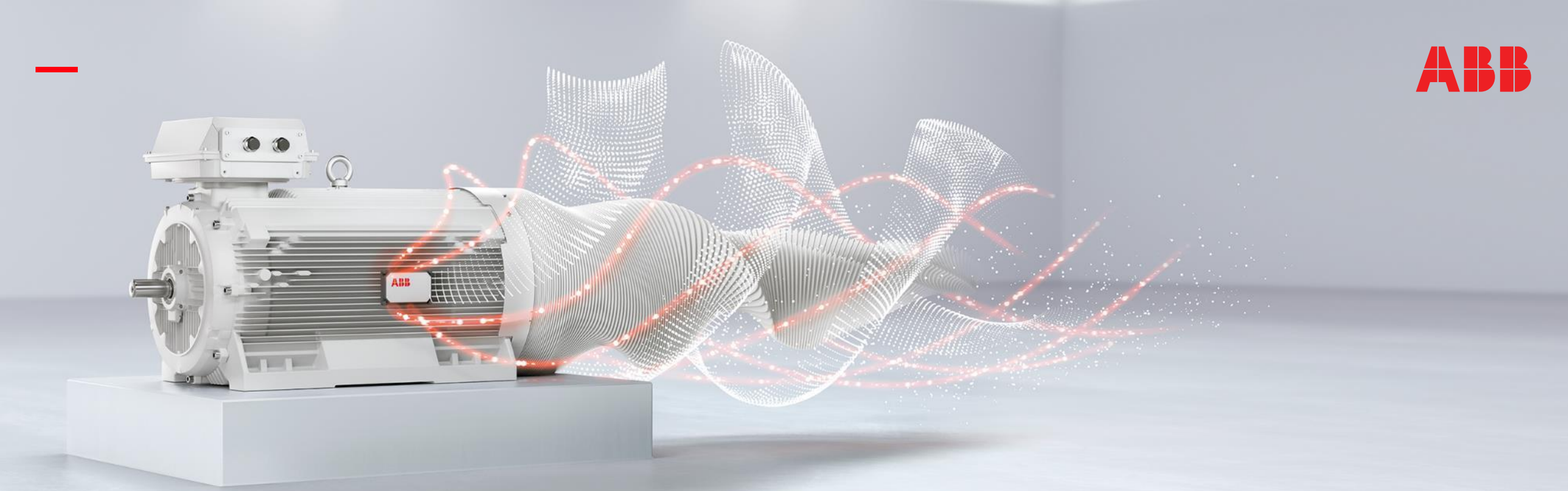


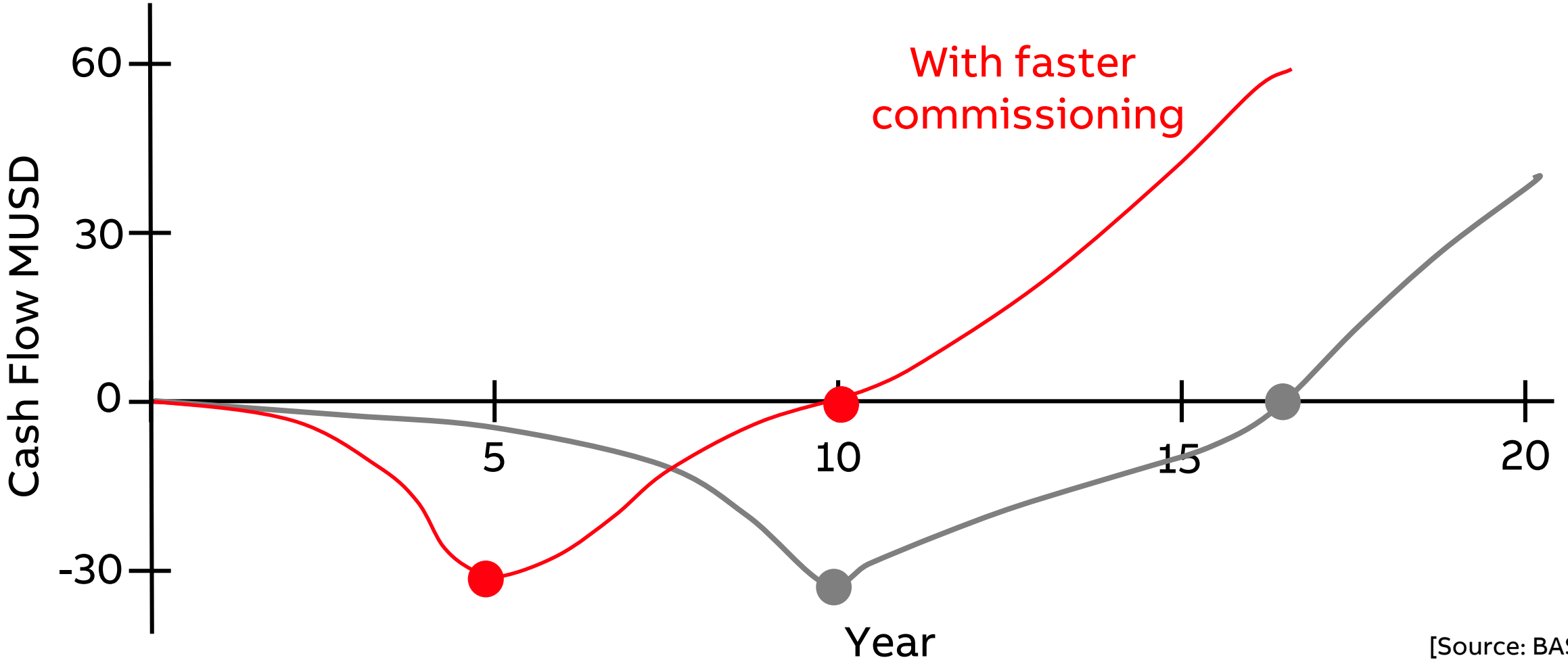
Self-commissioning Industrial IoT Systems

Heiko Koziolek

Senior Principal Scientist, ABB Corporate Research Ladenburg

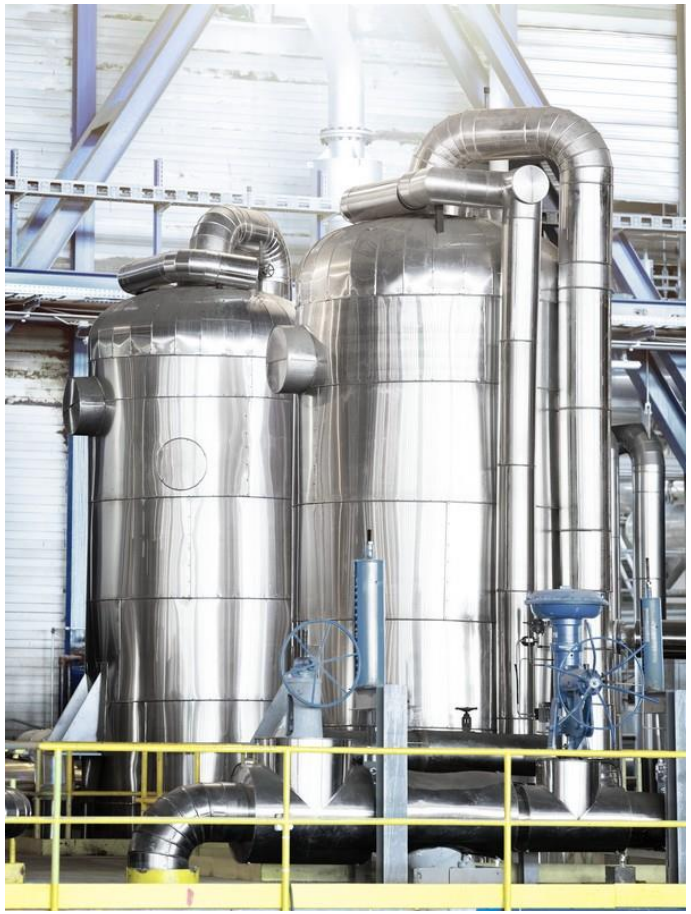

ABB
Feed In
Sand
Iron Ore
Bauxite
Preheat
E.P. Heating / Compressor
Central Air Supply
Silo Discharge / Homogen
Aux.Drive For Mill Motor
Raw Mill Trns. Aerapol
Raw Mill Transport
Separator and Circulation
Waste Gas Fan
Electrostatic Precipator
Hot Gas Generator
Mill Motor
Mill Feeding
Discharge
Lubrication

Chemical Plant: Typical Investment



[Source: BASF]

