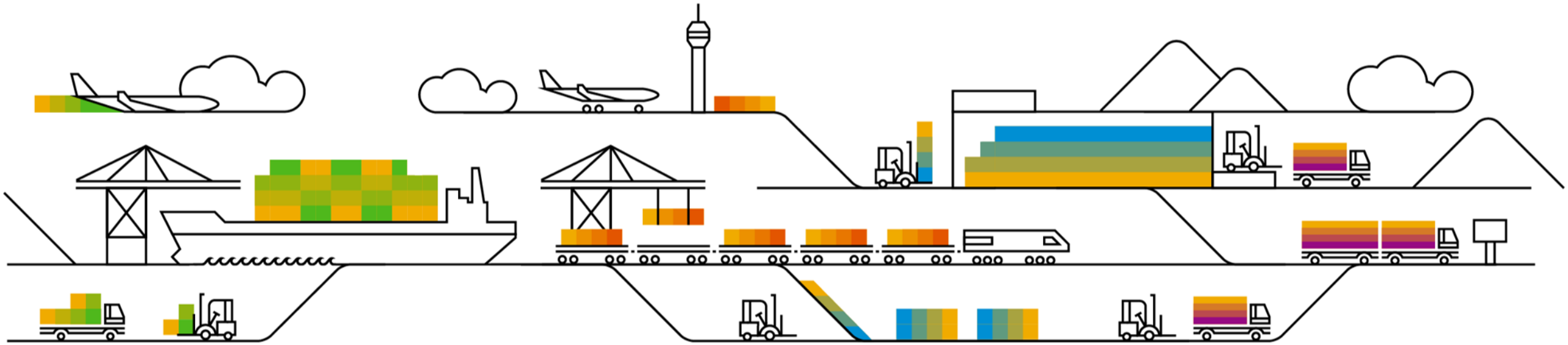


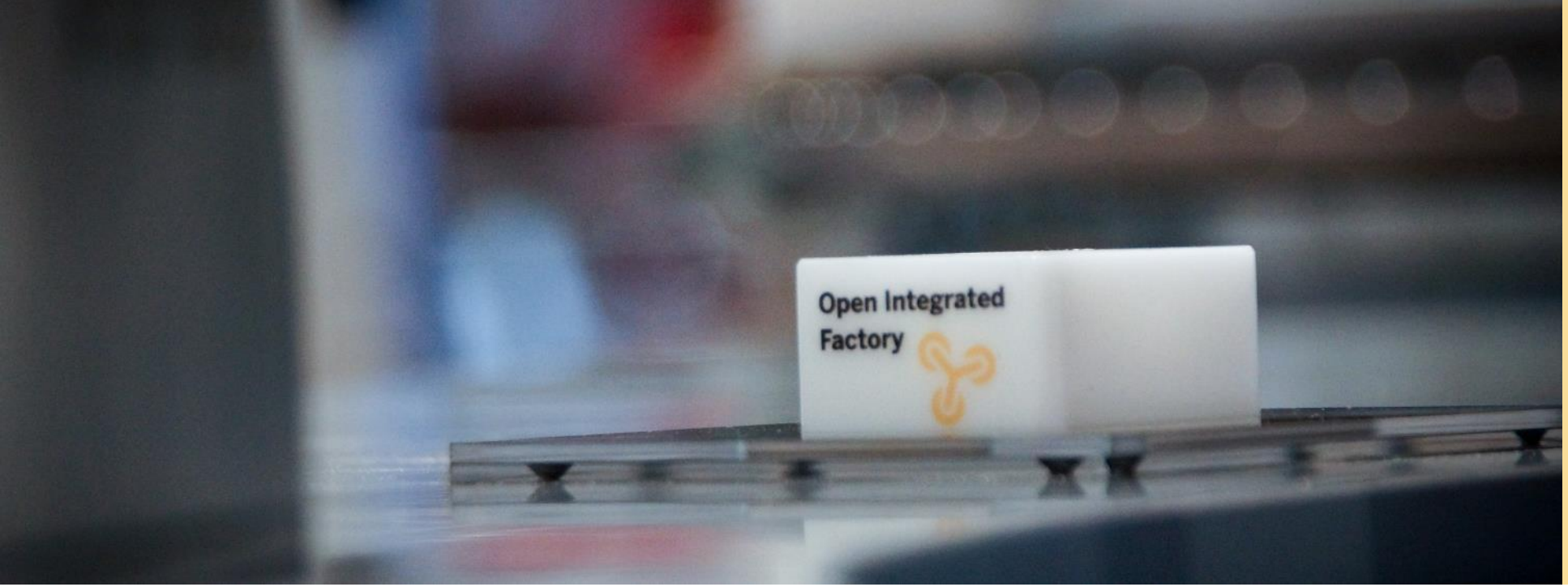
Manufacturing Execution in combination with Autonomous Agents based on SAP and OPC UA

Ruediger Fritz, SAP

October 11th 2017

PUBLIC

SAP Run Simple



OPEN INTEGRATED FACTORY – GENERATION 2017

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Generation 2017

Industrie 4.0 | LIVE and REAL

https://www.youtube.com/watch?v=7AAfLkaNKEc

Ralf Lehmann
SAP SE

Smart Products

Open Integrated Factory

Generation 2017

Ralf Lehmann
SAP SE

April 24 – 28, 2017
Hannover, Germany

HANNOVER MESSE

Embedded Software to Automation Process

Digital Manufacturing Insights

SAP DMI

Machine Learning Process

Leonardo Edge Processing

PROCESSES

- Make-to-Order
- Engineer-to-order

SAP HYBRIS (Order entry)

Make-to-Order Process

SAP POD

Tray with Chip

Substells (3 Magazines)

STORAGE

SAP POD

SAP POD

STORAGE

Lid (1 Magazine)

KUKA SCHUNK asentics

Honeywell

METTLER TOLEDO

CUBE

MEDIA SCREEN

cab

Honeywell

KUKA SCHUNK asentics

asentics

SCREEN

NOK

OK

PROGLOVE

SAP (Rework)

OK

PROGLOVE

SAP (Finishing)

ETO Shelf (resources)

Outbound Warehouse

Shelf (Pick by motion)

Engineer-to-Order Process

PLM CAD

MES 3D Print

3D Printer

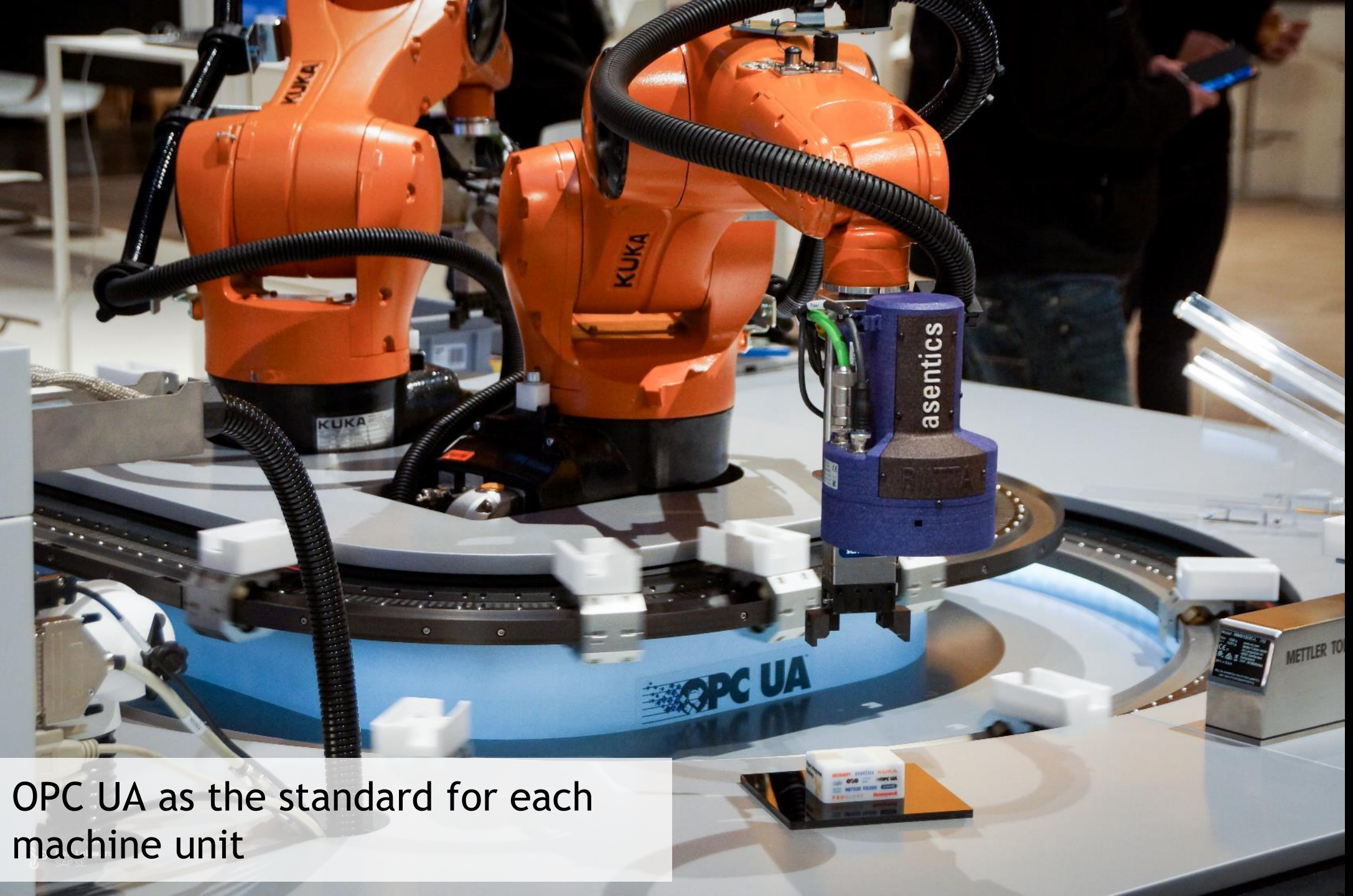
Autonomous Agent Process

Resource A | Resource B | Resource C | Resource D

SAP IoT Simulator

Handover to IoT Simulator Process

Overall: IT/OT Convergence



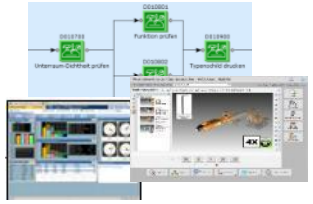
Open Integrated Factory

Generation 2017

OPC UA as the standard for each machine unit

Partner Consortium
Hardware

The System Layers
The Digital Plant in the Extended Supply Chain



Connectors

MONITOR

DESIGN | PLAN | RESPOND | PRODUCE | DELIVER | OPERATE

SAP ERP S/4

- Production plan
- Bill of materials (BoM)
- Variant management
- Production steps ...*

