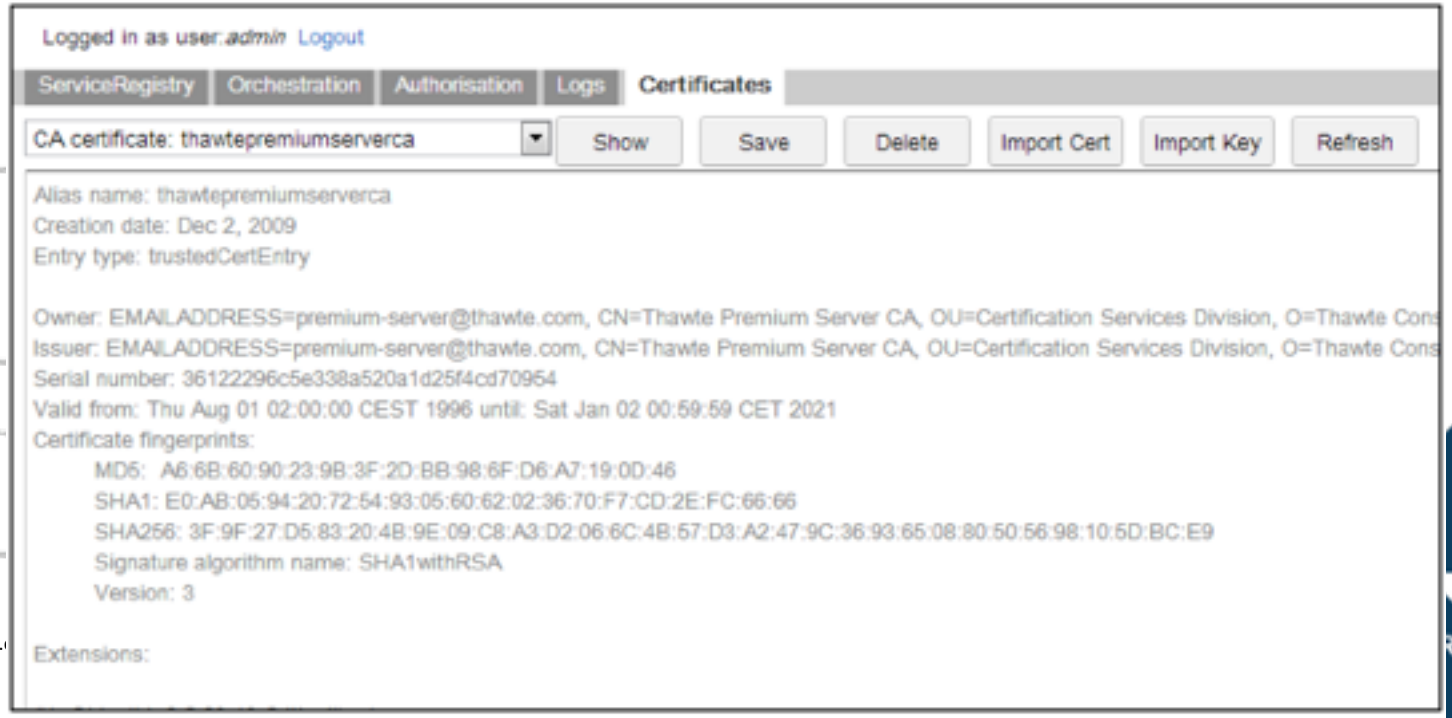


SoSD: System-of-Systems Description
SoSDD: System of Systems Design Description
SysD: System Description
SysDD: System Design Description
SD: Service Description
IDD: Interface Design Description
CP: Communication Profile
SP: Semantic Profile