Typical Control Loop Example

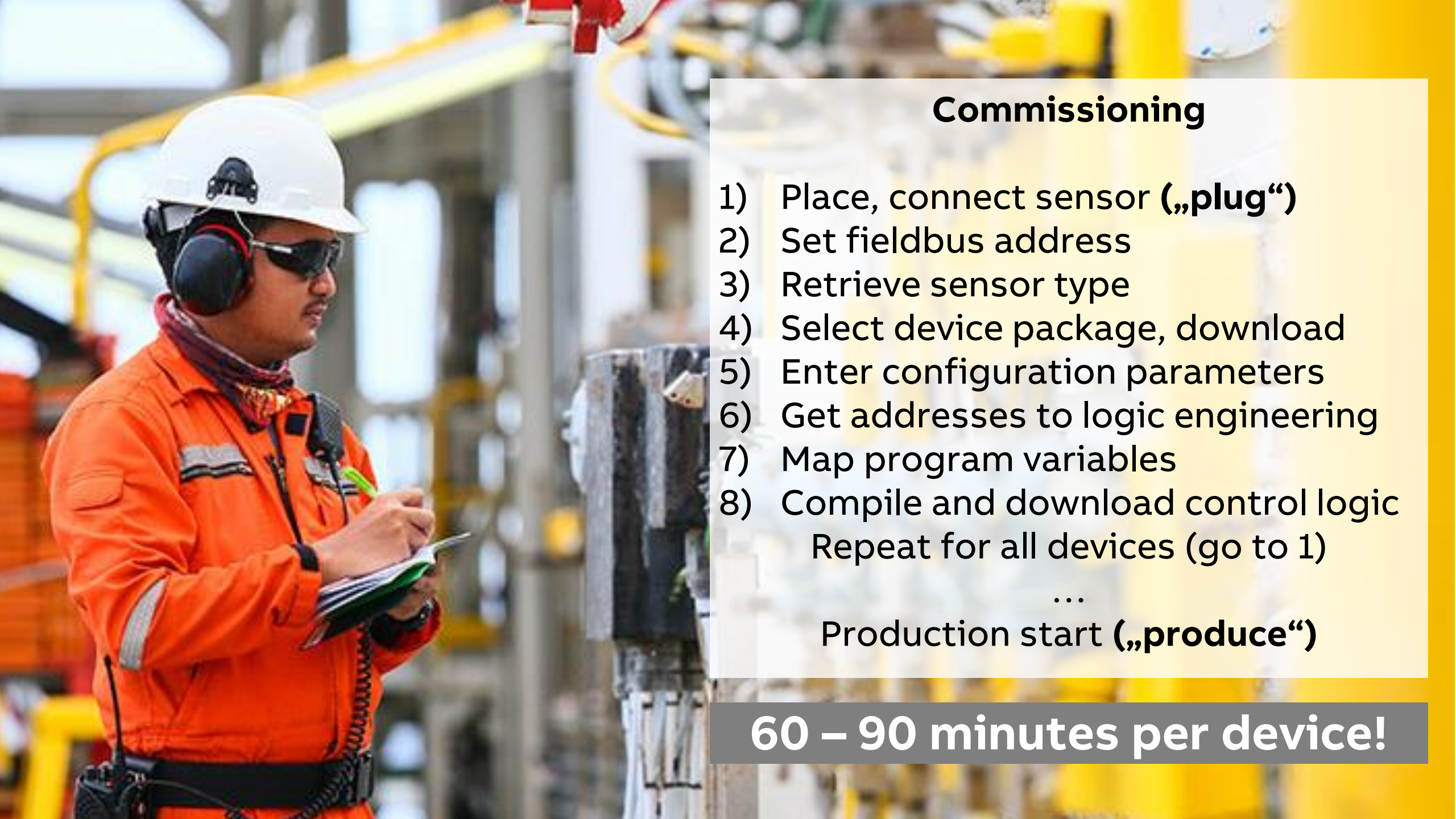


Industrial Boiler

Laser Level Transmitter

Automation Controller

Pneumatic Valve



Commissioning

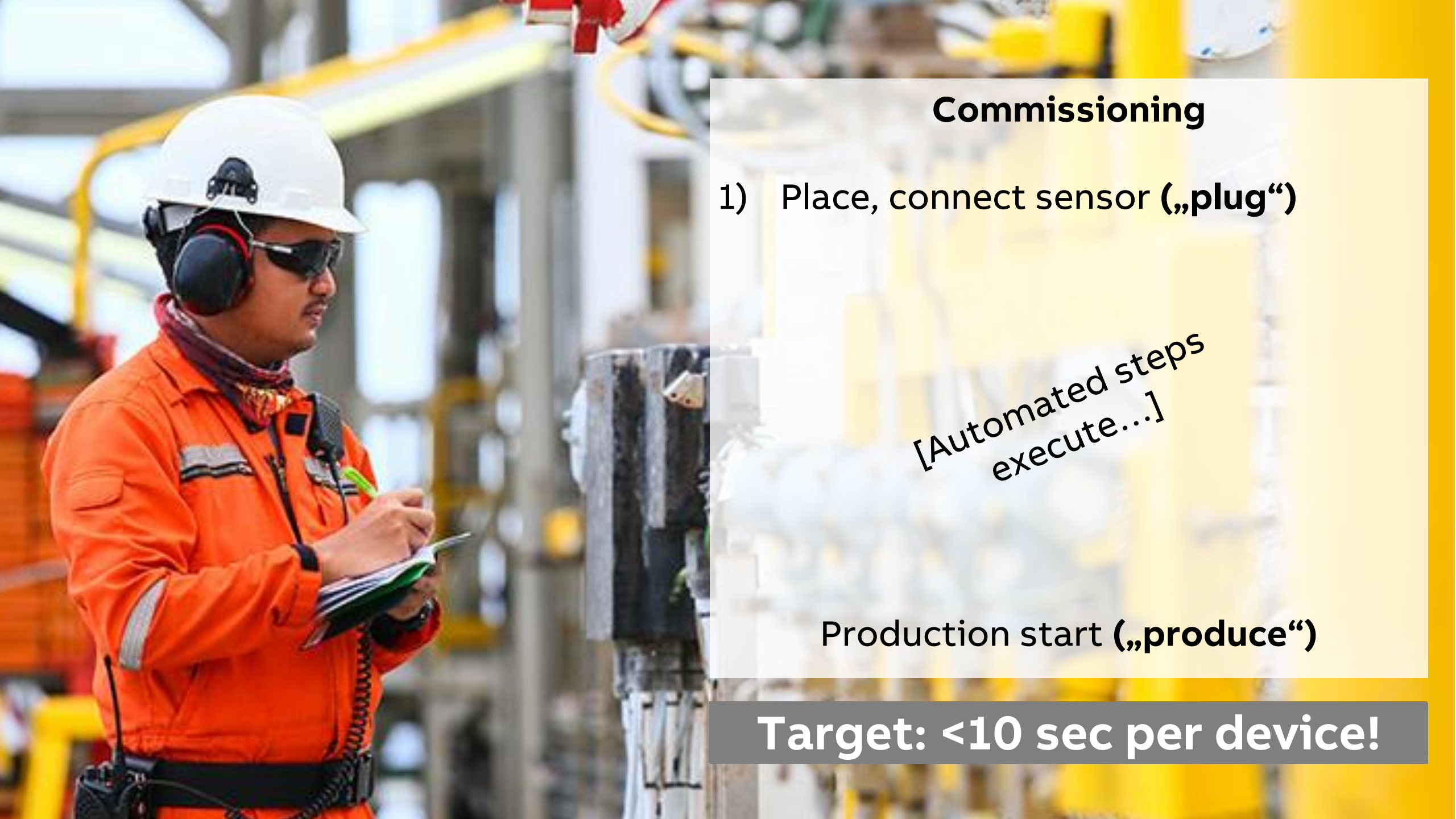
1) Place, connect sensor **(„plug“)**
2) Set fieldbus address
3) Retrieve sensor type
4) Select device package, download
5) Enter configuration parameters
6) Get addresses to logic engineering
7) Map program variables
8) Compile and download control logic

Repeat for all devices (go to 1)

…

Production start **(„produce“)**

60 – 90 minutes per device!



Commissioning

1) Place, connect sensor **(„plug“)**

[Automated steps execute…]

Production start **(„produce“)**

Target: <10 sec per device!