- Serial Numbers
- Quality results per lot
- Order confirmation
- Inventory update, Equipment usage ... *

SAP MES (ME & MII)

- Production details management
- Detailed and flexible
- Production step routing
- Shop floor controls for each step...*

- Log parametric data
- Tolerance checks
- Return „conformance" or „non-conformance" decisions

SAP PCo OPC UA

- Mapping of ME production details to PLC control parameters (recipe)
- Buffer recipe for fast access
- Set/Get parameters – Server/Client ...*

- Mapping of measured values/results to Business Data Modell

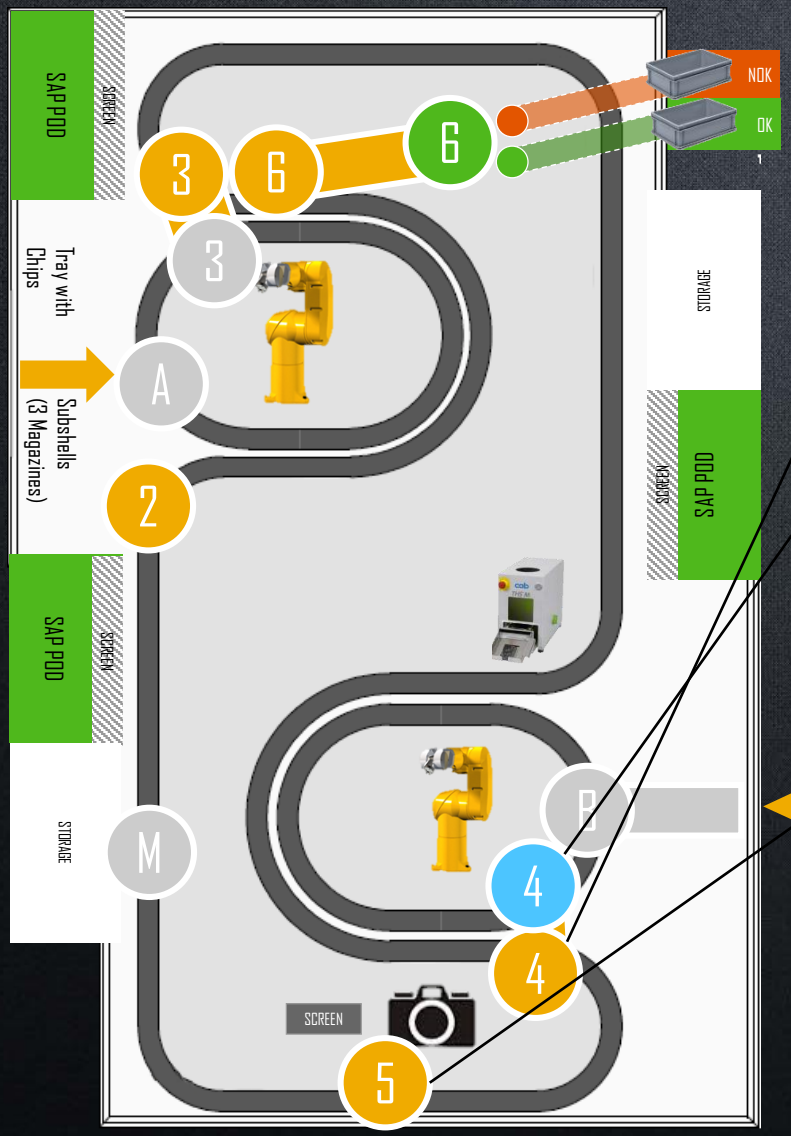
OPC UA PLC (Machine)

- Sensor detects material carrier
- Requests control parameters from ME ...*

- Machine reports completion and requests next operation

*only excerpt of involved entities

Automation Workflow Example



…

Loop M → PCo: “Mover with SFC 123 arrived at Pos Y4”

PCo → Loop B: “Move SFC 123B to Pos B4”

Loop B → PCo: “Mover with SFC 123B arrived at Pos B4”

PCo: (Get Lock for Rob B)

PCo → Rob B: “Do Job #3 – Handle SFC123”

Rob B → PCo: “Job #3 – Handle SDF123 done”

PCo → Loop B: “Release Mover” (move on)

PCo → Loop M: “Move SFC 123 to Pos 5”

Loop M → PCo: “Mover with SFC 123 arrived at Pos 5”

PCo → Cam: “Take Photo [Par: expected colour blue]”

Cam → PCo: “Camera result: [not blue, URL to .jpg …]

Log Non-Conformance in ME-System

…

Real Life Example: Open Integrated Factory – Generation 2017

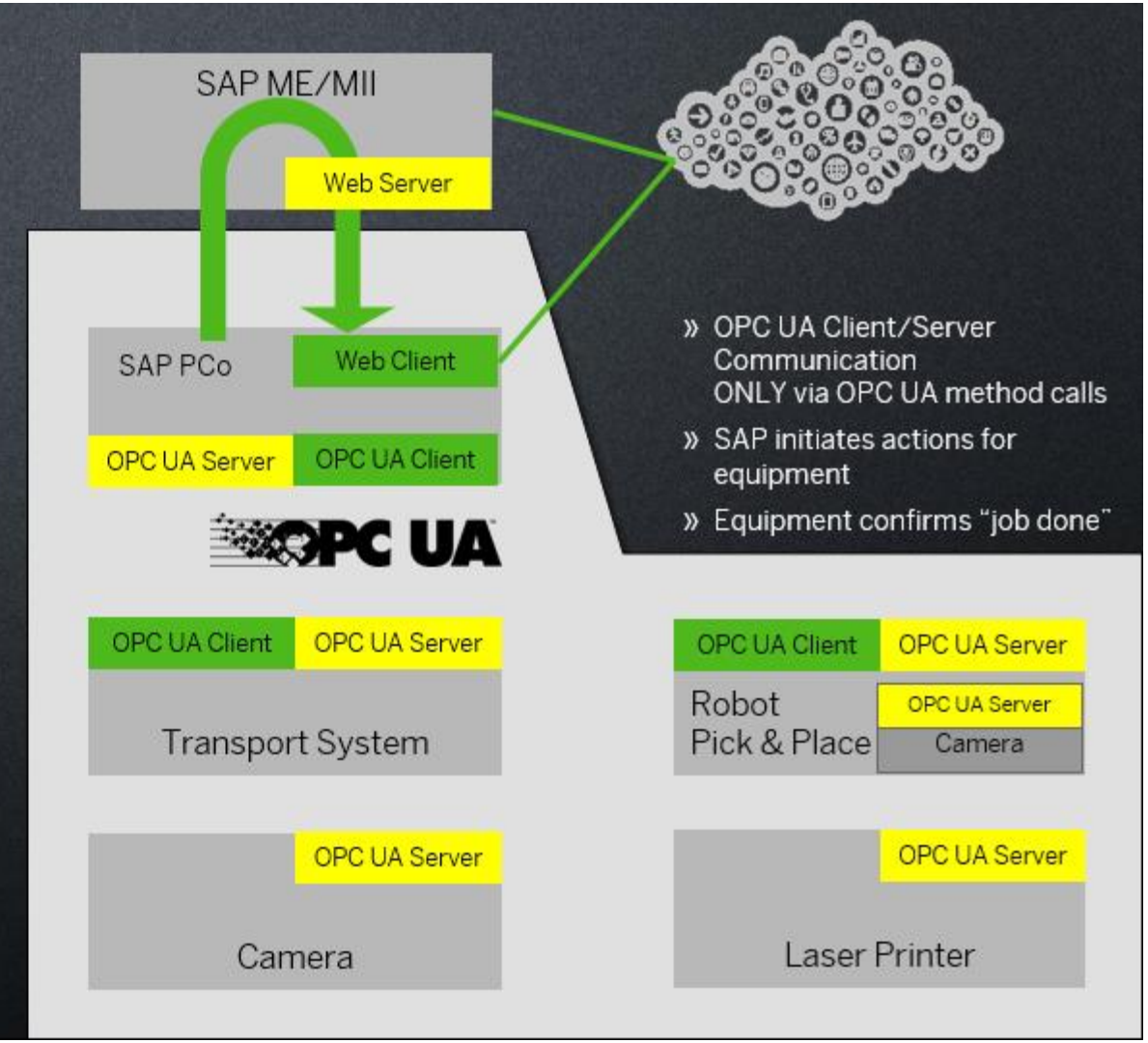
Machine Units seen as Service Providers and Service Consumers (SOA)

(1) Each machine unit is independent
- In a departure from convention, the units are not linked to each other by a single program inside a single PLC
- Each unit comes with its own controller