ARROWHEAD

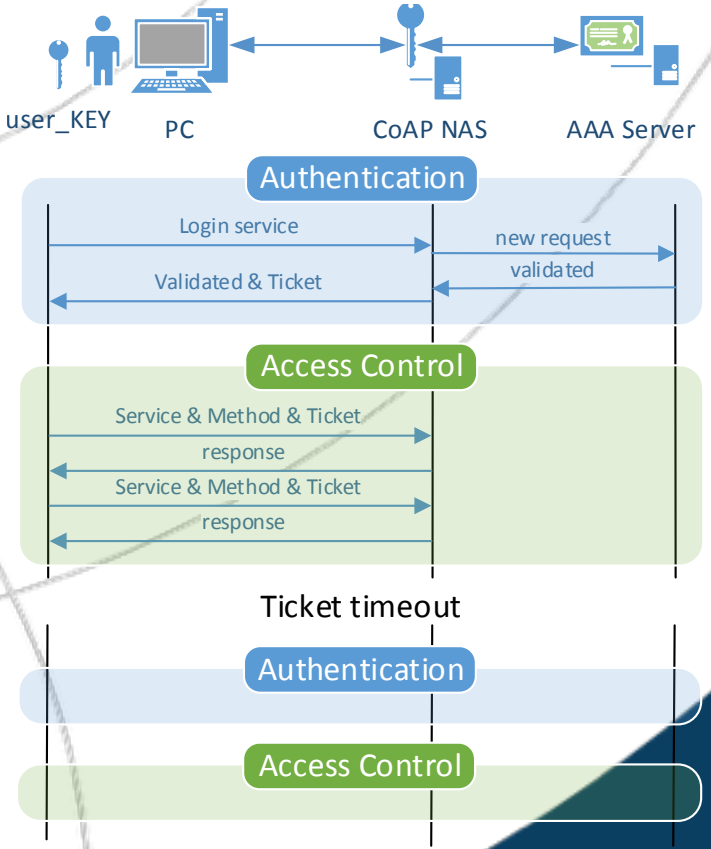
Whats in the works Arrowhead

- Development tools
  - Management tool



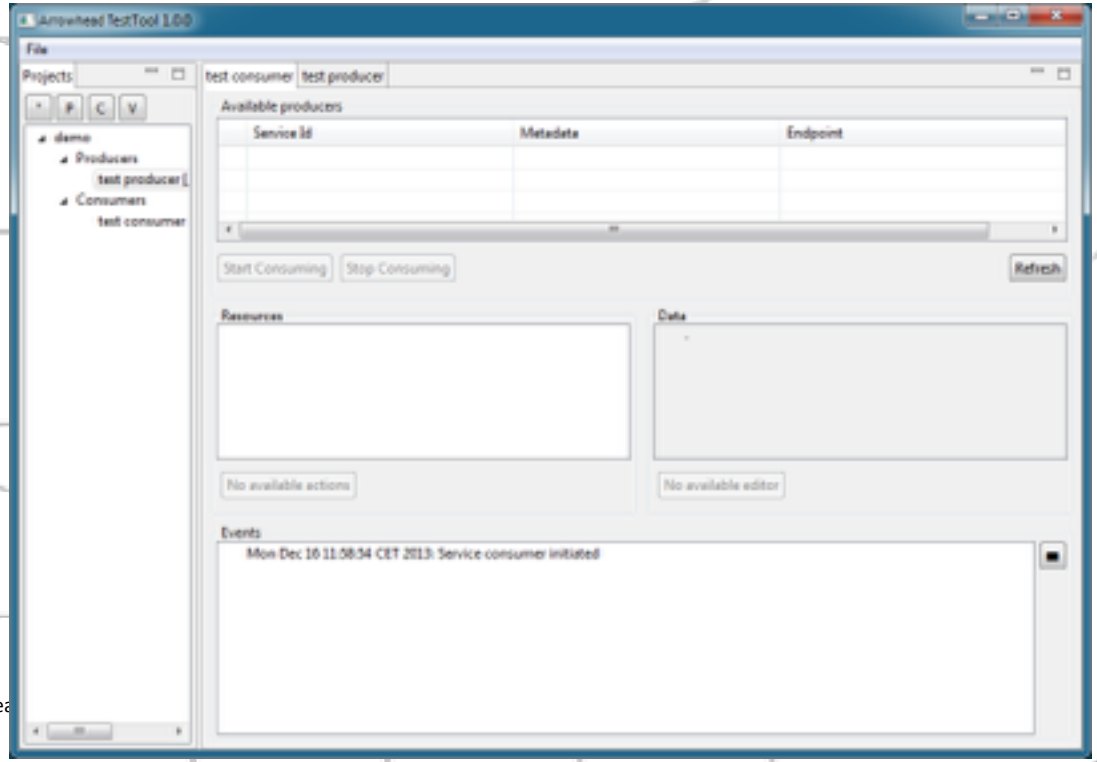
Whats in the works Arrowhead

- Security support
  - Security at service level
  - Data encryption



Whats in the works Arrowhead

- Test tools for cloud automation.