Plug & Produce

Industrial Boiler

Requirement 1: Automated Network Discovery

Laser Level Transmitter

Requirement 3: Automated Signal Matching

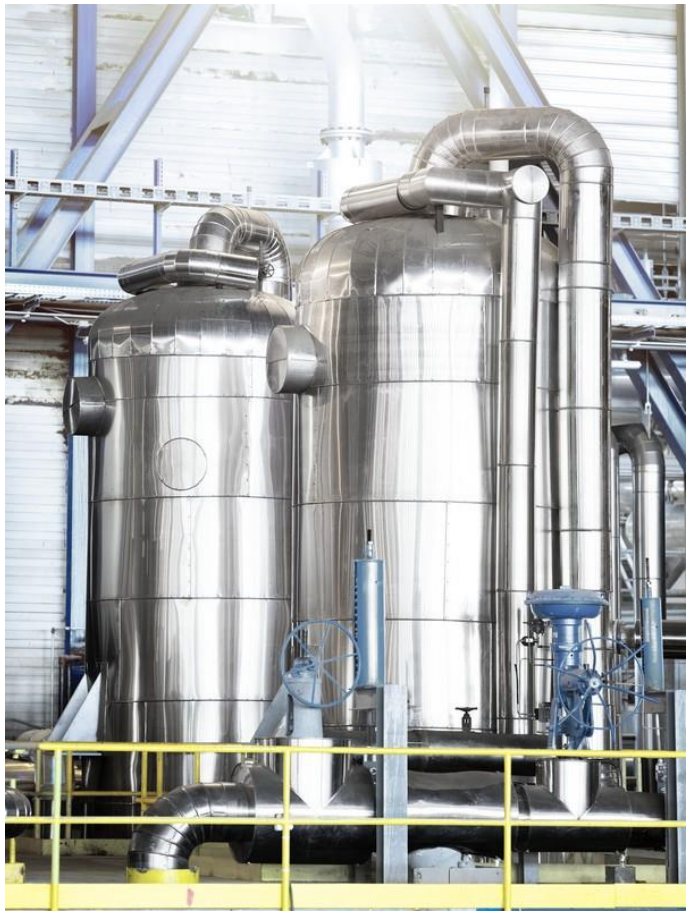
Automation Controller

Requirement 4: Real-time Communication

Requirement 5: Human Approval Step

Requirement 2: Standardized Device Descriptions

Plug & Produce



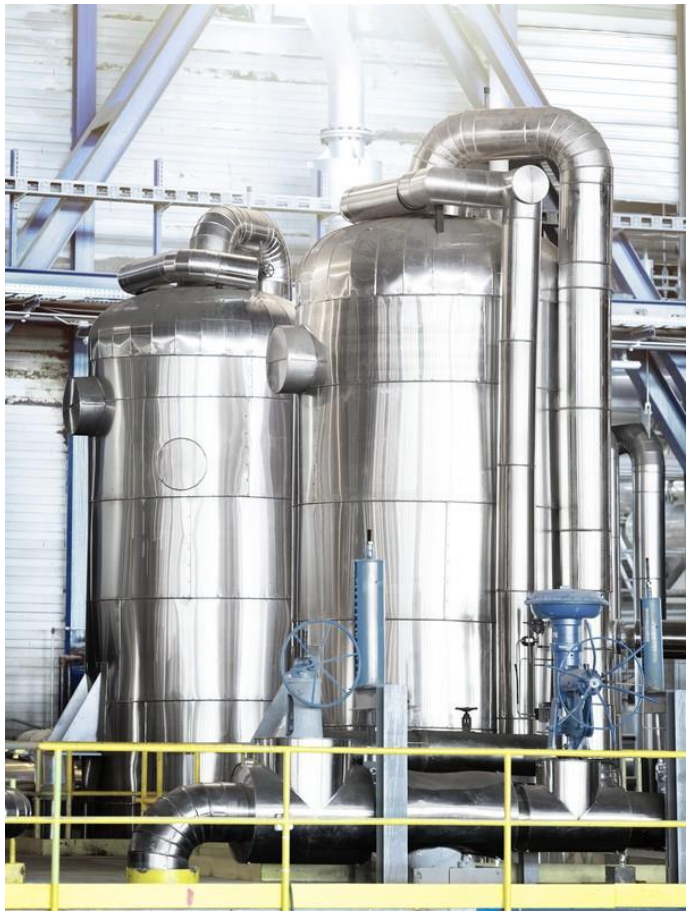
Industrial Boiler

Laser Level Transmitter

Automation Controller

Pneumatic Valve

Plug & Produce Architecture



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

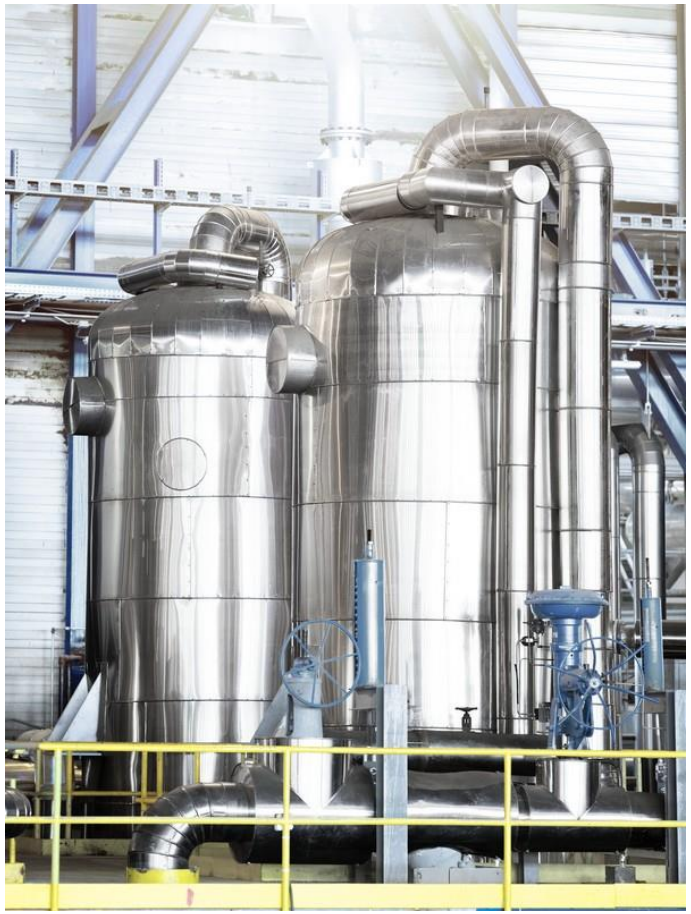
OPC UA CLIENT & SERVER

Automation Controller

OPC UA SERVER

Pneumatic Valve

Plug & Produce Architecture



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

OPC UA CLIENT

Plug & Produce Software Service

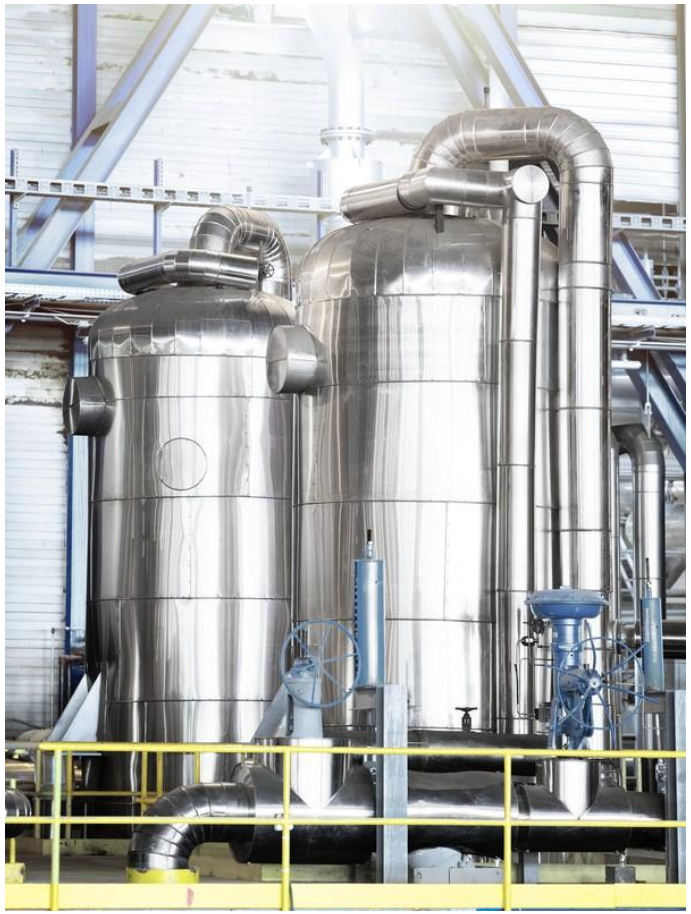
OPC UA CLIENT & SERVER

Automation Controller

OPC UA SERVER

Pneumatic Valve

Plug & Produce Architecture



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

OPC UA CLIENT

Plug & Produce Software Service

Our Main Contribution

OPC UA CLIENT & SERVER

Automation Controller

OPC UA SERVER

Pneumatic Valve

OPC UA: IEC 62541

Industrial Internet-of-Things Connectivity and Information Modeling

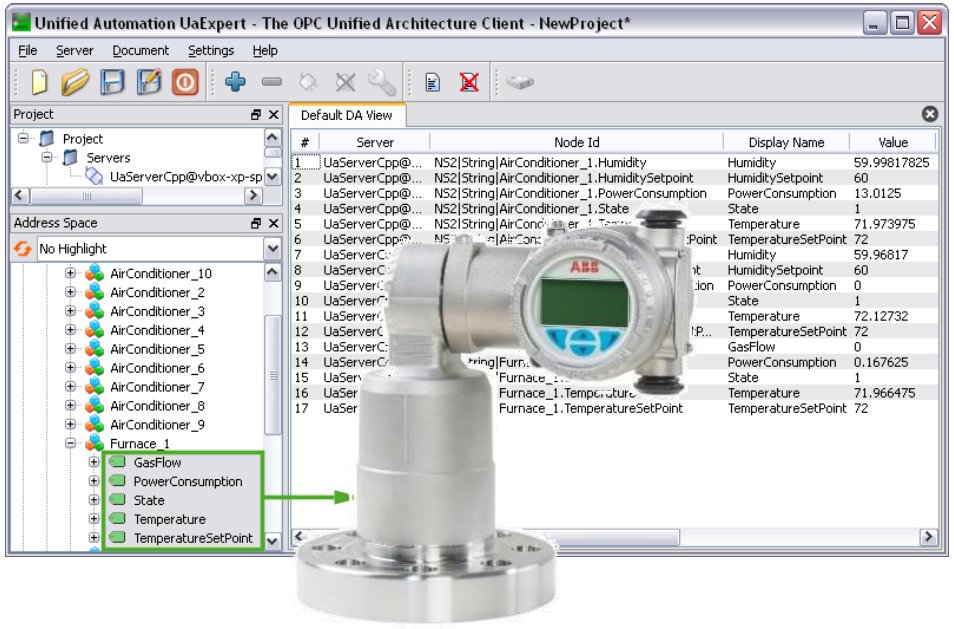
Features

Communication: HTTP, UA Binary, AMQP, …

Platforms: Windows, Linux, VxWorks, …

Object-oriented Model: Static, dynamic, …

Services: Connect, Subscribe, Alarms, History, …



Laser Level Transmitter

OPC UA recommended by Plattform Industrie 4.0, enables path to the cloud.

Plug & Produce

Industrial Boiler

Requirement 1: Automated Network Discovery

OPC UA SERVER

Laser Level Transmitter

Requirement 3: Automated Signal Matching

OPC UA CLIENT & SERVER

Automation Controller

OPC UA CLIENT

Plug & Produce Software Service

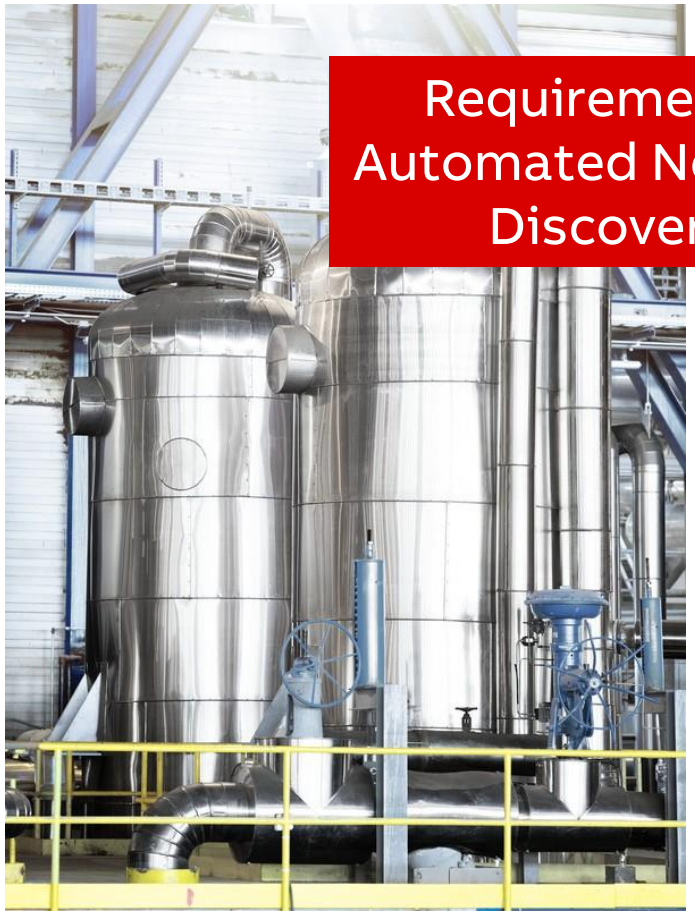
Requirement 2: Standardized Device Descriptions

