



Implementation of event-driven Industrial IoT-Systems with Azure IoT Edge and NATS.io

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Agenda

- 1 IT@Schaeffler-Framework
- 2 NATS.io Messaging System
- 3 Open Platform Communications Unified Architecture
- 4 Gateway Development
- 5 Workshop Results
- 6 Digital Production System

Connectivity and integration are the foundation of Smart Factories

Why

All relevant use cases for a Smart Factory require **access to current and high-quality data**, whether it is transparency about system states, prediction of problems and potential solutions, analytics, machine learning or **autonomous production**.

What

- Standardization of edge **hardware** to a clearly defined, manageable number of alternatives → Equipment
- Delivery of data in standard formats via standard **protocols** → Gateways
- A unified, secure and scalable data **distribution platform** to connect many agents → Messaging System

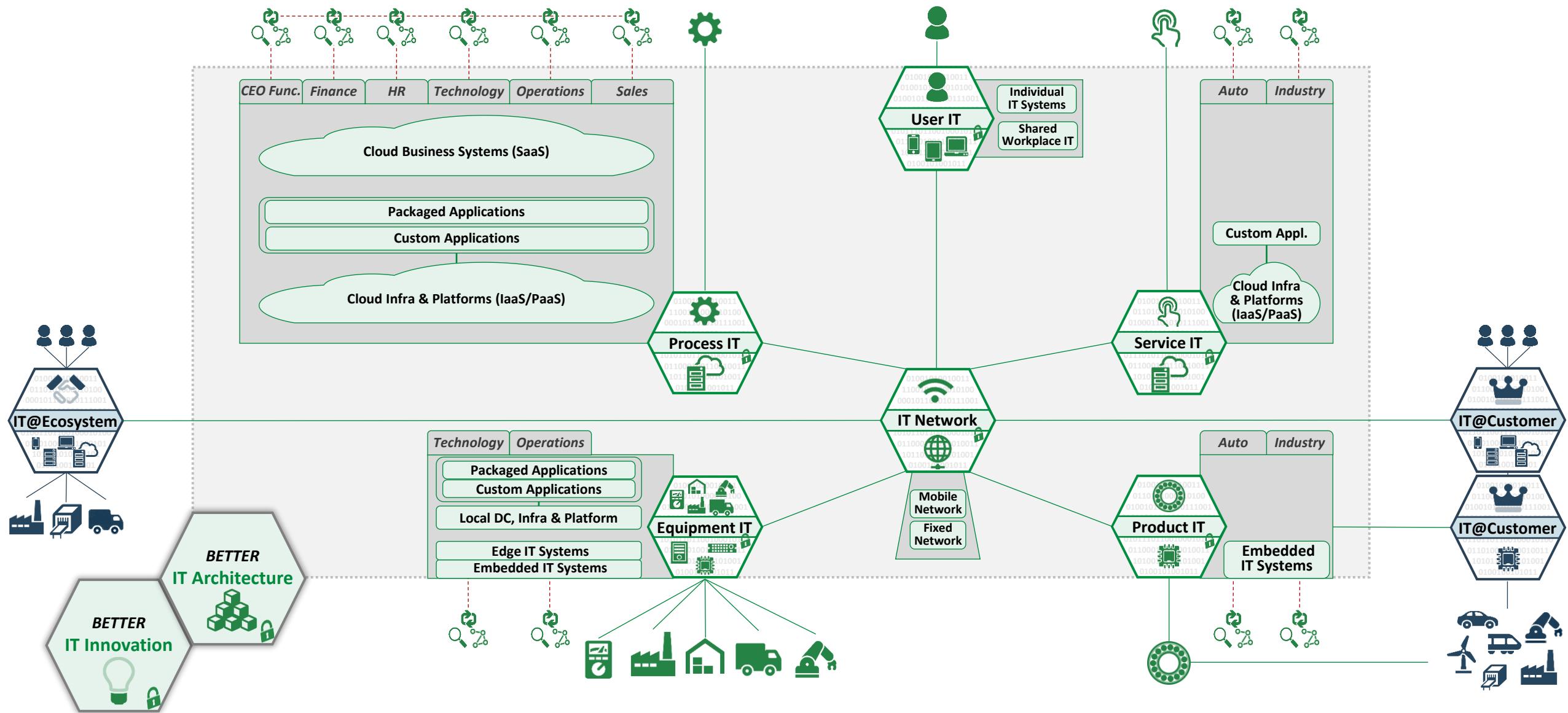
Architecture

How

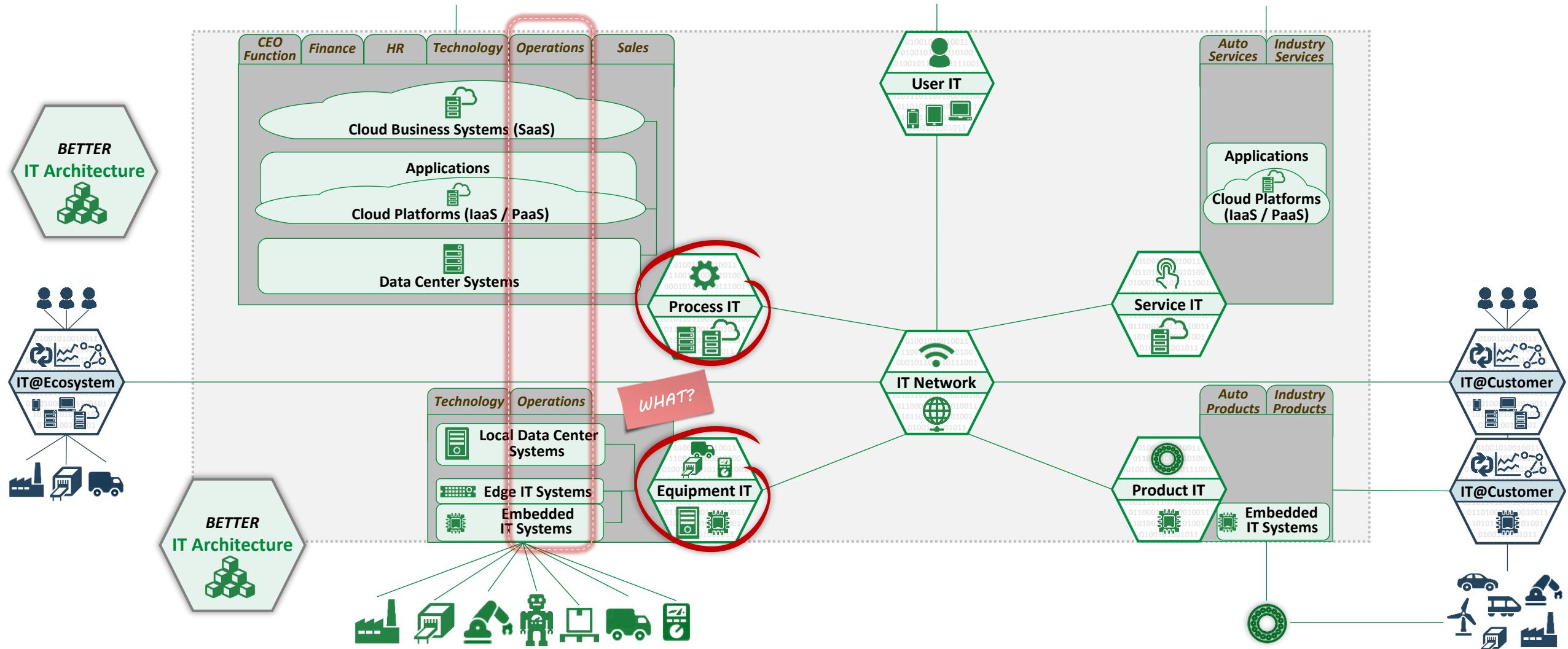
- The requirements for IT infrastructure need to be clarified
- The required solution components and infrastructure need to be assigned to Product Owners who provide
 - Documentation on the features and ‘unique selling points’ of their products
 - Operating models incl. roles and responsibilities
 - Dates for availability of the production-ready versions

