Automation System of Systems built on IoT
Arrowhead Framework: concepts and basic architecture

Professor Jerker Delsing
Luleå University of Technology, Sweden
IoT Product Segments

Conveyor (Tier2) Components and Parts (Tier3)

- Drive Heads
- LTU & Winches
- Belt Structure
- Belting
- Pulleys
- Feeder Breakers
- Components (a.u. idlers, motors, etc.)

Suppliers of these Products are:

- Potential partners, and;
- Future Service Providers

One customer, KGHM, one component

- 120 km conveyers
- 720,000 idler bearings
Collaborative automation

A European Roadmap for Industrial Process Automation
based on global trends and industrial needs. www.ProcessIT.eu
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.
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
ISA-95 systems in to the cloud?
Arrowhead approaches

- TCP/IP everywhere, middleware nowhere.
  - Internet of Things - IoT
  - System of systems - SoS

The Integrating approach
- Service Oriented Architectures - SOA
Classical automation system characteristics

- Centralised controllers, DCS, SCADA, PLC,
- Pull based - time slotted streaming of all data
- Hard real time
- Design time bindings

Seams to have an upper bound of $X \times 10^5$ I/O’s
Cloud based automation systems

- Choice of centralised or distributed control and data to information computations
- Push on event or pull
- Late binding - runtime binding
- Hard real time?
The global cloud approach

A Survey of Commercial Frameworks for the Internet of Things. Hasan Derhamy, Jens Eliasson, Jerker Delsing, and Peter Priller, SOCNE workshop at ETFA 2015, Luxemburg
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

- Inter cloud actions are necessary and possibly secure!

www.arrowhead.eu
IoT - properties

- Things comes and goes
- May have limited bandwidth
- May have limited energy supply

Integration of IoT systems have to be dynamic
  - Based on demand and availability
Cloud integration of any IoT device

- Communication HW
  - Existing commercial technology

- Providing support for local clouds
  - Arrowhead Framework: mandatory core systems

- Providing support for automation functionalities:
  - Arrowhead Framework: core systems

- Providing support for multiple SOA protocols
  - Arrowhead protocol transparency system
Arrowhead Framework - support for: System of systems in a local cloud

- Mandatory core systems:
  - Information infrastructure
  - System management
  - Information assurance

ARROWHEAD FRAMEWORK COMPLIANT NETWORK

Application system

ARROWHEAD
How to build local cloud?
SOA - Abstracting IoT data to services

Services are produced
Services are consumed

Service producer
IoT System A

Application service

Service Consumer
IoT System B

Exchange information
How to build local cloud?
Fundamental conceptual overview
Startup Application System B and establish connection
Hard real time IoT 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 - Standardised by W3C

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EXIP: A Framework for Embedded Web Development
In: ACM Transactions on the Web. 8, 4, 29 p.23
Arrowhead core systems

- Plant description system
- Deployment system
- Configuration system
- Event handler system
- CEP system
- Historian system
- Meta service registry system
- User registry system
- Certificate distribution system
- Quality of Service system
- Technology/protocol transparency system
- Semantics transparency system
- Service inventory system
Real time local cloud automation & inter cloud automation
Engineering of IoT automation systems
a System of systems approach

- Plant description system
- Orchestration of services
  - Dynamics supported by CEP
- Configuration system
- Authorisation system
- QoS system
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
Can we build Arrowhead automation systems today?

Robust communication
IoT sensors, actuators, PLC:s, etc.
DCS and SCADA functionality
MES and ERP functionality

Cloud integration technology
Engineering tools cloud automation
Test tools and simulators
Migration to cloud automation
Suitable security

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

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Arrowhead Framework

Public by fall 2015

Wiki at forge.soa4d.org/projects/arrowhead-f
  - Documentation
  - Cookbook
  - Mandatory core systems: images and code
  - Tools
    - System management, orchestration etc.
  - Test tool
  - Sample simple service - code
  - Sample automation services - code

Selected/interested people to be invited for pre-usage!
Load balancing - Luleå Sweden

- Adaptive control curve service
- Load balancing of individual building peak 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.
Automation implementations

- 18 automation demos and 12 seminar presentations are prepared for
  - ECS fair, Stockholm Nov 3-4 2015.
  - Smart Production
  - Samt Building
  - Smart Energy efficiency
  - Smart Mobility

- Arrowhead Framework reduces engineering time
  - From 5-6 days -> 6-8 hours (Abelko)
  - From 4-5 weeks -> 1 week (BnearIT)
Conclusions - Critical platform properties

Security
- Scalable and flexible security solutions

Latency
- Provide local clouds with latency “guarantees"

Dynamics/Continuous
- Engineering, orchestration, configuration and deployment

Scalability
- For massive numbers of resource constrained IoT and CPS devices
Conclusions - Critical system properties

- Trust in cloud automation systems
- Real life - at scale - demonstrators enables
  - Standards,
  - Society and political acceptance
Arrowhead Vision

Enable collaborative automation by networked embedded devices.

I do think we are well on our way!!!
Arrowhead.eu
an
Artemis and ProcessIT.EU project

gerker.delsing@ltu.se