OPC UA SERVER

Requirement 4: Real-time Communication

Requirement 5: Human Approval Step

Plug & Produce



Industrial Boiler

Requirement 1:
Automated Network
Discovery

OPC UA SERVER

Laser Level
Transmitter

OPC UA CLIENT

Plug & Produce
Software Service

OPC UA CLIENT & SERVER

Automation Controller

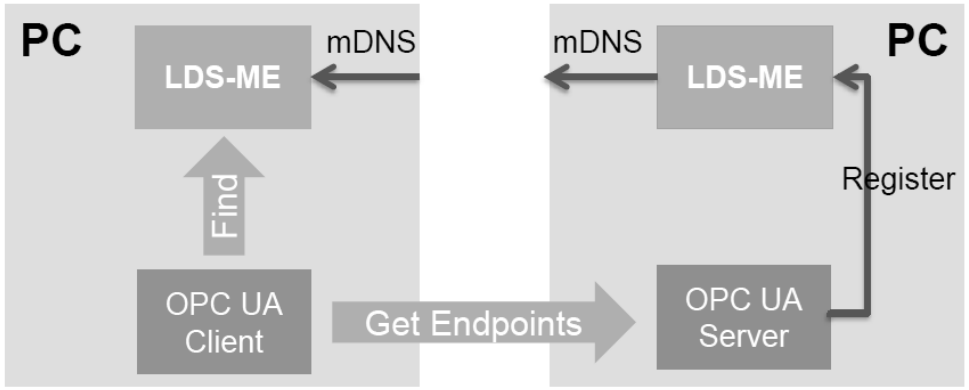
OPC UA SERVER

Pneumatic Valve

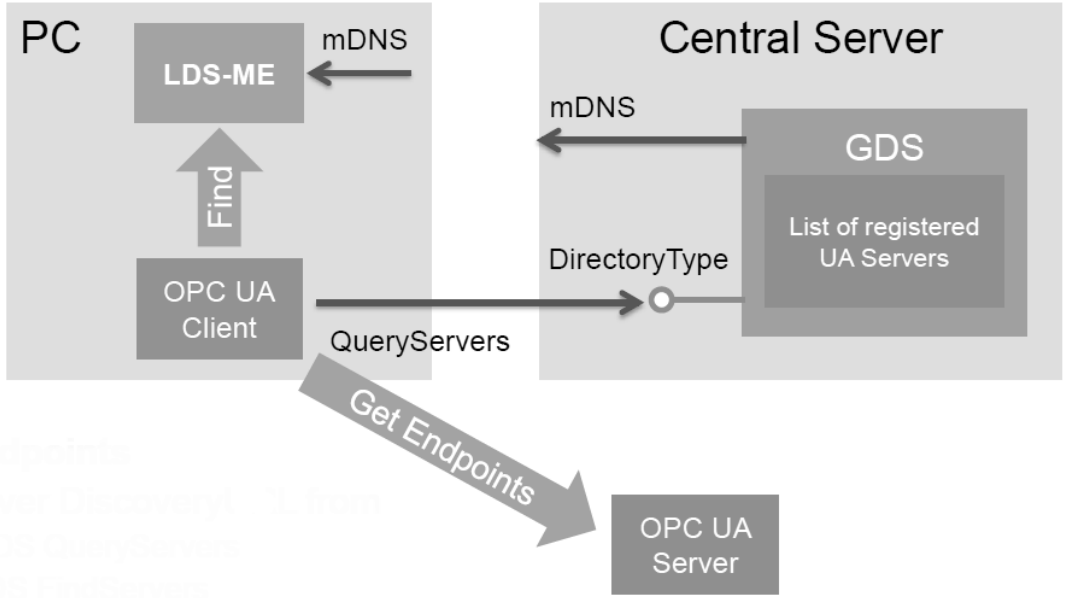
OPC UA Discovery

IEC 62541-12

Local



Global



[Source: OPC Foundation]

Multiple ways to discover OPC UA Servers on field devices and controllers.

Plug & Produce

Industrial Boiler

Requirement 2: Standardized Device Descriptions

OPC UA SERVER

Laser Level Transmitter

OPC UA CLIENT

Plug & Produce Software Service

OPC UA CLIENT & SERVER

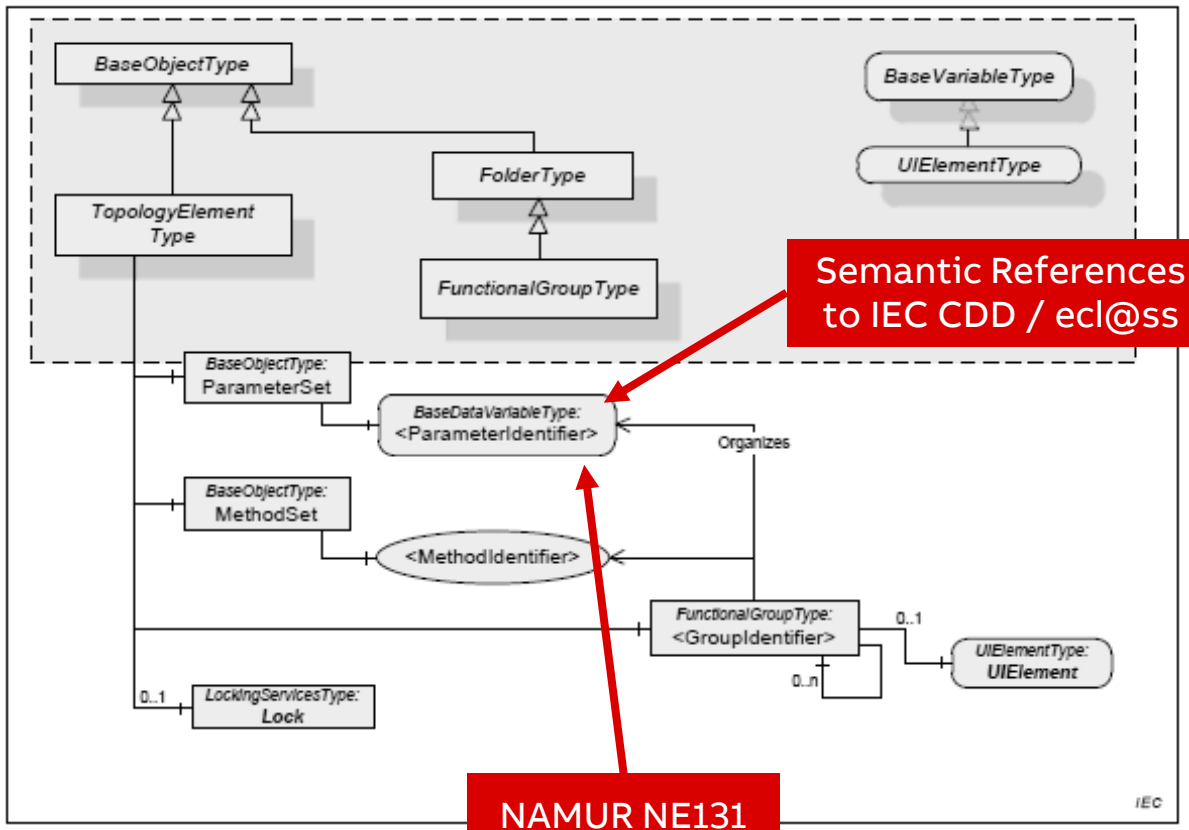
Automation Controller

OPC UA SERVER

Pneumatic Valve

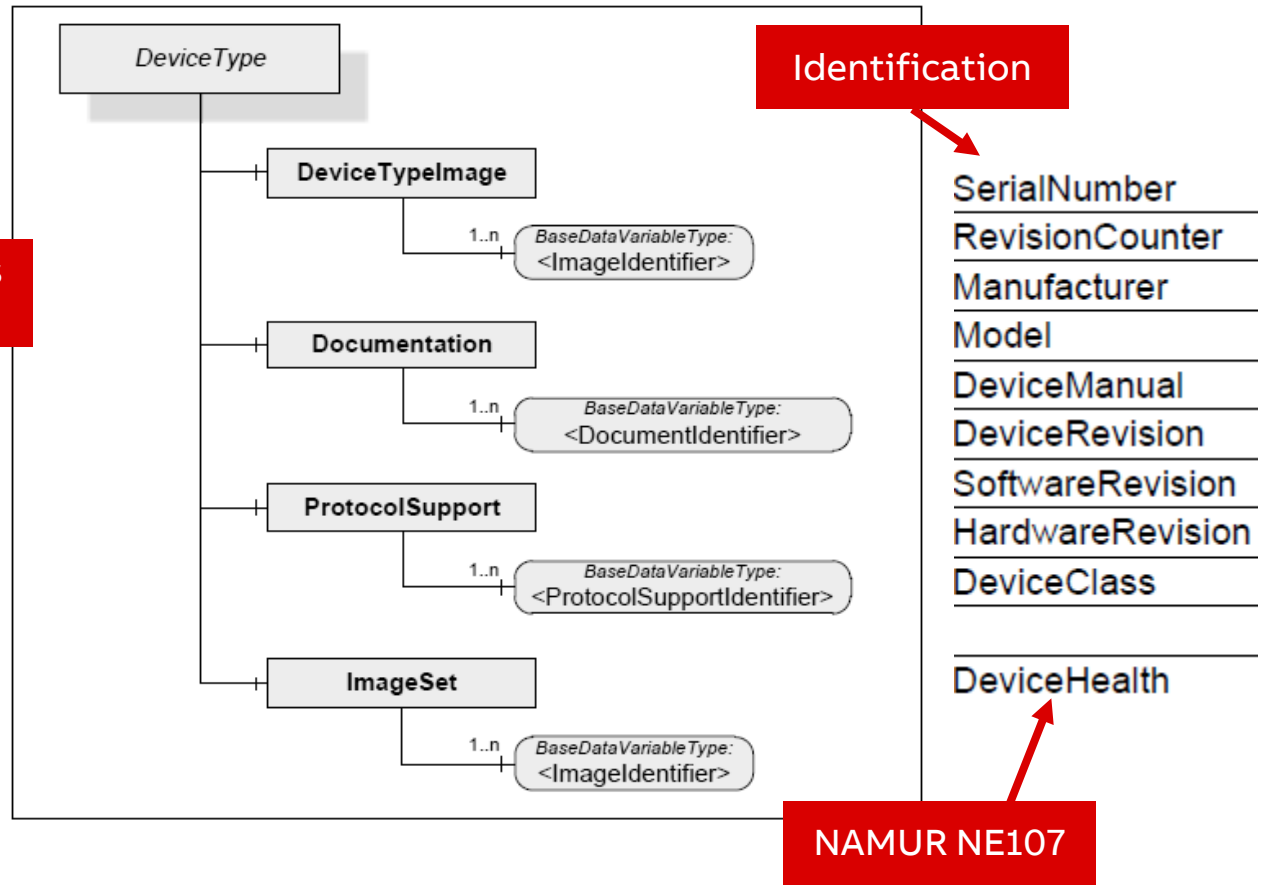
OPC UA for Devices

IEC 62541-100



Semantic References to IEC CDD / ecl@ss

NAMUR NE131



NAMUR NE107

NAMUR NE131 – Revision October 2017

Standard Device Parameters

~30 parameters valid for any sensor / actuator

NE131 Parameter	Category	Comment
Process variable	Configuration Parameter	Relevant for multivariable measuring devices only
Process value	Runtime Value	Not relevant for PnP use case, new values get created in device
Unit	Configuration Parameter	PnP-relevant, but may use default from vendor?
Upper range value	Configuration Parameter	PnP-relevant
Lower range value	Configuration Parameter	PnP-relevant
Diagnostic status	Runtime Value	Not relevant for PnP use case, new values get created in device
Simulation	Function / Status	Not relevant for PnP use case
Simulation value	Configuration Parameter	Not relevant for PnP use case
Damping	Configuration Parameter	PnP-relevant
Set PV to zero	Function	Not relevant for PnP use case
Tag name	Configuration Parameter	PnP-relevant, but vendor may have pre-specified it based on ordering info
Factory reset	Function	Not relevant for PnP use case
Last change date	Runtime Value	Not relevant for PnP use case, gets set to date of plug-in
Change counter	Runtime Value	Is this reset if a new device is plugged in?
Display language	Configuration Parameter	PnP-relevant, default to English?
Password	Configuration Parameter	PnP-relevant, default password possible?
Sensor type	Configuration Parameter	PnP-relevant, default valid in most cases, otherwise provided by vendor?
Sensor connection	Configuration Parameter	PnP-relevant, default valid in most cases?
Sensor reference	Configuration Parameter	PnP-relevant, default valid in most cases?