Operating
Model

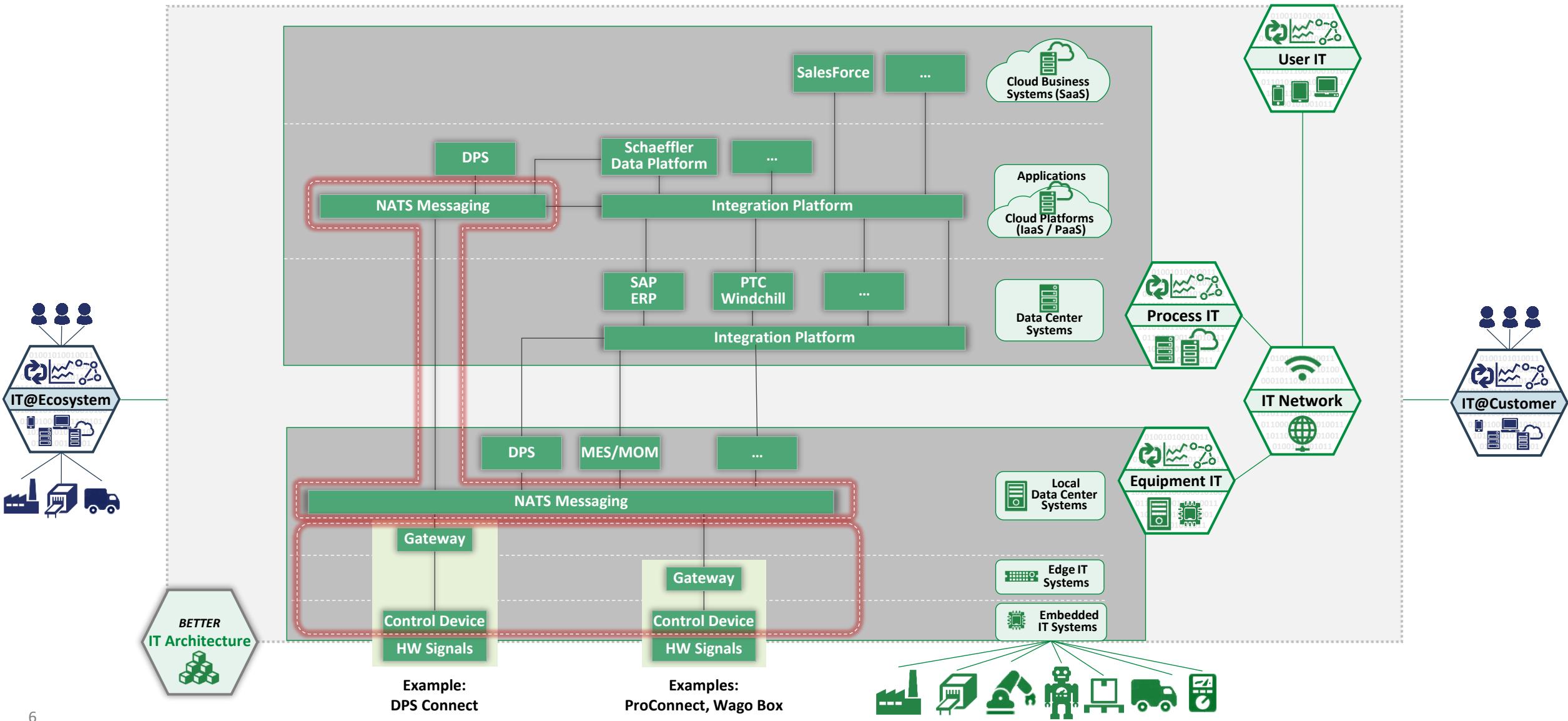
Better IT Architecture – System Deployments across distributed Cloud and Edge Environments