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Automation engineering

Automation is a service based on products

Simplicity of automation service engineering is market key

Arrowhead Framework reduces engineering time

From 5-6 days -> 6-8 hours (Abelko)

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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	➡Demonstrated in industrial env.
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	➡First products on the market

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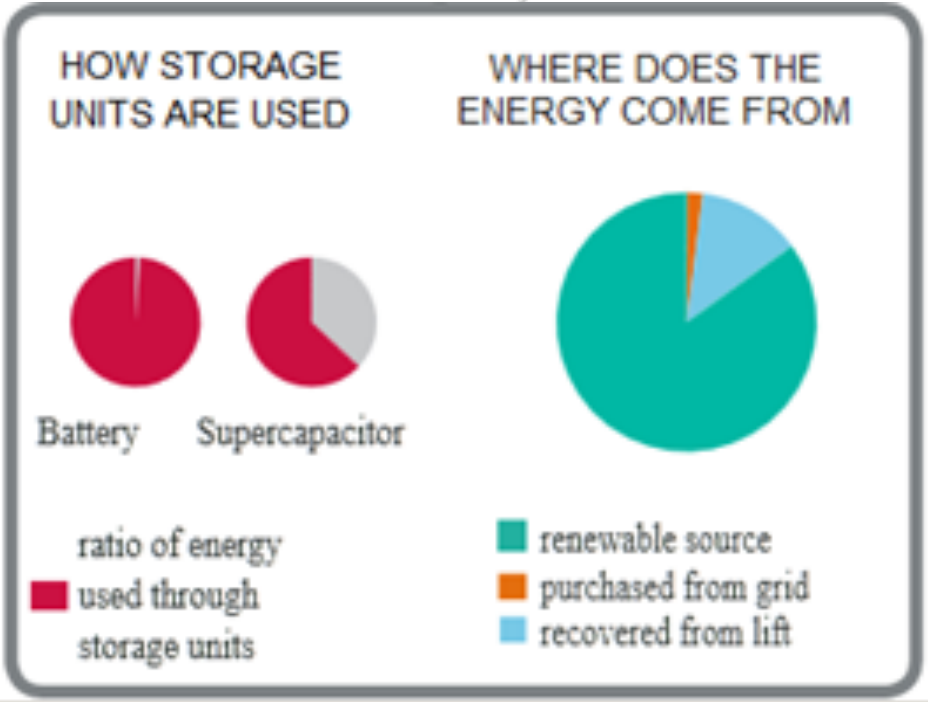
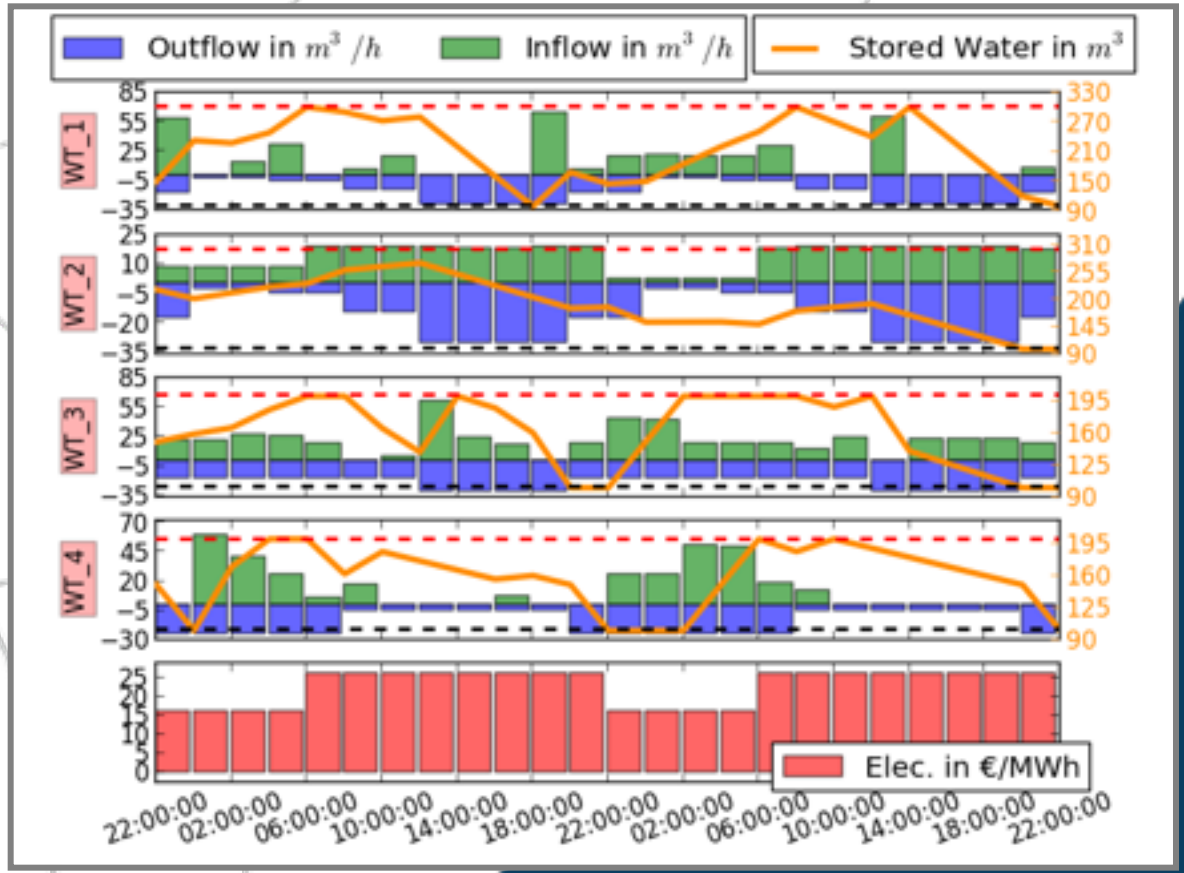
Lift micro grids