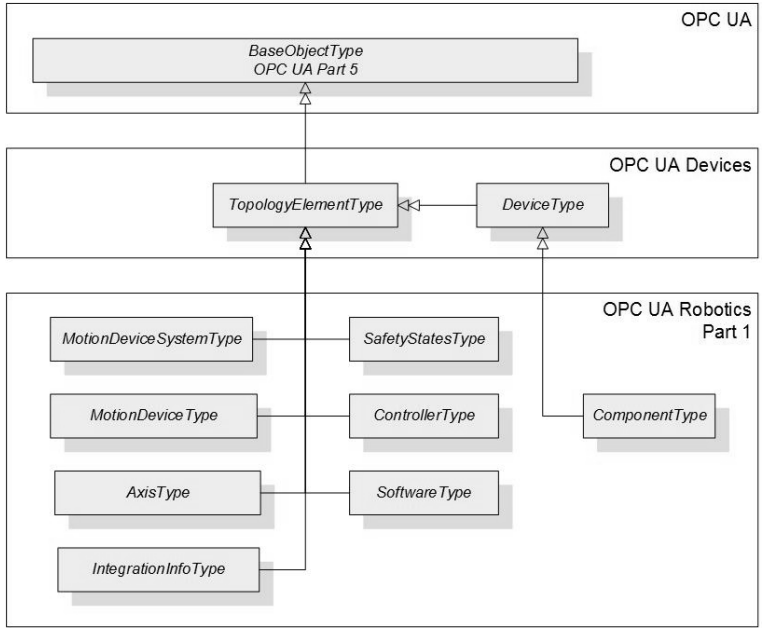
Retrieve from engineering repository during PnP

Only few configuration parameters required for Plug&Produce.

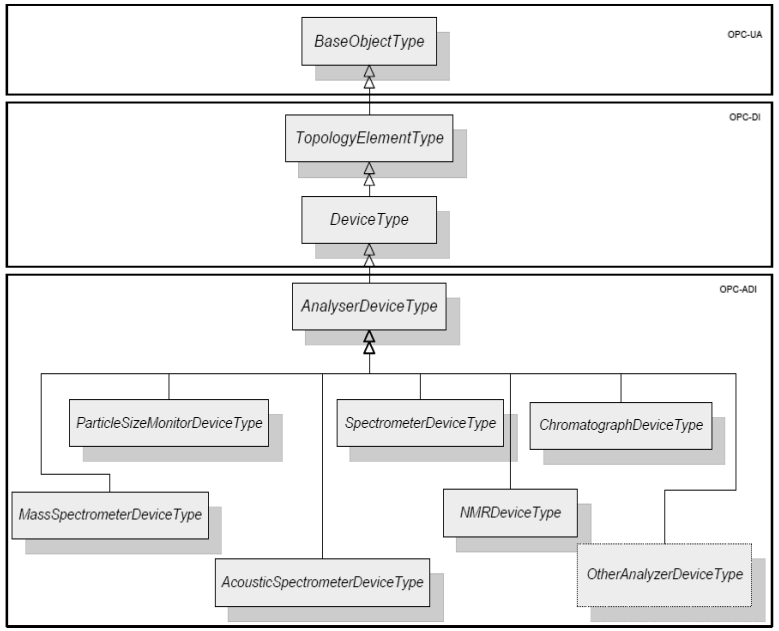
OPC UA Companion Standards

Based on OPC UA for Devices

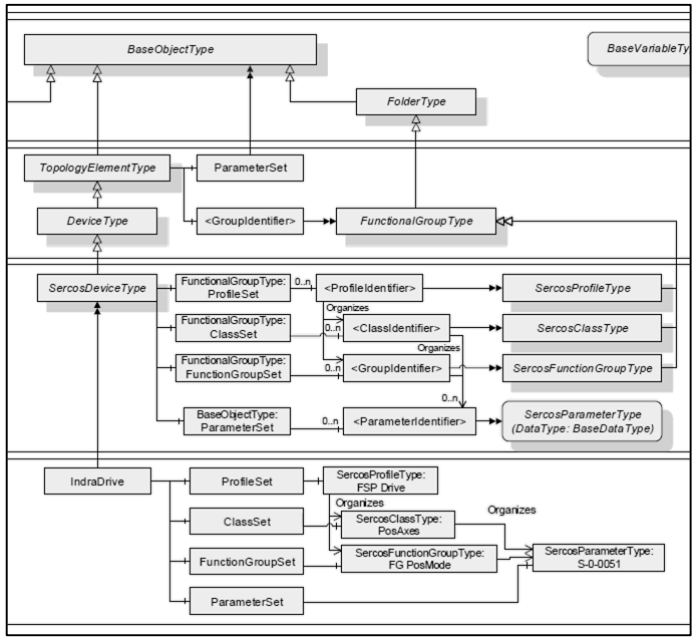
OPC UA for Robotics



OPC UA for Analyzer Devices

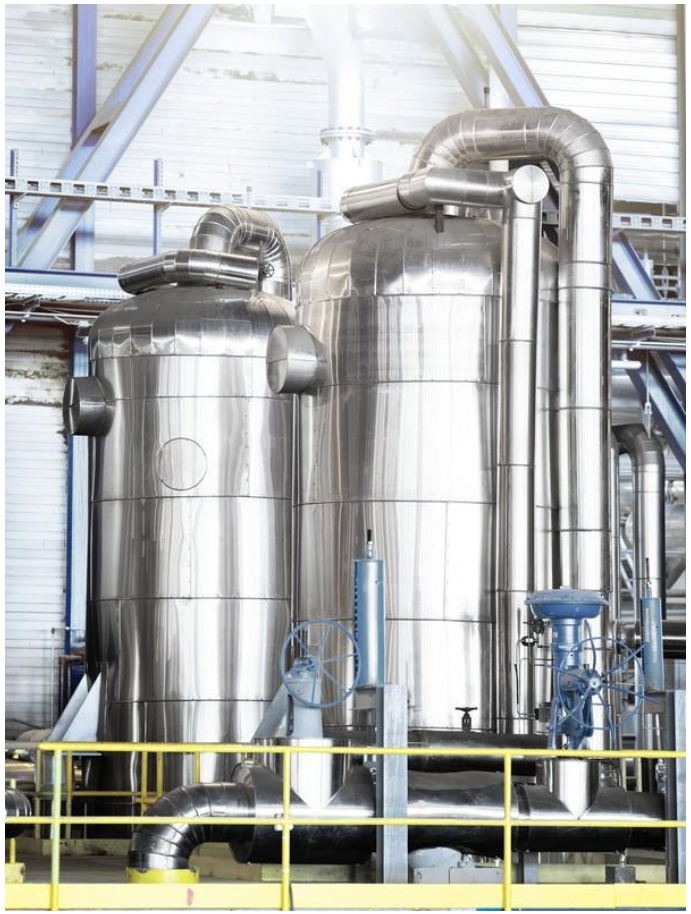


OPC UA for Sercos Devices



Numerous OPC UA device models available or being prepared.