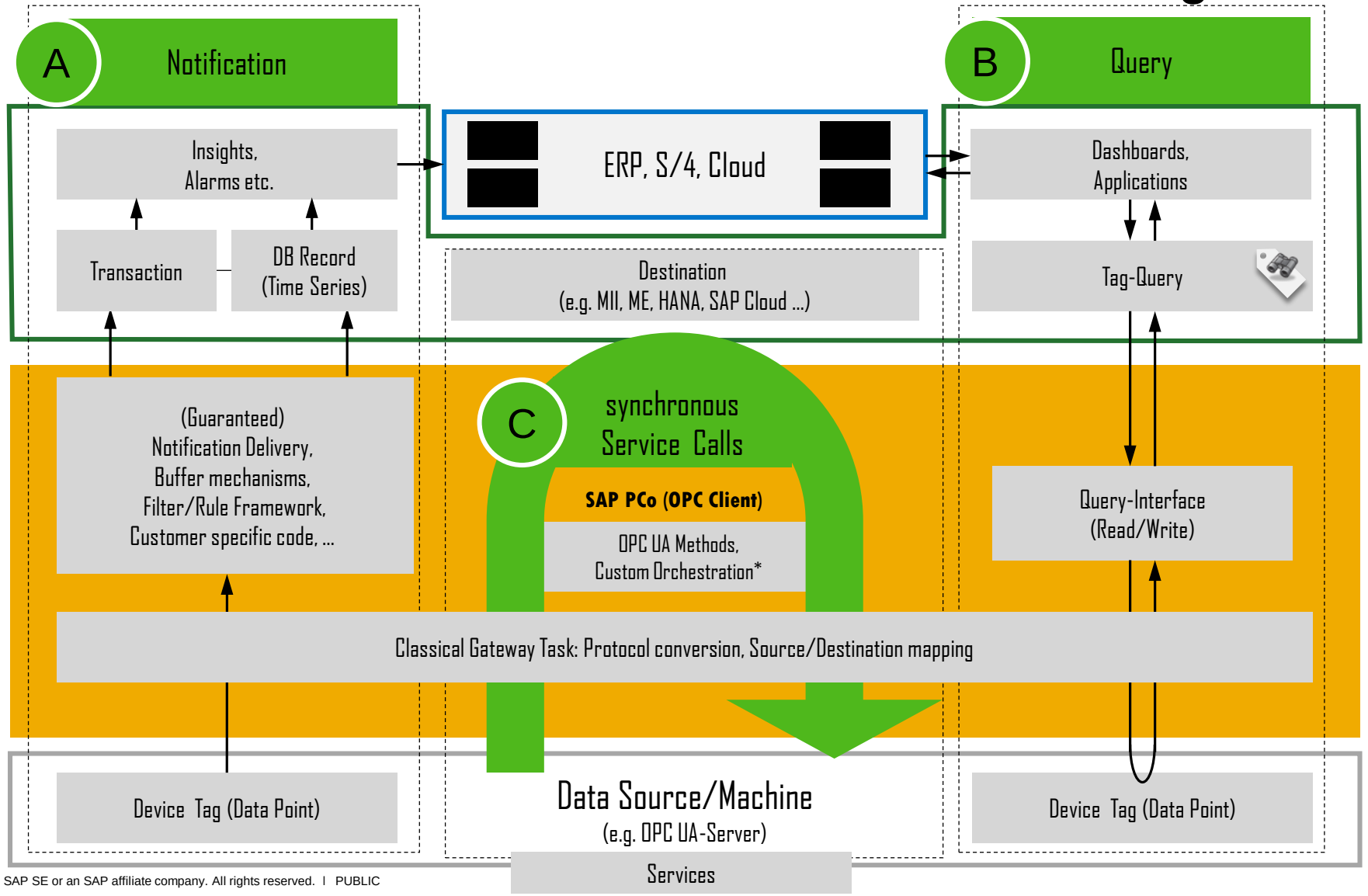
(2) Units are talking to each other on the basis of OPC UA
- From business perspective (production order details like routing and recipe/set-points) the units are orchestrated by SAP Plant Connectivity (Vertical Integration)
- From technical perspective, some machine units – here Camera and Robot - exchange information directly (Horizontal Integration)

(3) Units are OPC UA Client and OPC UA Server at the same time
- A server can offer tags, events and methods
- A client can consume/react on tag changes and events and can call methods

(4) Units publish their capabilities
- a Service Oriented Architecture with regards to hardware is possible



SAP Plant Connectivity: OPC Client and OPC Server Communication Patterns in Context of Machine Integration



Foundation:

OPC UA

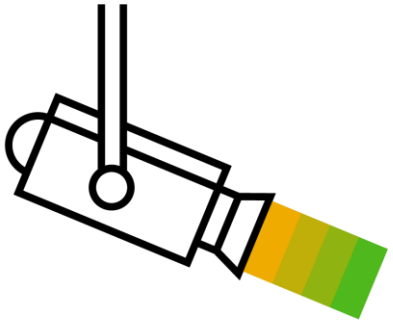
*Project specific configuration/implementation

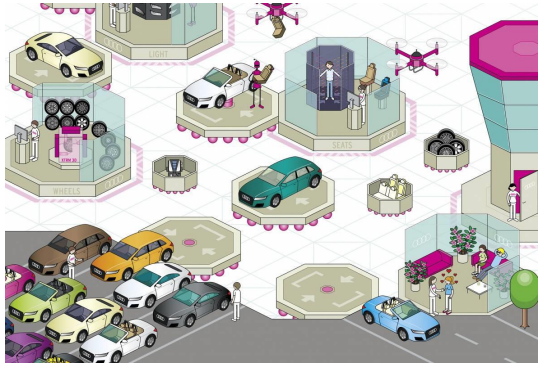
Autonomous Agents based on OPC UA in Production

PUBLIC

SAP Run Simple

Challenges to Manufacturing Today…





Source: http://blog.audi.de/2016/11/23/modulare-montage-statt-fliessband

Cyber-Security

- Increasing Interoperability = Increasing Vulnerability
- Manage Complexity

Modular Assembly

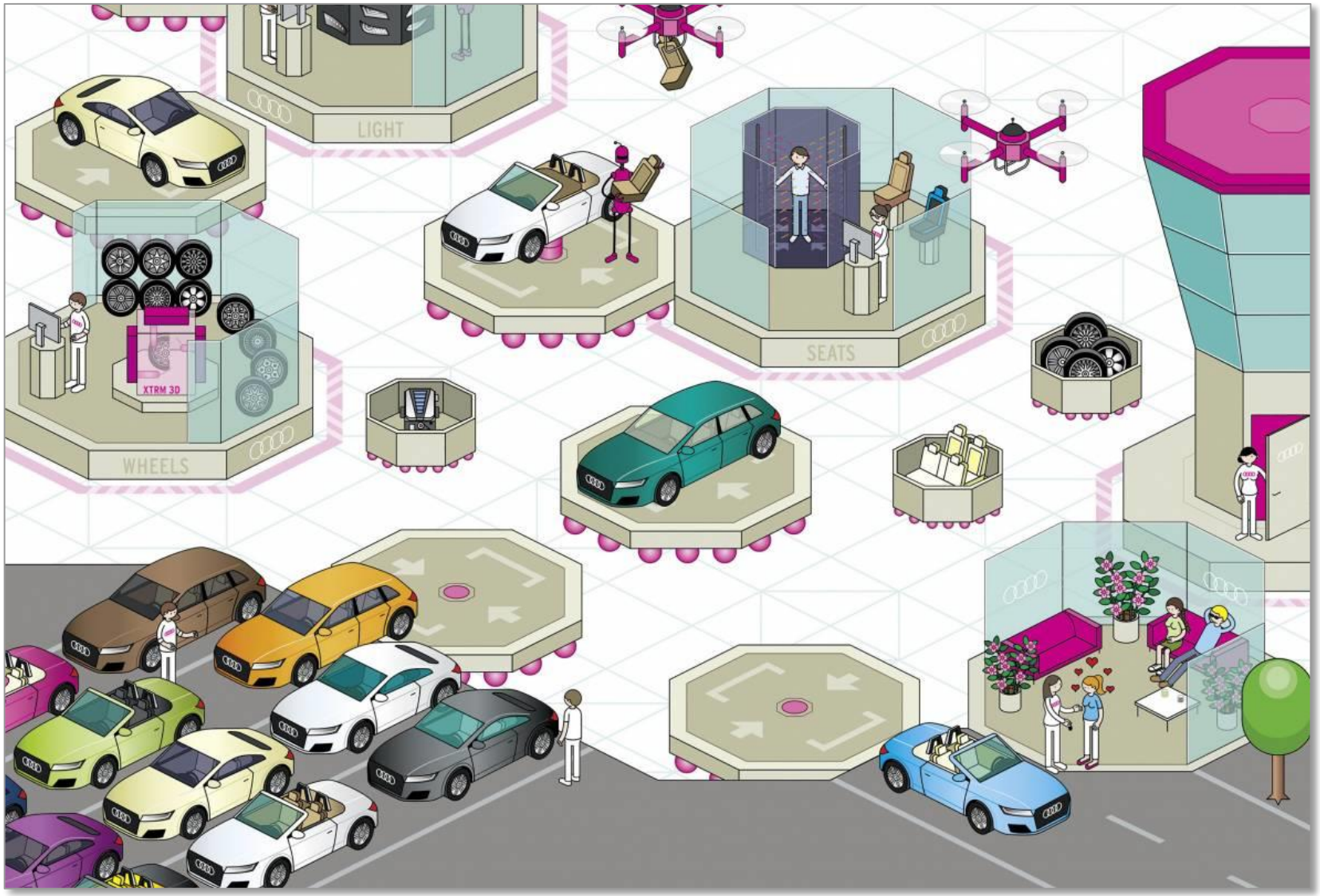
- Assembly Line replaced by Cellular Manufacturing
- New organizational structures require ad-hoc decisions
- Increasing Interoperability

AI / Machine Learning

- Insight to Automation (immediate action)
- Pattern Recognition
- Autonomous Systems, Edge Processing

AI : Artificial Intelligence

Challenges to Manufacturing Today…



Source: http://blog.audi.de/2016/11/23/modulare-montage-statt-fliessband

Modular Assembly

- Assembly Line replaced by Cellular Manufacturing
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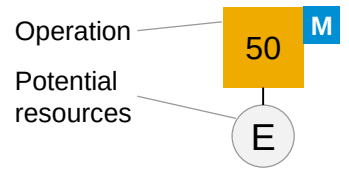
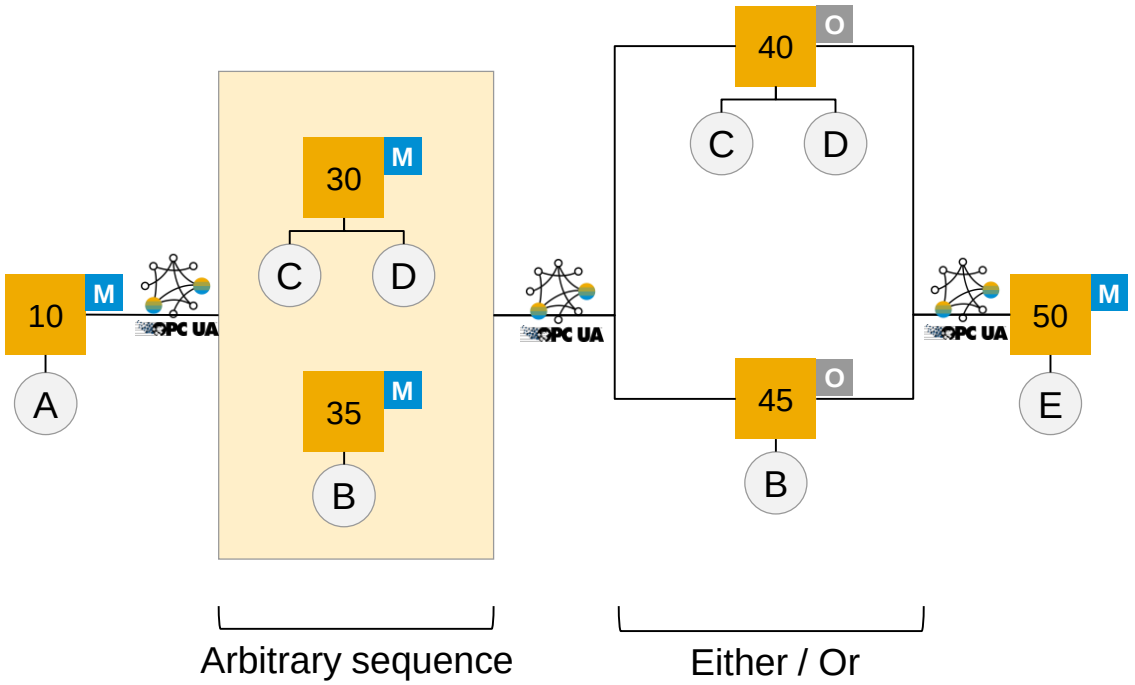
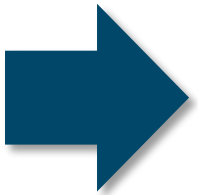
- Increasing Interoperability