- Renewable - PV at building roof
- Recovery from lift operation
- Grid supply
- Use of 3 shared services: energy tariffs, prediction, energy planning
- Energy savings up to 65%



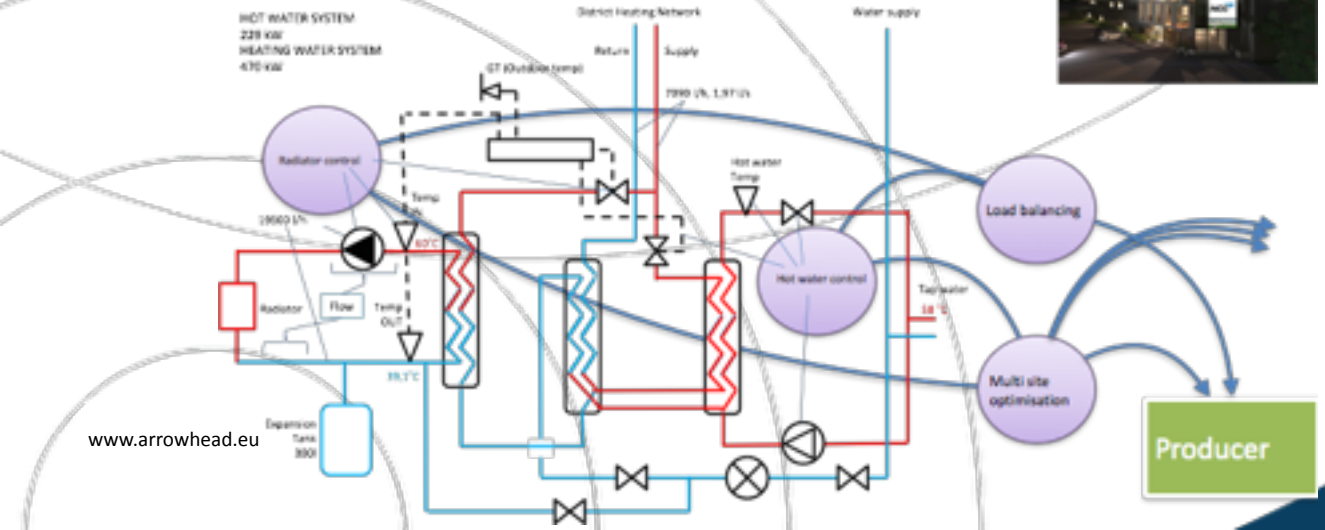
Water distribution grid

- Use of prediction service enables flexibility in energy demand
- Energy savings 15%



Load balancing - Luleå Sweden

- Adaptive control curve service
- Load balancing of individual building peek energy demands service
- Multi site optimisation service
  - Interacting with load balancing and the adaptive control curve
- Stena (housing company) claims 5% savings in energy usage.



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Arrowhead Framework

- Public by fall 2015

- Documentation
- Cookbook
- Support wiki
- Core system code
- Tools -Open source and commercial
- Sample automation services - code

ARROWHEAD

Critical platform technologies

Security - scalable and flexible security solutions

Latency - how provide "clouds" with latency “guarantees"

Dynamics/Continuous - engineering, configuration and deployment

Scalability - for massive numbers of resource constrained IoT and CPS devices

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Critical system properties

- Trust in cloud automation systems

- Real life - at scale - demonstrators enables
  - Standards,
  - Society and political acceptance

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Conclusions

- Very **large scale** IoT system of systems
- Critical automation **trust** requires
  - Latency control and Security
  - Scalability
  - Ease of continuous engineering
- Solutions enabling **dynamic** automation systems:
  - Design and Engineering
  - Deployment, Operation and Maintenance

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Arrowhead.eu

an

Artemis and ProcessIT.EU project

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