Plug & Produce



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

Requirement 3: Automated Signal Matching

OPC UA CLIENT

Plug & Produce Software Service

OPC UA CLIENT & SERVER

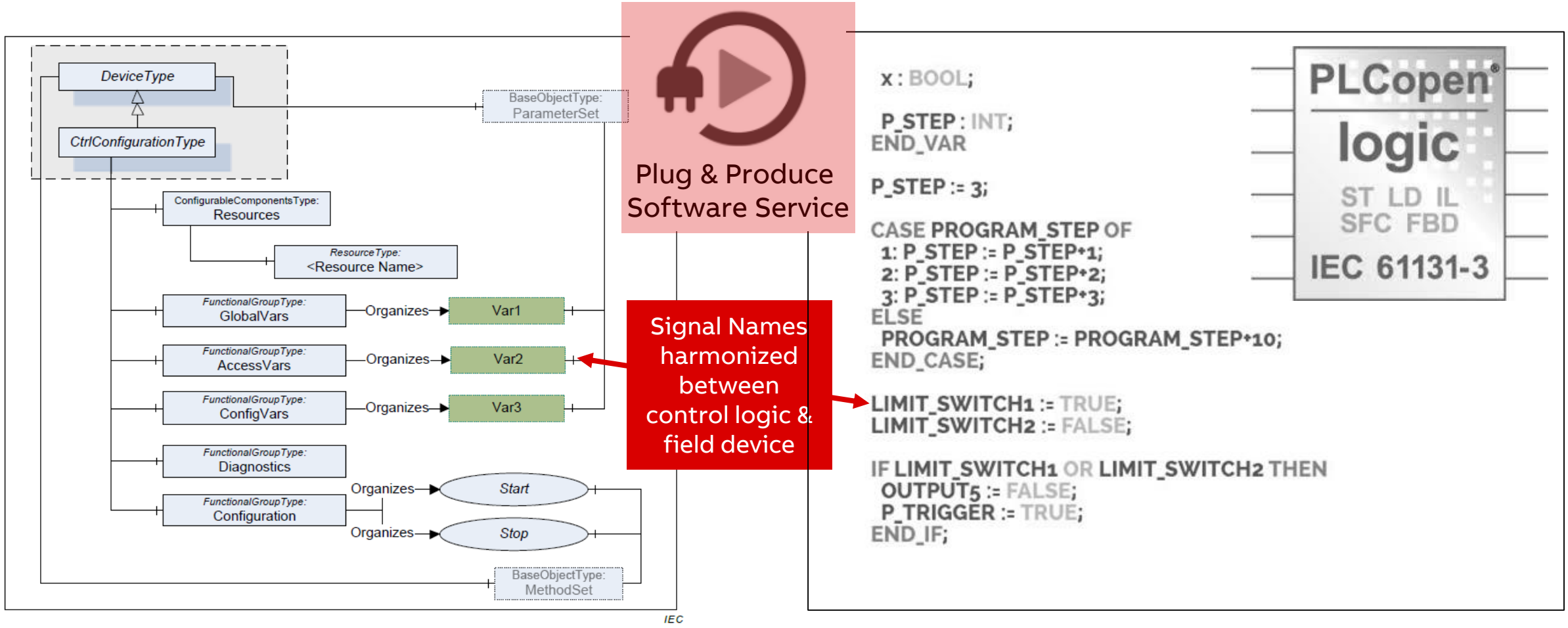
Automation Controller

OPC UA SERVER

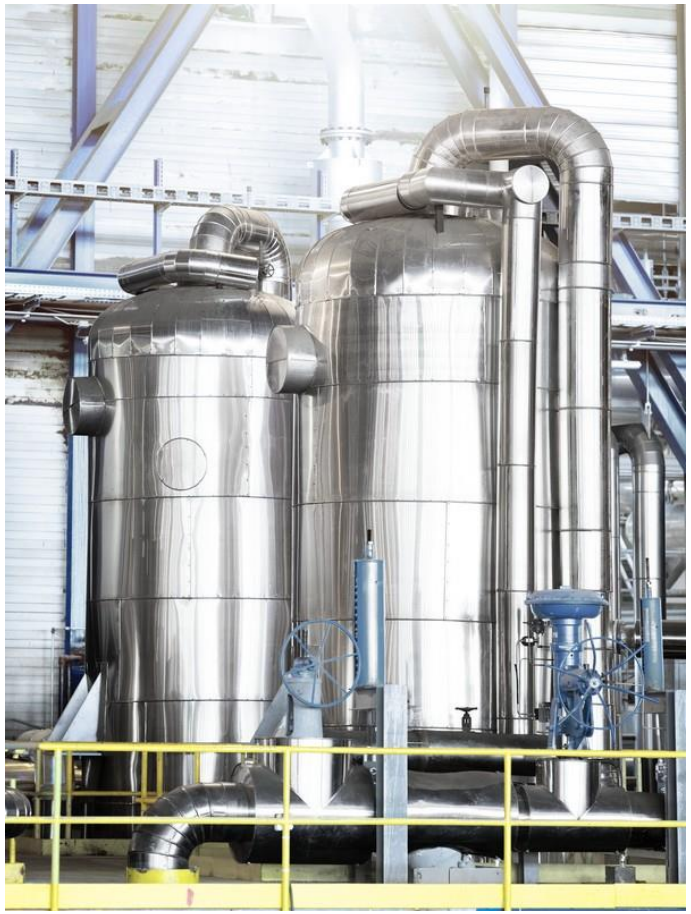
Pneumatic Valve

PLCopen Control Logic

IEC 61131-3



Plug & Produce



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

OPC UA CLIENT

Plug & Produce Software Service

OPC UA CLIENT & SERVER

Automation Controller

OPC UA SERVER

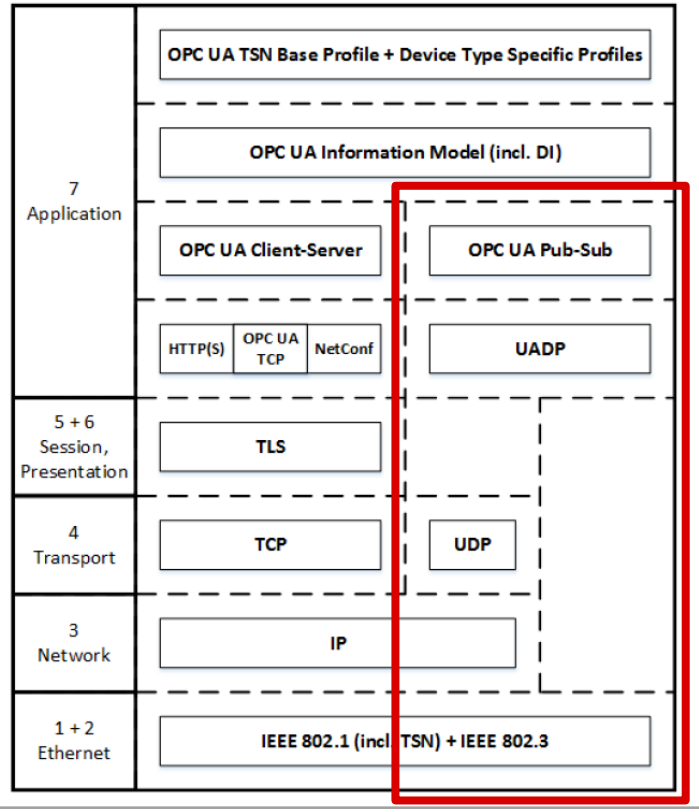
Pneumatic Valve

Requirement 4: Real-time Communication

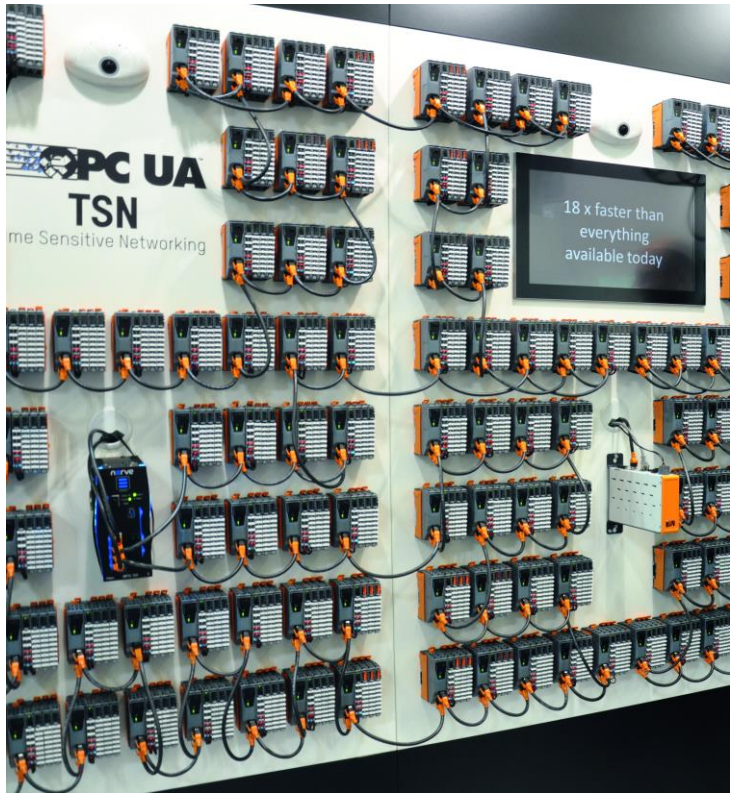
OPC UA Pub-Sub & Time-sensitive Networking (TSN)

IEC 62541-14 & IEEE 802.1Qbv, IEEE 802.1Qcc

ISO/OSI Layers



Testbed SPS Drives 2017



Whitepaper from “Shaper Group”

OPC UA TSN
A new Solution for Industrial Communication

D. Bruckner[†] R. Blair[¶] M-P. Stanica[*] A. Ademaj[‡] W. Skeffington[§] D. Kutscher[‖] S. Schriegel[**]
R. Wilmes[††] K. Wachswender[‡‡] L. Leurs[*] M. Seewald[xi] R. Hummen[xii] E-C. Liu[xiii] S. Ravikumar[xiv]

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[‡]TTTech Computertechnik, *astrit.ademaj@tttech.com*
[§]General Electric Company, *wesley.skeffington@ge.com*
[‖]Huawei Technologies, *dirk.kutscher@huawei.com*
[**]Fraunhofer IOSB-INA, *sebastian.schriegel@iosb-ina.fraunhofer.de*
[††]Phoenix Contact Electronics, *rwilmes@phoenixcontact.com*
[‡‡]Intel Corporation, *karl.wachswender@intel.com*
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[xi]Cisco Systems, *maseewal@cisco.com*
[xii]Hirschmann Automation and Control, *rene.hummen@belden.com*
[xiii]Moxa, *ericcc.liu@moxa.com*
[xiv]Kalycito Infotech, *siddharth.r@kalycito.com*

Abstract—The industrial communication market is dominated by Ethernet-based fieldbus systems. Although they share similar requirements and market segments, their implementations and ecosystems differ considerably. The majority of them have a corresponding umbrella organization that is guided and financed by one big market player who drives development of the technology. Stakeholders in the value chain are usually not well aligned in their decisions for particular technologies. As a result, end customers and device manufacturers are faced with a multitude of technologies that need to be produced, run, diagnosed, maintained and kept in stock. While the availability of products and services is largely satisfactory, dealing with multiple solutions generates high costs and limits IoT capability. This joint position paper introduces OPC UA TSN as a vendor-independent successor technology and presents the current view. We have found that – by choosing the right set of features – it is able to fulfill both today's and tomorrow's industrial communication requirements while in the mid-term leveraging the cost benefits of standard Ethernet hardware. The TSN network infrastructure as an evolution of AVB is simultaneously able to carry all types of industrial traffic, from hard real-time to best-effort, while maintaining the individual properties of each method. OPC UA is a major evolution from the OPC