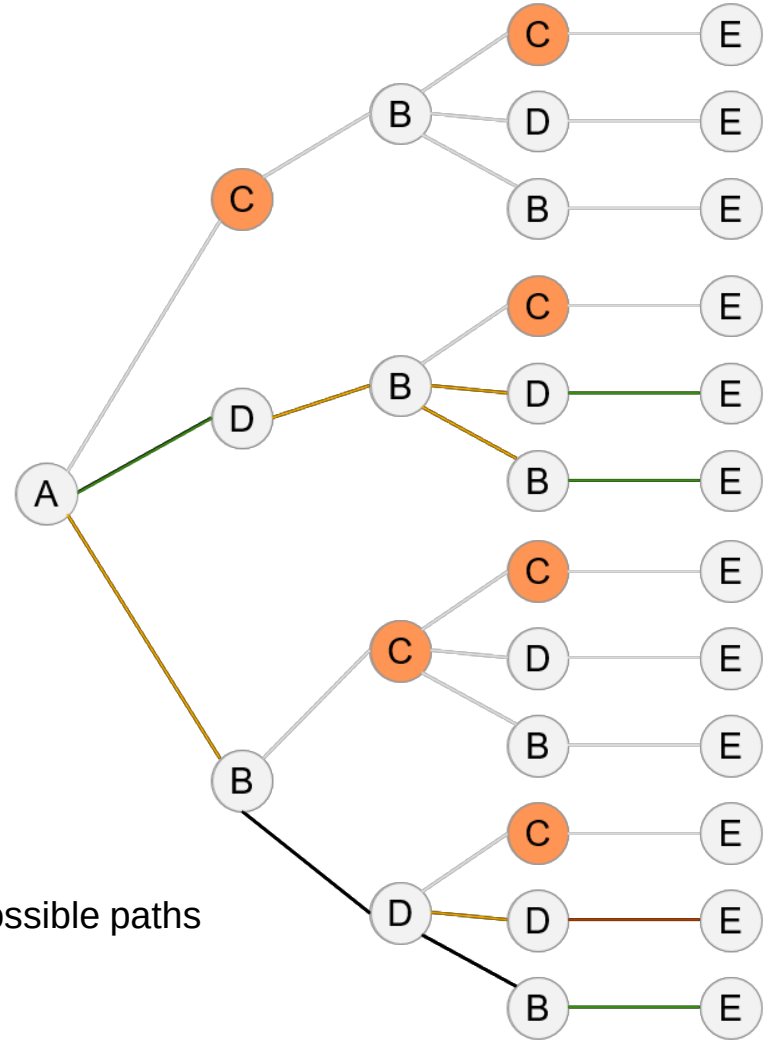
Modular Assembly



» Dynamic Routing → alternative operations, alternative resources
Ad-hoc decisions based on frequent machine-to-machine communication (status, set-up, availability …) linked to business data (order details, master data …)