Plug & Produce

Industrial Boiler

Requirement 1: Automated Network Discovery

Requirement 2: Standardized Device Descriptions

OPC UA SERVER

Laser Level Transmitter

OPC UA SERVER

OPC UA CLIENT

Plug & Produce Software Service

Requirement 3: Automated Signal Matching

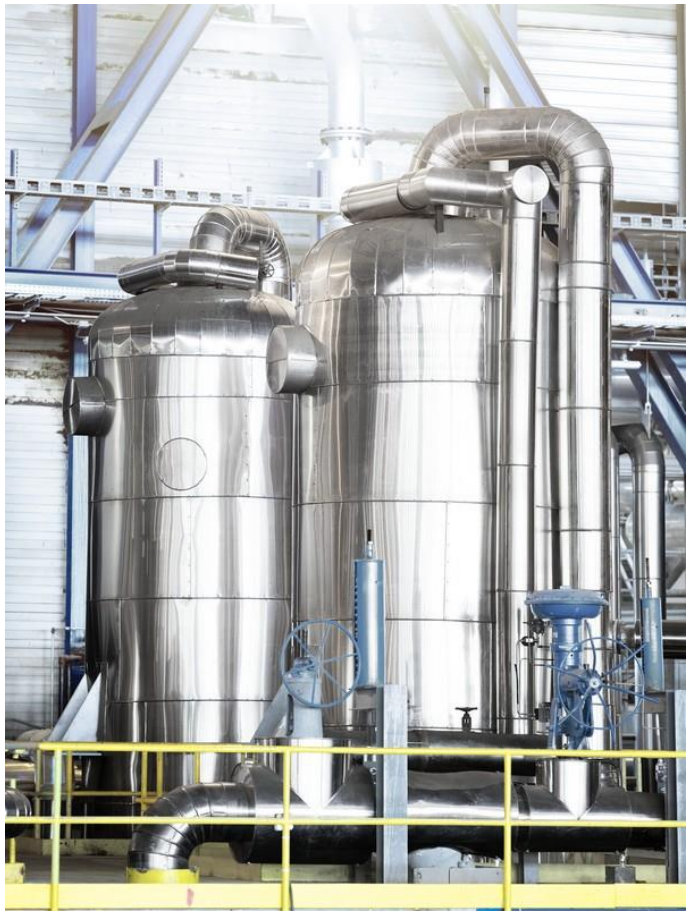
OPC UA CLIENT & SERVER

Automation Controller

Requirement 4: Real-time Communication

Requirement 5: Human Approval Step

Plug & Produce



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

OPC UA CLIENT

Plug & Produce Software Service

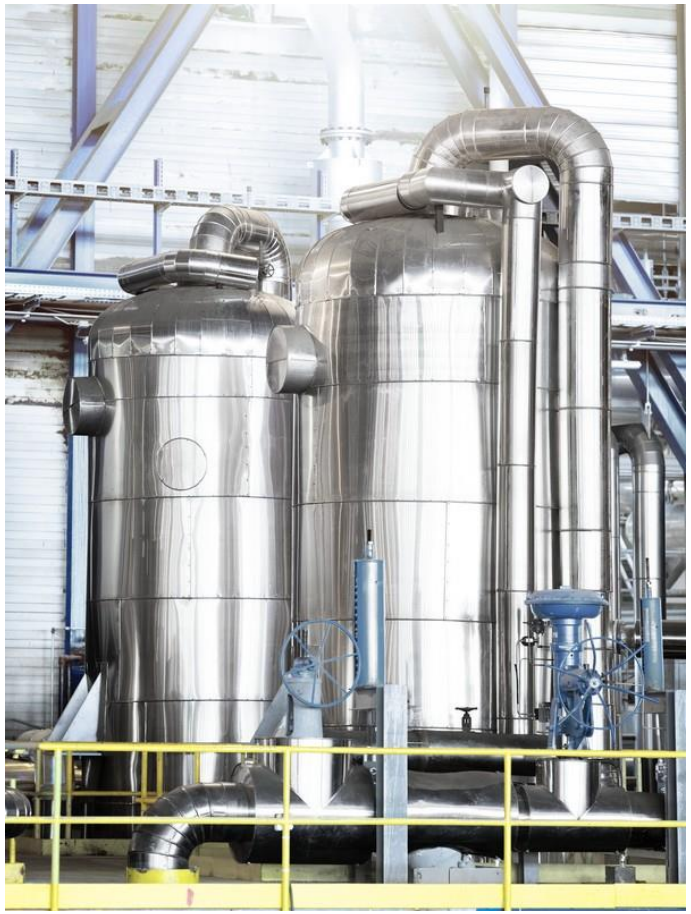
OPC UA CLIENT & SERVER

Automation Controller

OPC UA SERVER

Pneumatic Valve

Plug & Produce Prototype



Industrial Boiler

OPC UA SERVER

Laser Level Transmitter

OPC UA CLIENT

OPC UA SERVER

Plug & Produce Software Service

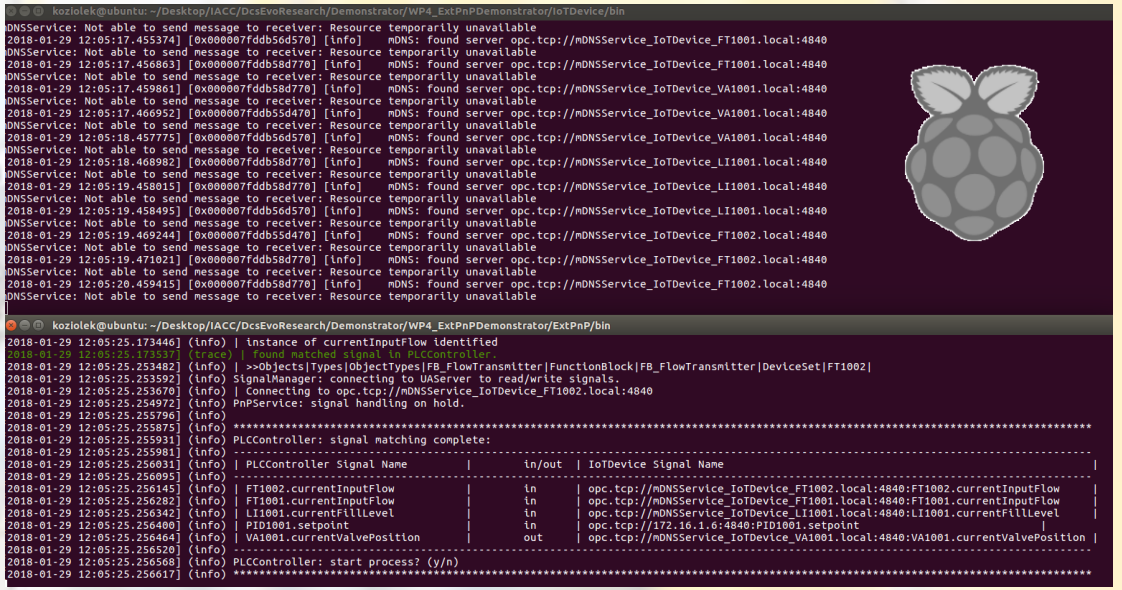
OPC UA CLIENT & SERVER

Automation Controller

Pneumatic Valve

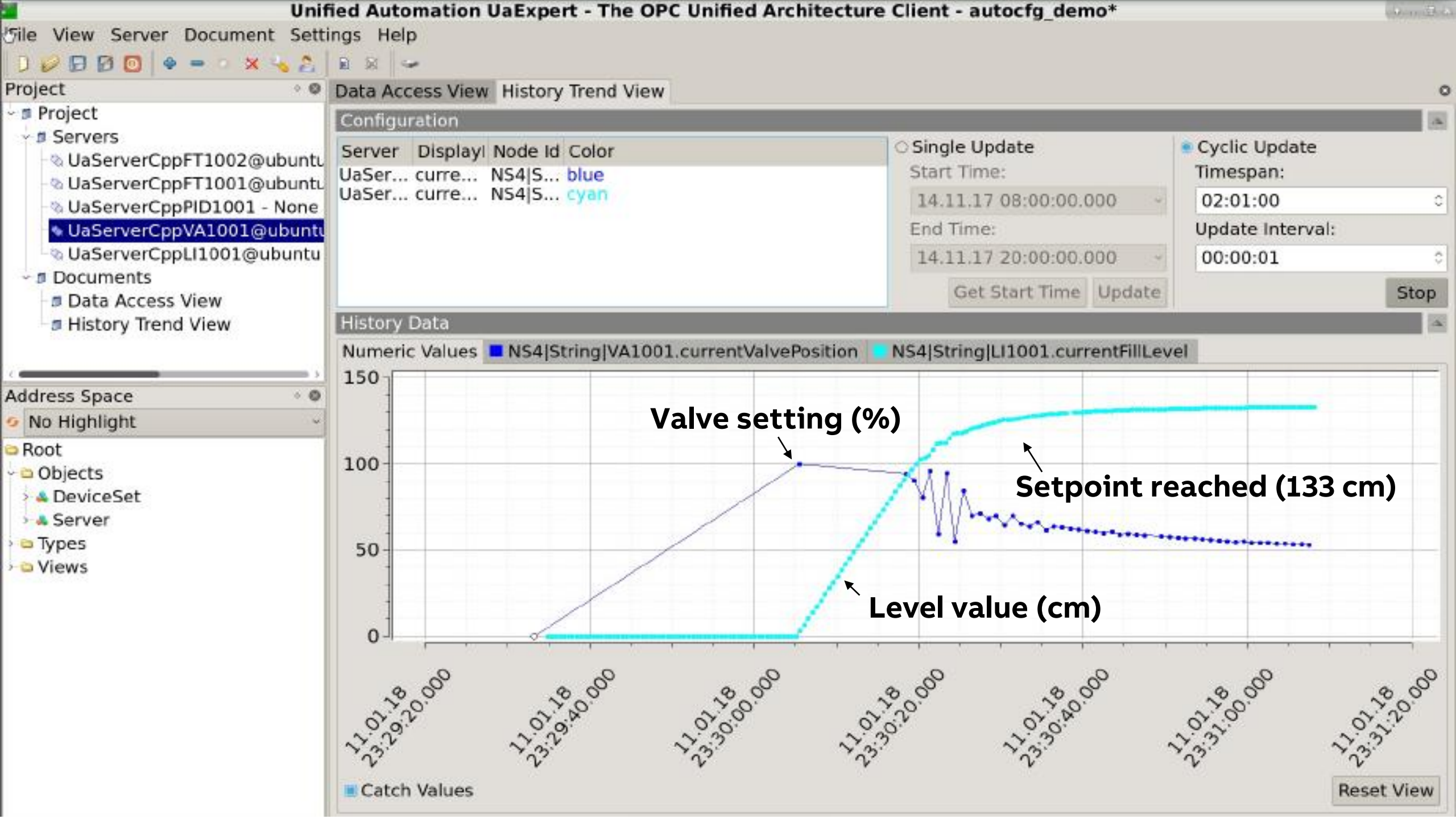
Commissioning

1) Place, connect sensor **(„plug“)**



Production start **(„produce“)**

<5 seconds for all devices!