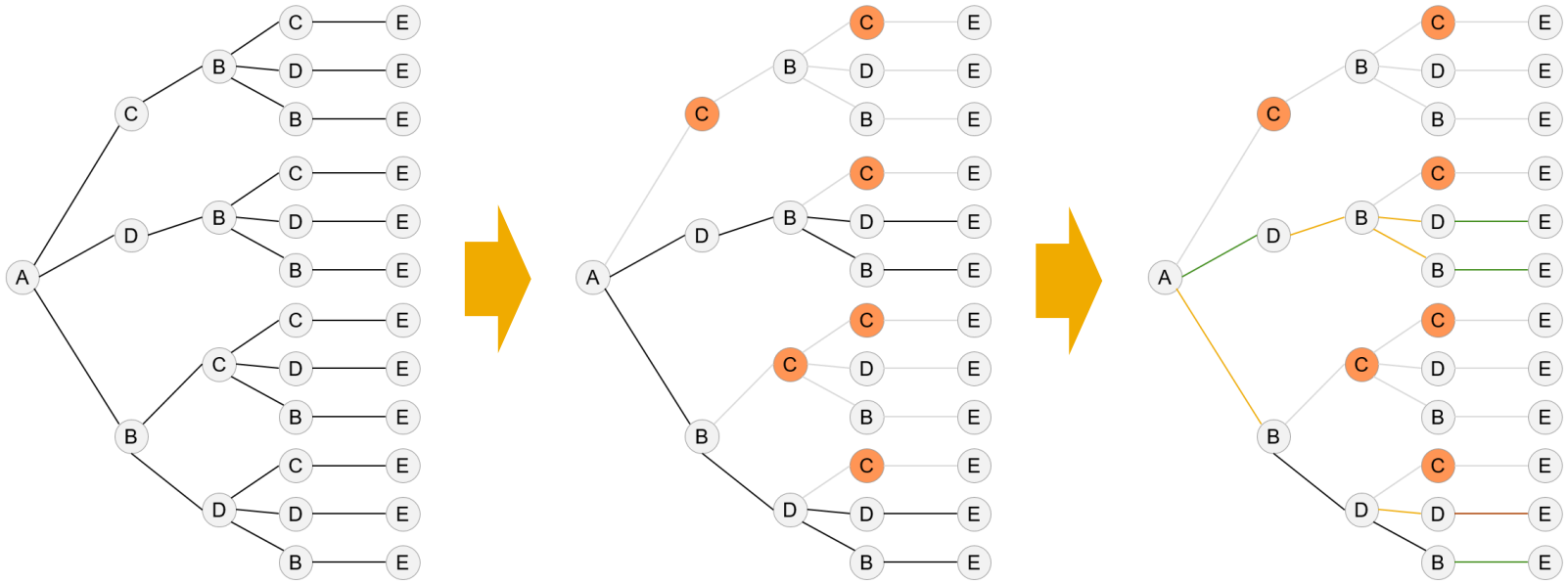


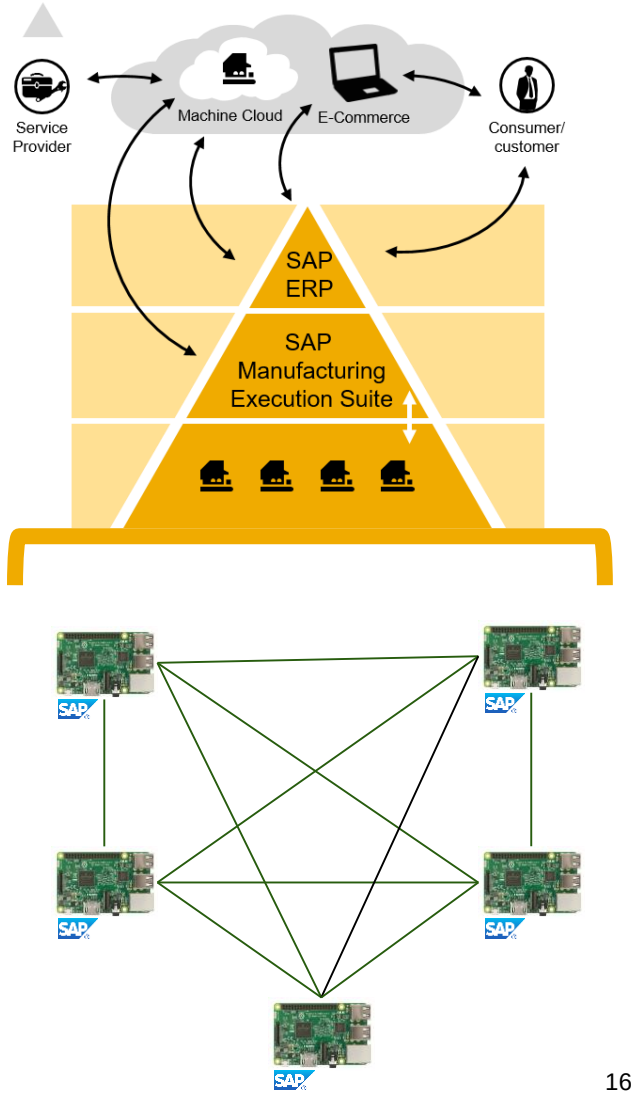


All possible paths

AI / Machine Learning

» Autonomous Systems, Edge Processing





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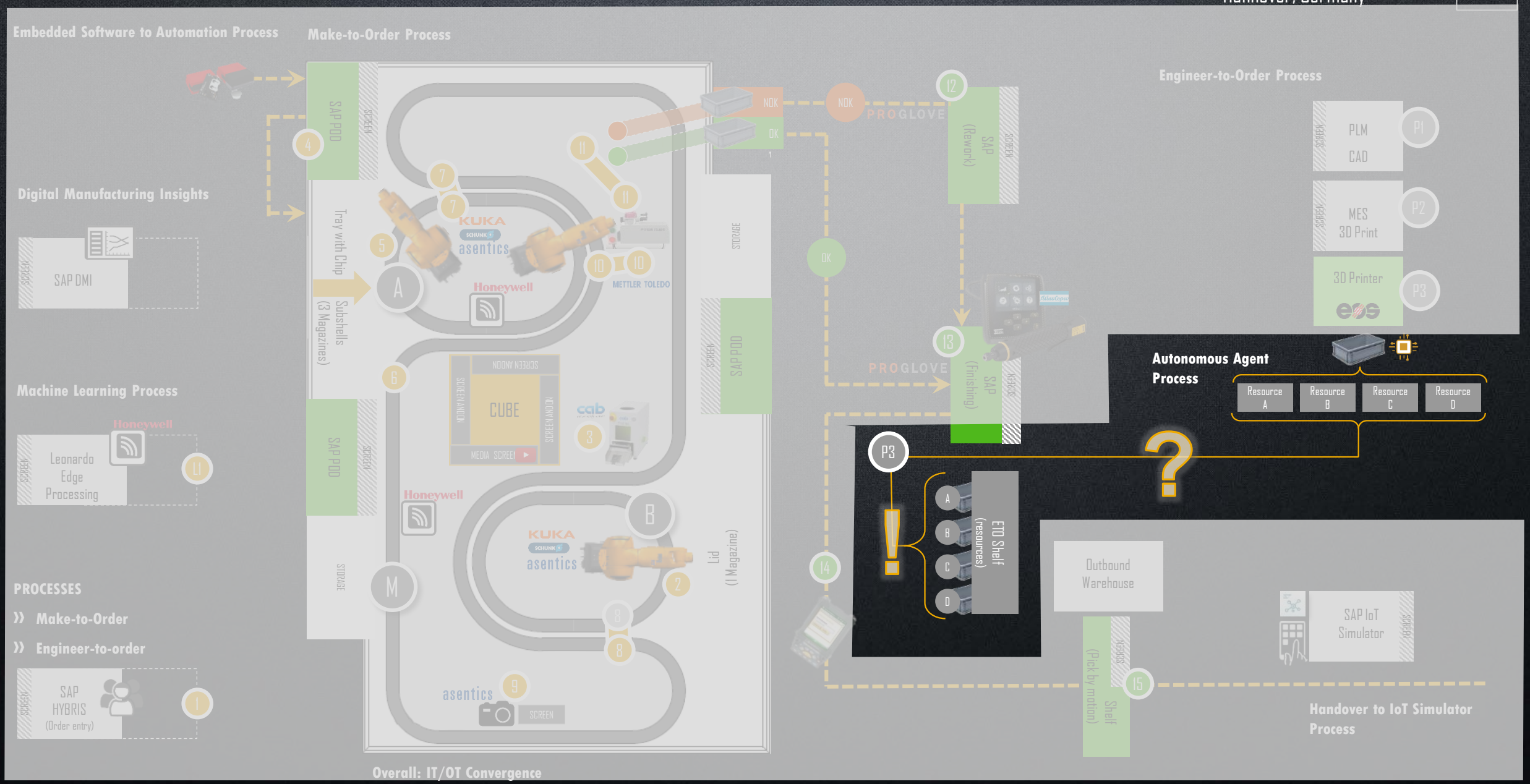


Low Cost Set-up for demonstrating a powerful concept of modern Manufacturing Execution

Open Integrated Factory

Generation 2017

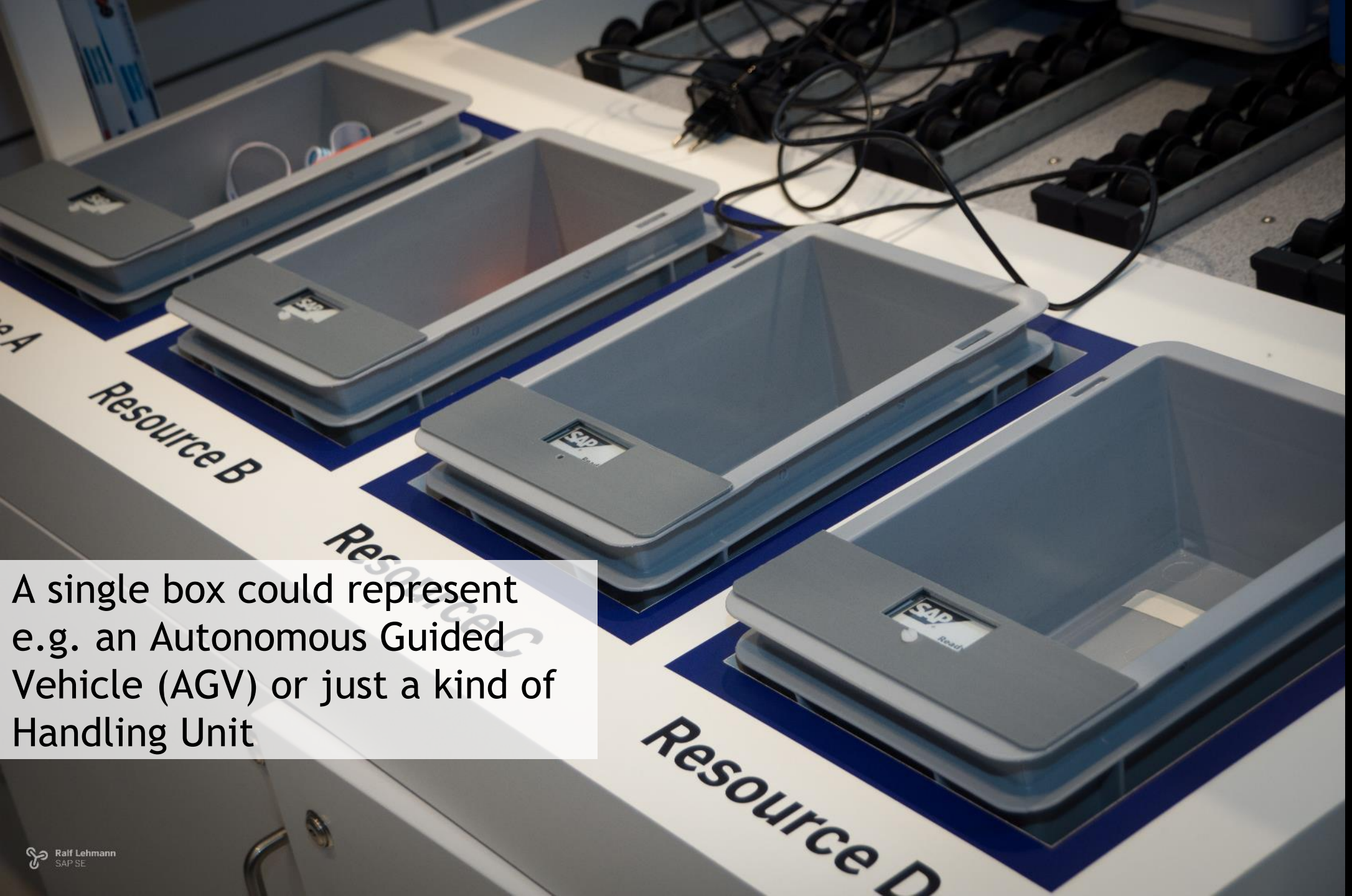
Ralf Lehmann
SAP SE

Resource A – D could represent e.g. 4 (identical) packing machines

Open Integrated Factory

Generation 2017

Ralf Lehmann
SAP SE



A single box could represent e.g. an Autonomous Guided Vehicle (AGV) or just a kind of Handling Unit

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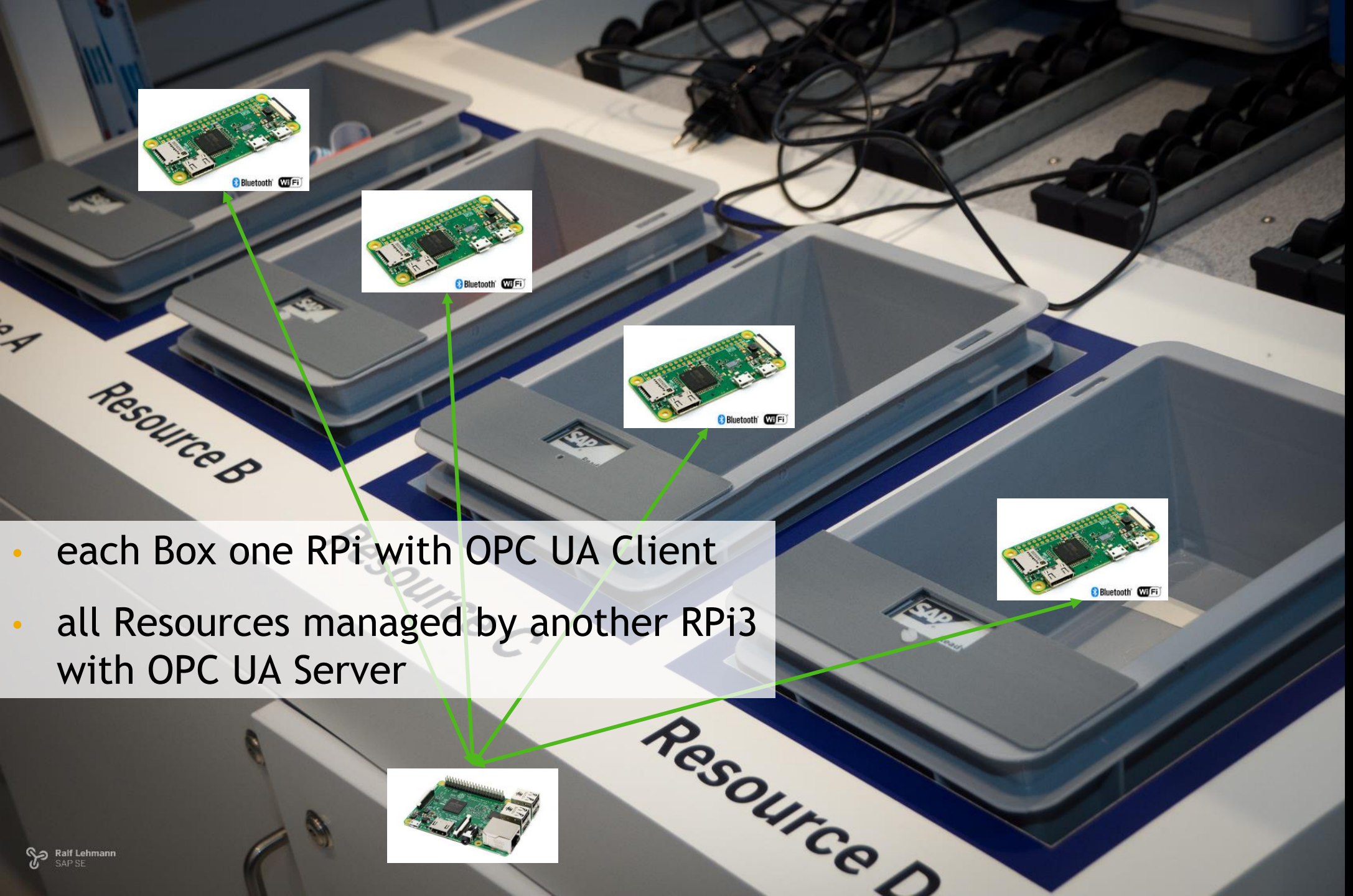
Generation 2017



Open Integrated Factory

Generation 2017

- each Box one RPi with OPC UA Client
- all Resources managed by another RPi3 with OPC UA Server

Ralf Lehmann
SAP SE

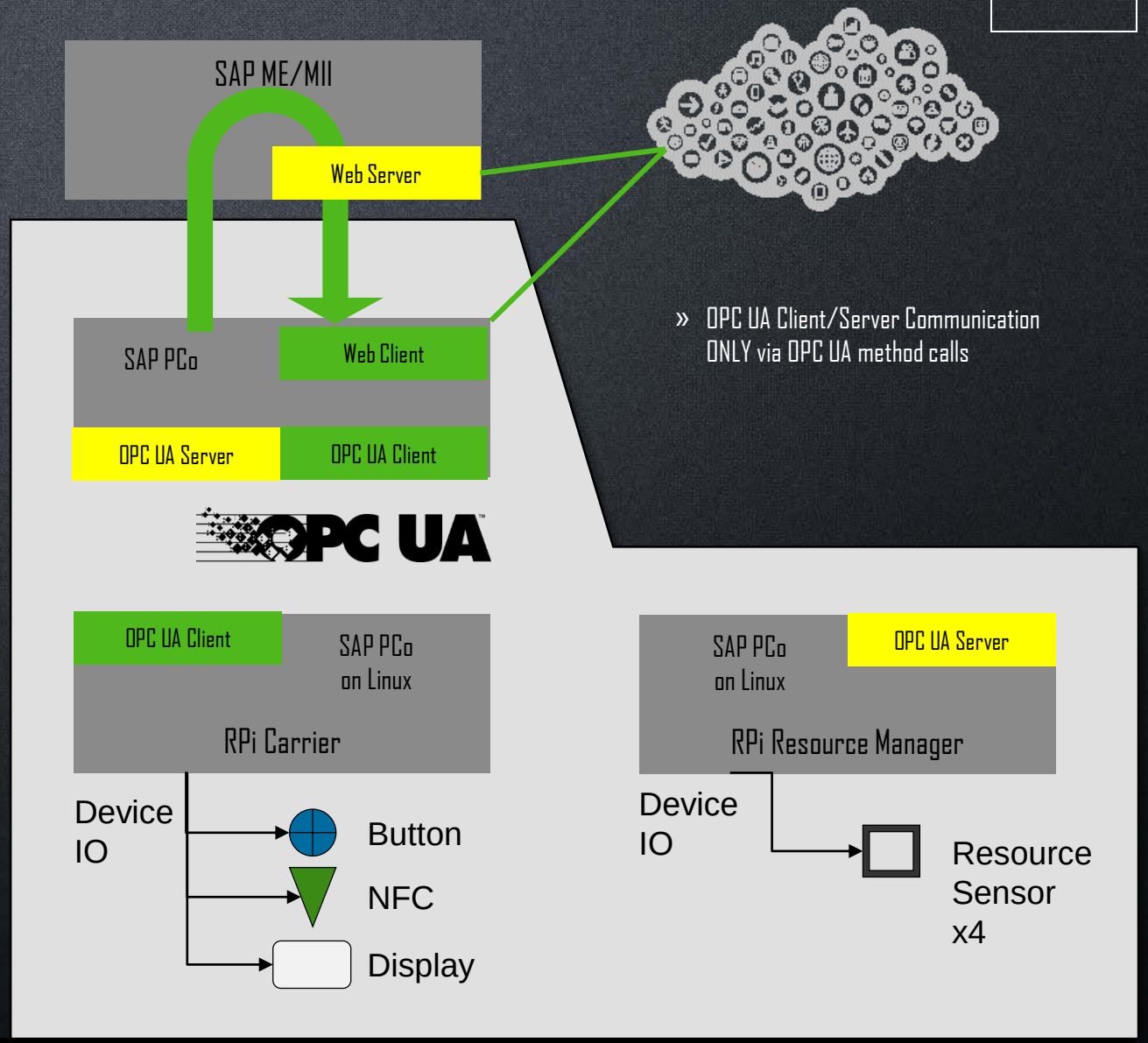
Technical Basis

SAP Plant Connectivity on RPi Linux

(1) Networking over Wireless LAN

(2) Software Development

- .Net Mono Framework
- OPC UA 1.0.3 libraries
- Custom-developed .Net dll to provide RPi Device IO connectivity



- OPC UA Client/Server Communication ONLY via OPC UA method calls

Negotiation can start – pressed Button initiates communication via WiFi

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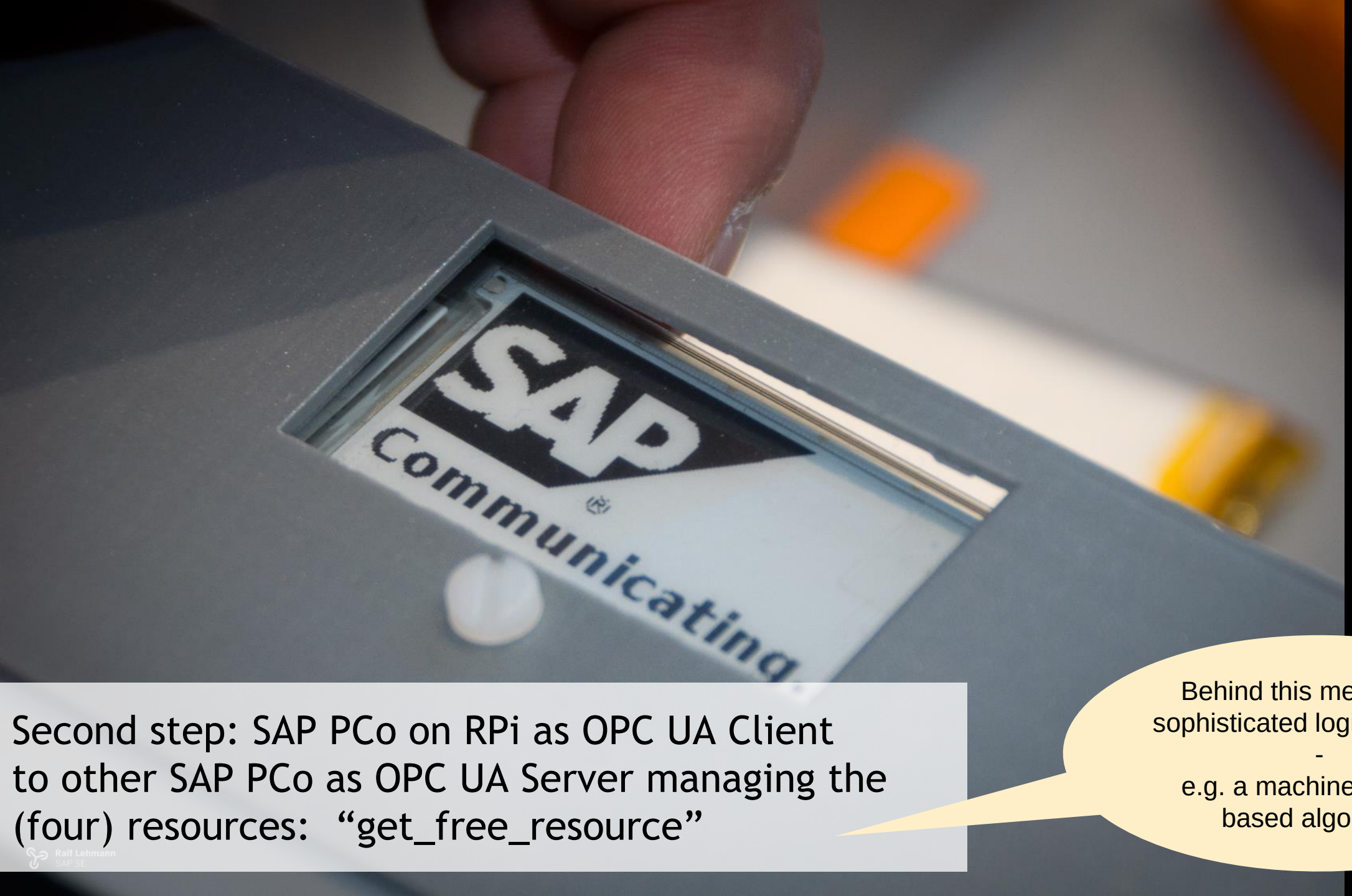
SAP SE

Open Integrated Factory

Generation 2017

First step: SAP PCo on RPi as OPC UA Client to
SAP PCo as OPC UA Server wrapping the SAP MES:
“get_current_sfc” (means get the Production Order from MES which is in work right now)



Open Integrated Factory

Generation 2017

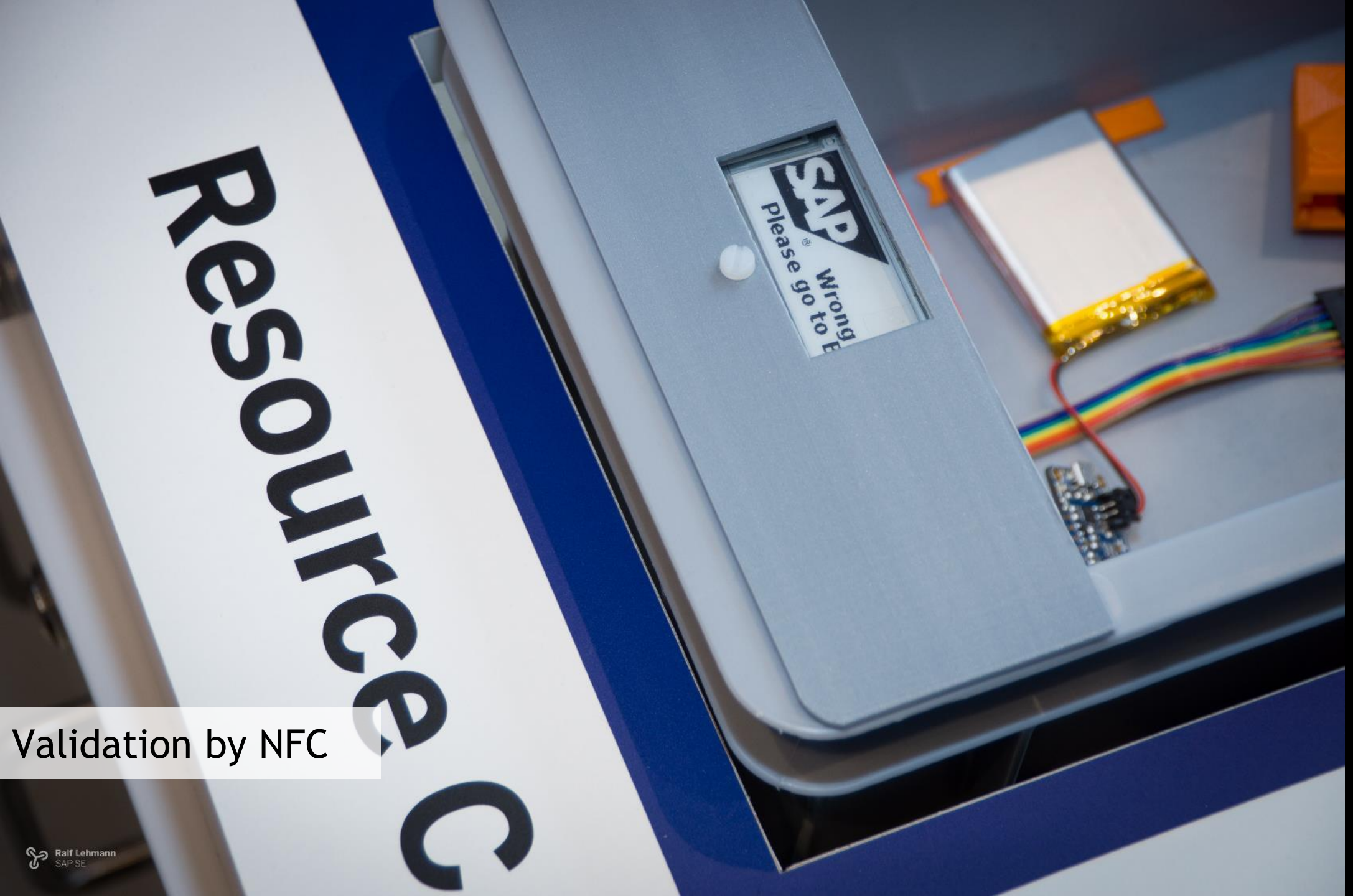
Second step: SAP PCo on RPi as OPC UA Client
to other SAP PCo as OPC UA Server managing the
(four) resources: “get_free_resource”