Unified Automation UaExpert - The OPC Unified Architecture Client - autocfg_demo*
File View Server Document Settings Help
Project
Project
Servers
UaServerCppFT1002@ubuntu
UaServerCppFT1001@ubuntu
UaServerCppPID1001 - None
UaServerCppVA1001@ubuntu
UaServerCppLI1001@ubuntu
Documents
Data Access View
History Trend View
Address Space
No Highlight
Root
Objects
DeviceSet
Server
Types
Views
Data Access View
History Trend View
Configuration
Server
Displayl
Node Id
Color
UaSer... curre... NS4|S... blue
UaSer... curre... NS4|S... cyan
Single Update
Start Time:
14.11.17 08:00:00.000
End Time:
14.11.17 20:00:00.000
Get Start Time
Update
Cyclic Update
Timespan:
02:01:00
Update Interval:
00:00:01
Stop
History Data
Numeric Values
NS4|String|VA1001.currentValvePosition
NS4|String|LI1001.currentFillLevel
150
100
50
0
Valve setting (%)
Setpoint reached (133 cm)
Level value (cm)
11.01.18 23:29:20.000
11.01.18 23:29:40.000
11.01.18 23:30:00.000
11.01.18 23:30:20.000
11.01.18 23:30:40.000
11.01.18 23:31:00.000
11.01.18 23:31:20.000
Catch Values
Reset View

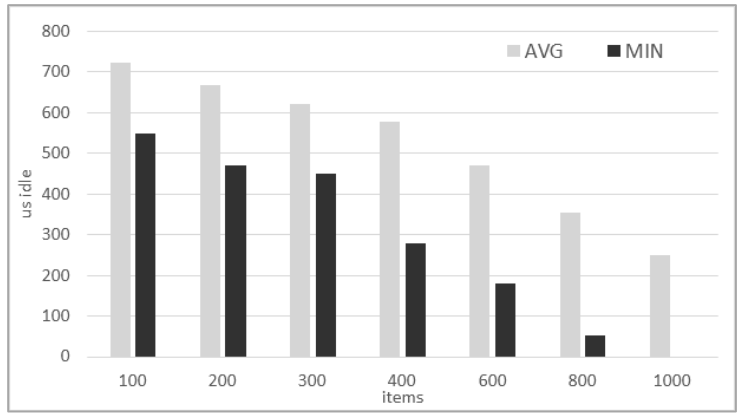
Performance Measurements

Raspberry Pi Jitter

Max measured jitter: 104 microseconds

→ Scenarios with 1 ms update rate can be analyzed reasonably

Publisher OPC UA Encoding

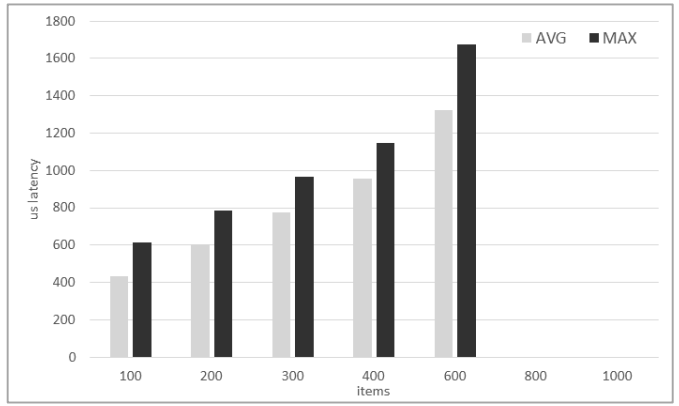


1 ms update rate

Publisher CPU idle time decrease with a higher number of encoded signals

800 signals / ms

Subscriber OPC UA Decoding



1 ms update rate

Subscriber latency increases with higher number of encoded signals

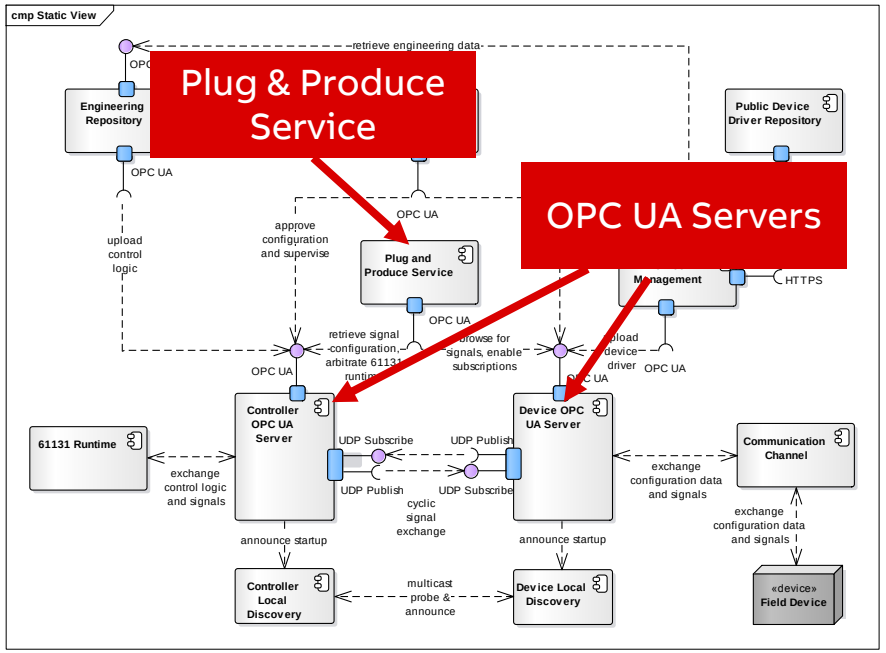
600 signals / ms

Prototype able to handle high-speed closed loop scenarios using OPC UA Pub-Sub.

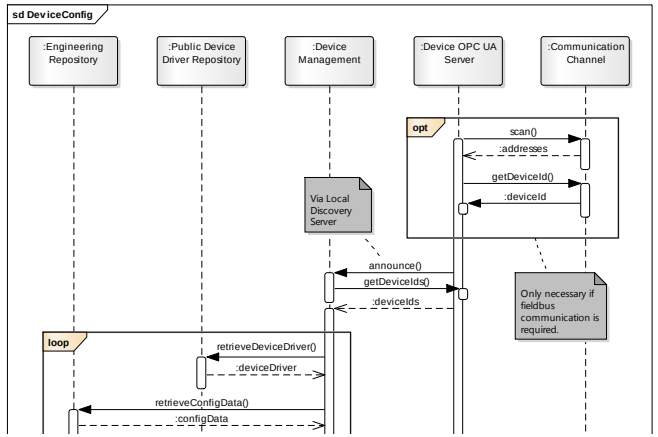
Industrie 4.0 Reference Architecture for Plug & Produce

Formally specified using UML

Static View: Components & Connectors



Dynamic Views: Discovery & Signal Matching



H. Koziolek, A. Burger, J. Doppelhamer: „Self-commissioning Industrial IoT-Systems in Process Automation: a Reference Architecture", In Proceedings of the IEEE International Conference on Software Architecture (ICSA 2018), pp. 87-97, May 2018

More detailed specification available in separate paper.

Industrie 4.0 Reference Architecture for Plug & Produce

Open Topics

More standardized device models

Infrastructure for Plug & Produce

More autonomy in the devices

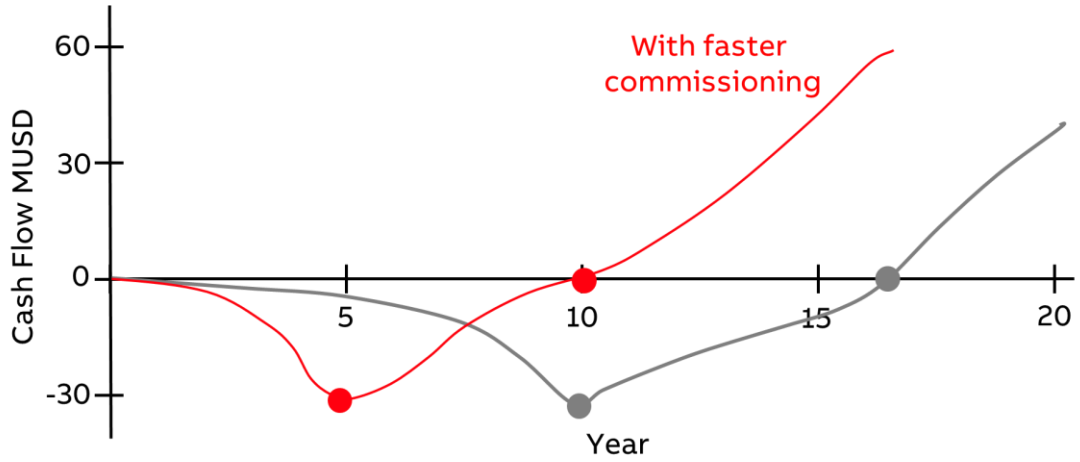
The road to Plug & Produce has just started!

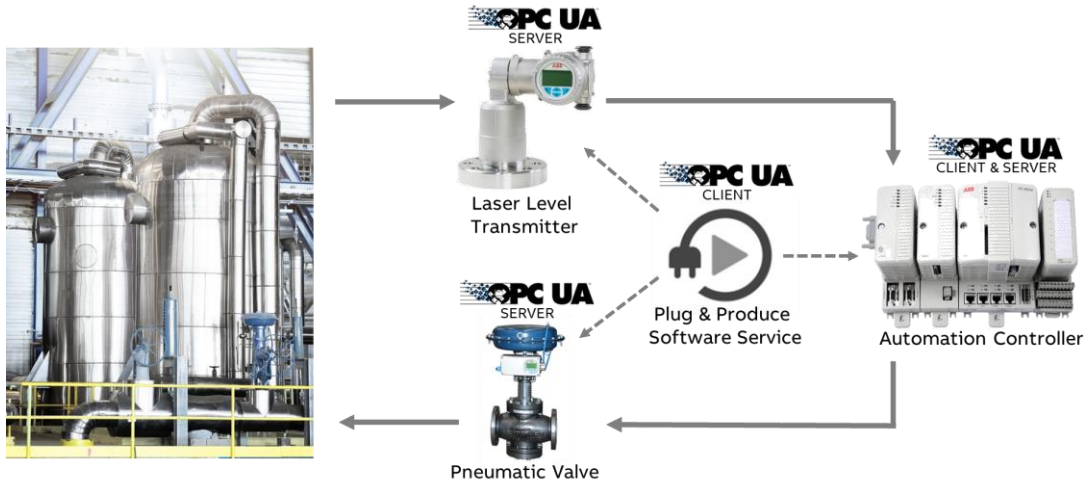
Summary

Challenge
Commissioning important cost factor

Solution
Plug & Produce across vendors

Implementation
- Reference architecture with PnP Service and existing industry standards
- ABB currently working on OPC UA connectivity for different types of devices





Implement the standards, create PnP Services, benefit from self-commissioning!