Behind this method any
sophisticated logic could run
-
e.g. a machine learning
based algorithm!

Open Integrated Factory

Generation 2017

Logic on OPC UA Server RPi proposes and allocates the appropriate Resource (OPC UA Method response)



Validation by NFC

Ralf Lehmann
SAP SE

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Generation 2017

Validation by NFC, follow up communication/ confirmation to SAP MES

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Generation 2017

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Generation 2017

Short comment about challenges of OPC UA …?

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SAP Run Simple

Thank you!

BECKHOFF

NAPCON by NESTEJACOBS

PROSYS OPC

Kepware TECHNOLOGIES

NOVOTEK

Rexroth Bosch Group

Valmet FORWARD

VTT

Thank you.

Contact information:

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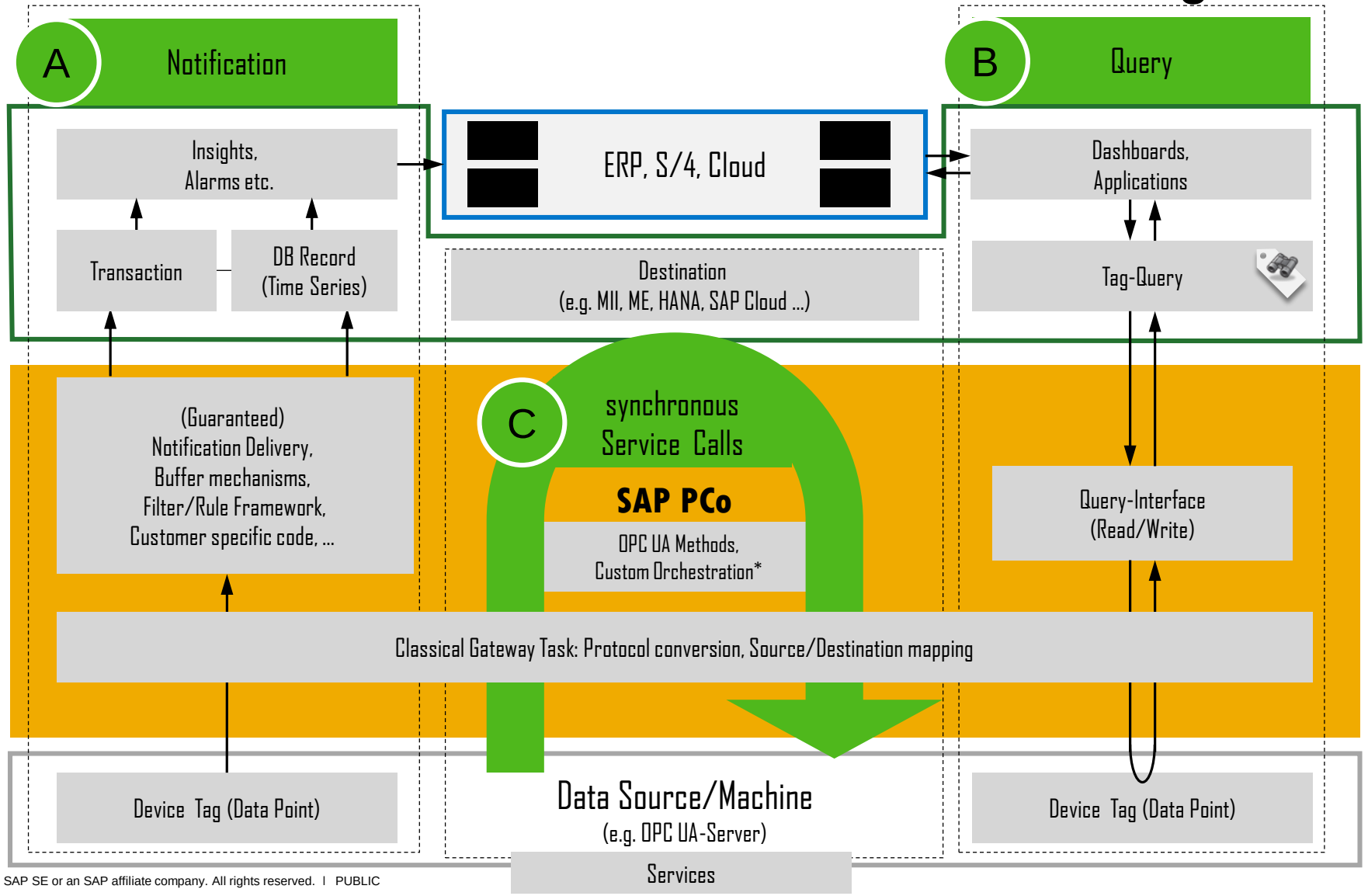
Director Product Management SAP Plant Connectivity
Dietmar-Hopp-Allee 16, 69190 Walldorf
0049 6227 740142
ruediger.fritz@sap.com

Partner logo

Appendix

SAP Plant Connectivity: OPC Client and OPC Server Communication Patterns in Context of Machine Integration

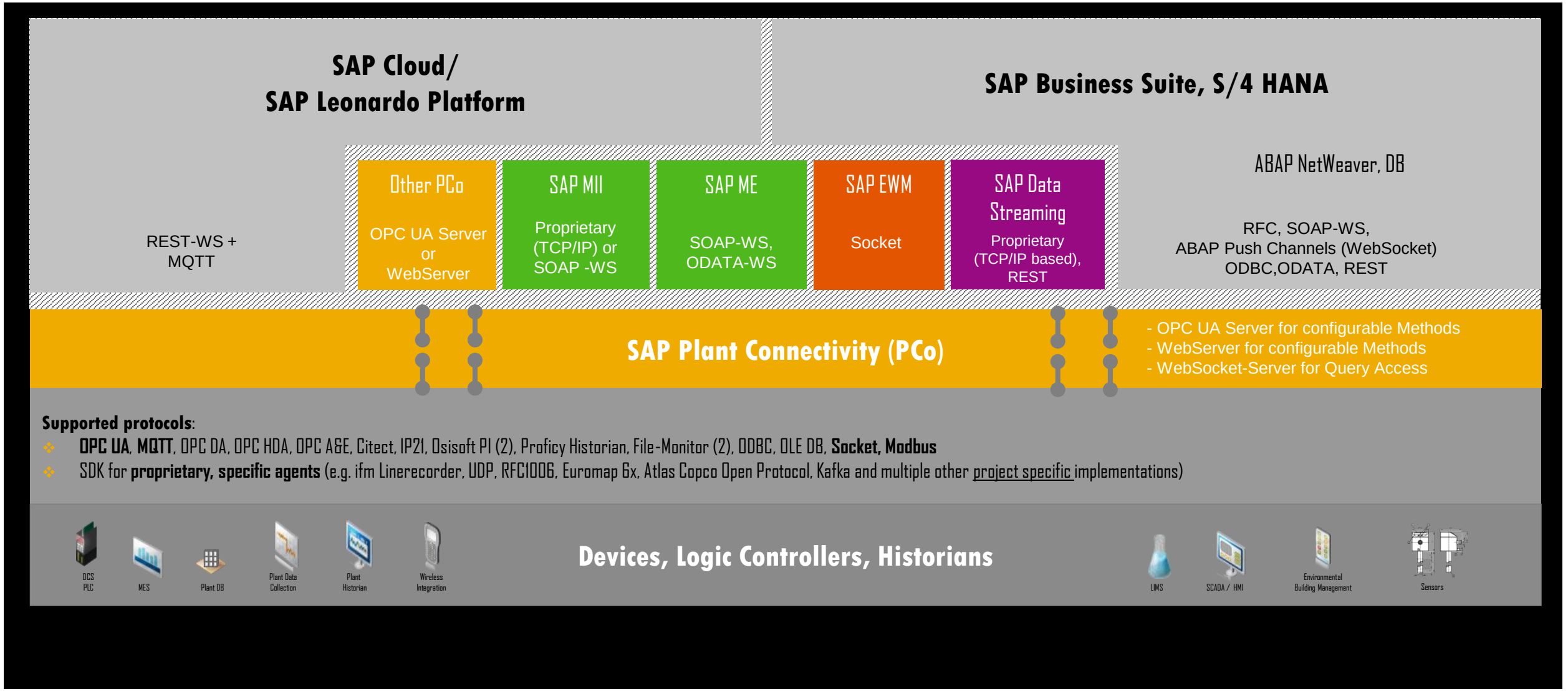


Foundation:

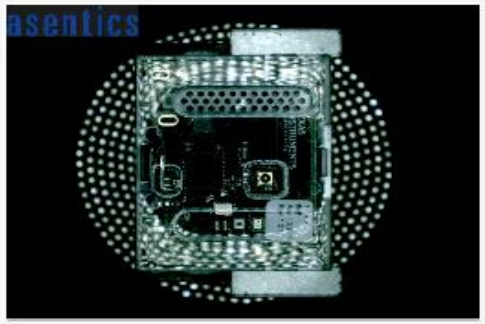
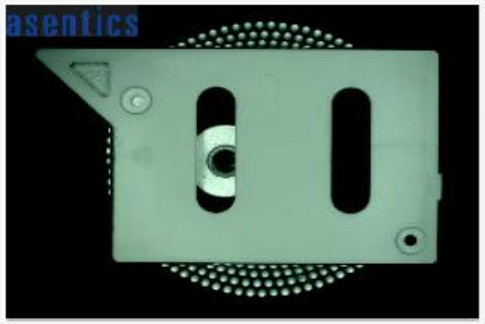
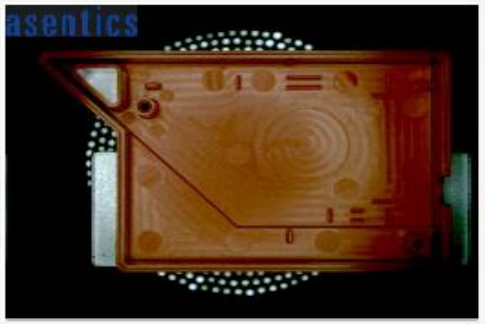
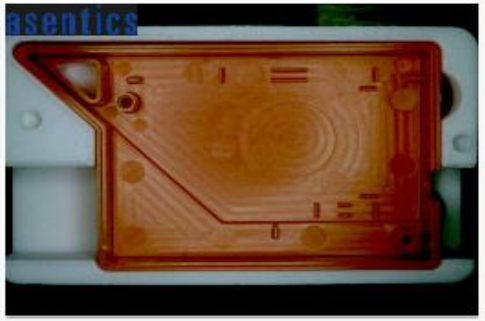
OPC UA

*Project specific configuration/implementation

SAP Plant Connectivity – more than just a simple Gateway for Connectivity



Customer Or... 31393 | Get Pictures | Close Window

C...	Top Tray	Bottom Tray
		
Chip in M...	Top Tray in Pr...	Bottom Tray in Mo...
		
Chip in Bottom Tray	Top Tray in M...	Finshed Product
		

Open Integrated Factory

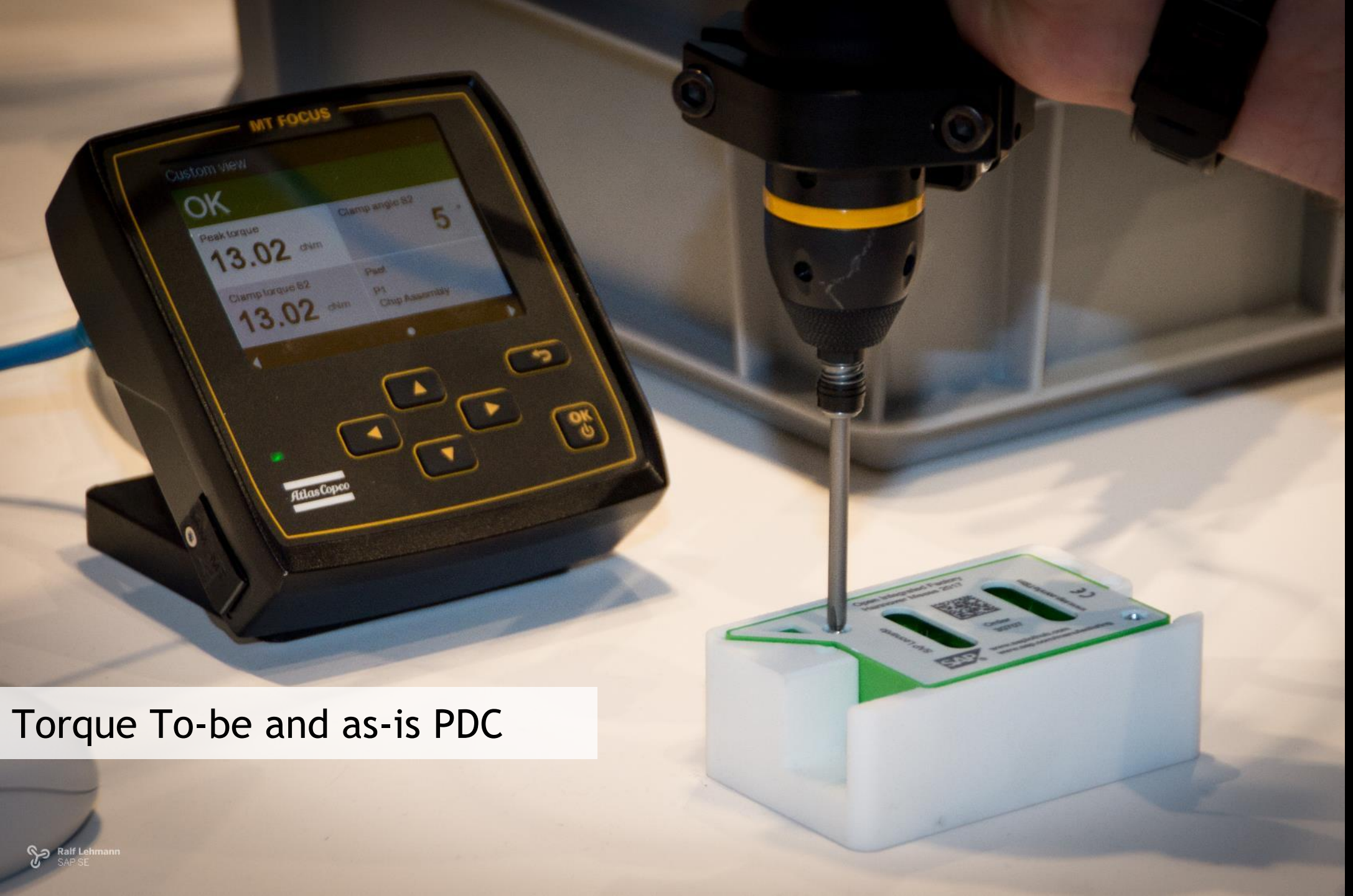
Generation 2017

Each production step documented and available for analytics

Another Device integration

Falk Singer
Atlas Copco

Open Integrated Factory
Generation 2017



Torque To-be and as-is PDC

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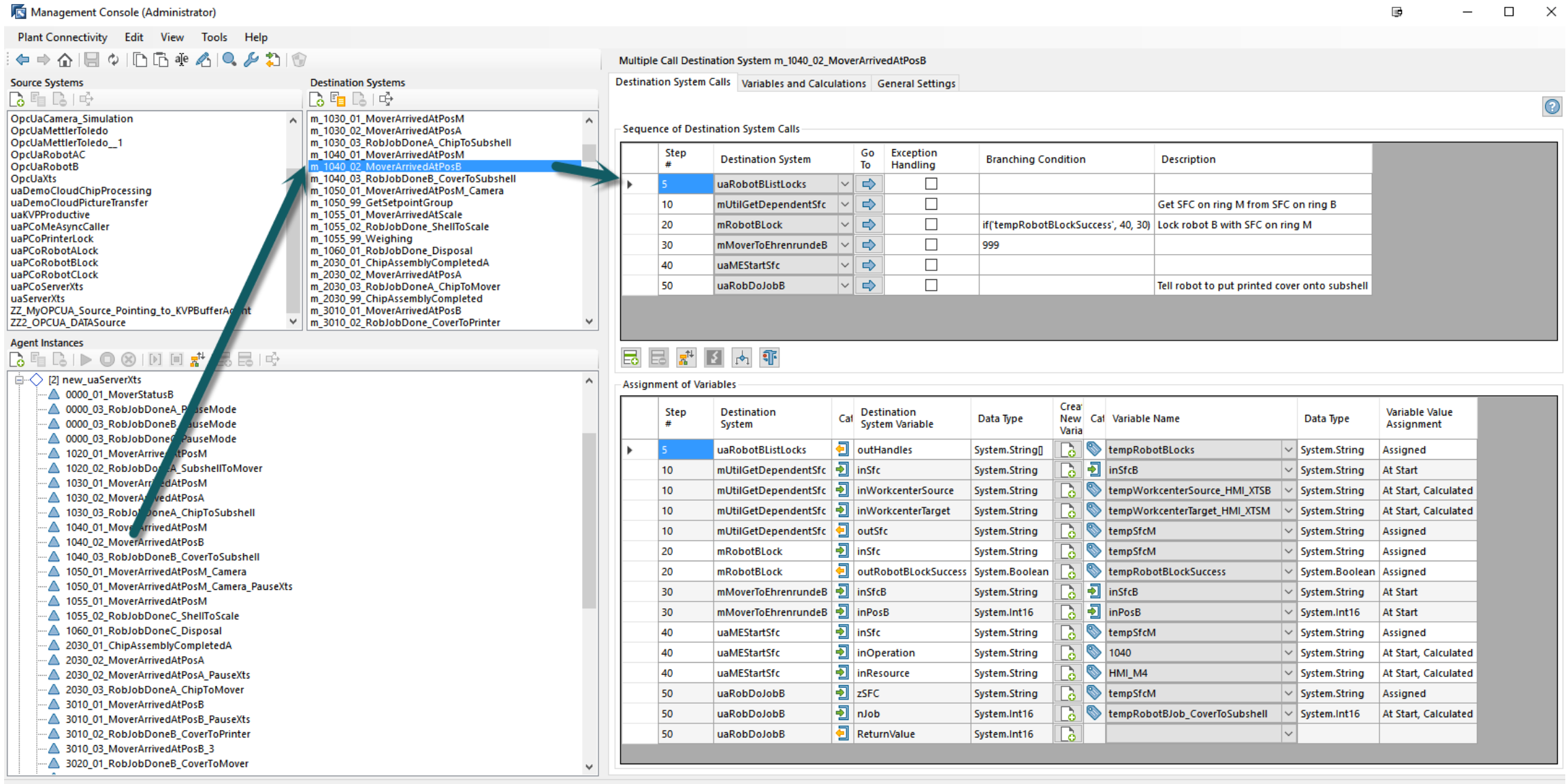
Ralf Lehmann
SAP SE

Plant Connectivity – An Example of Configuration



AI / Machine Learning with immediate action on automation level

» SAP PCo (OPC Client) → Cloud / Data Lake → Apply Model to Dynamic Edge Processing → SAP PCo to Automation