IT@Schaeffler - Context



IT Architecture – Context Production IT – Equipment IT Integration



Agenda

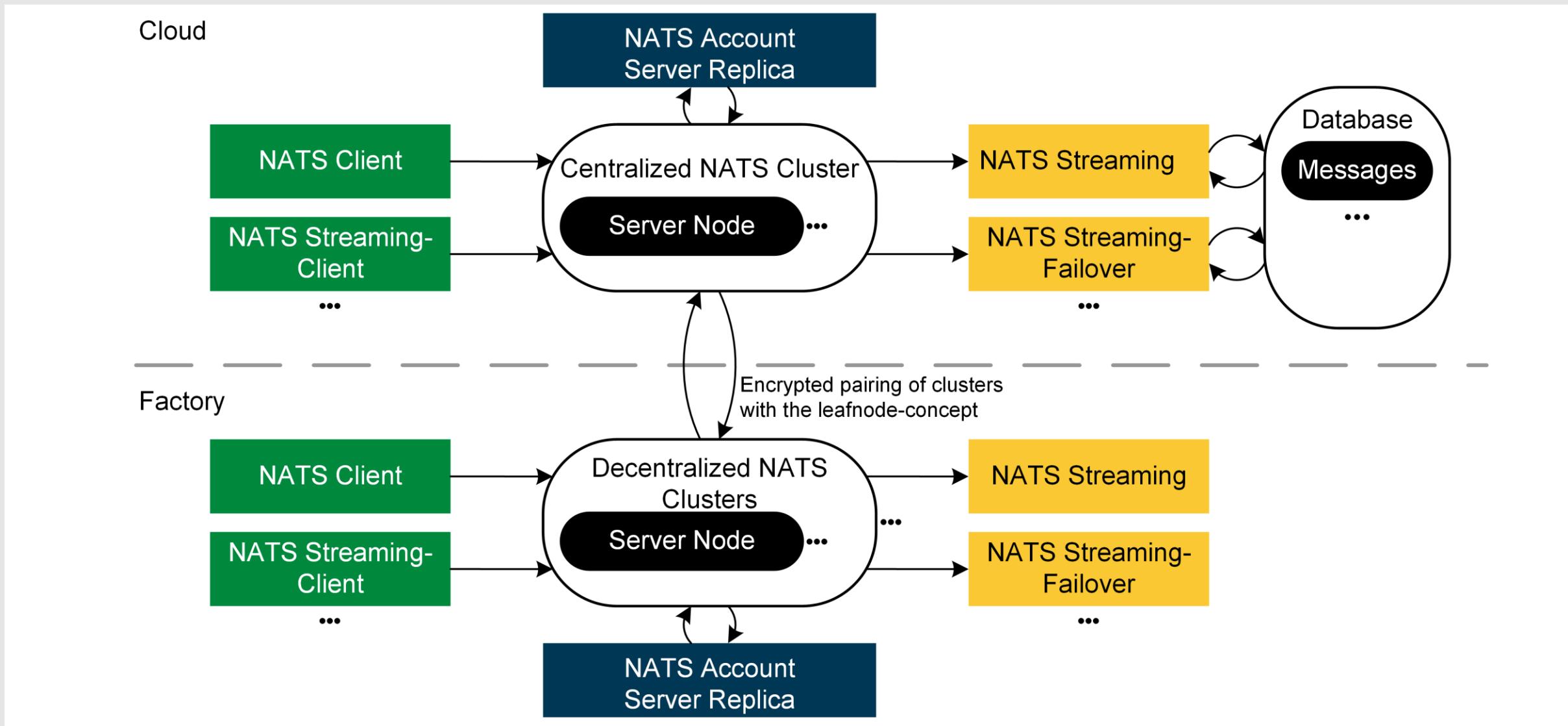
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Why NATS.io?

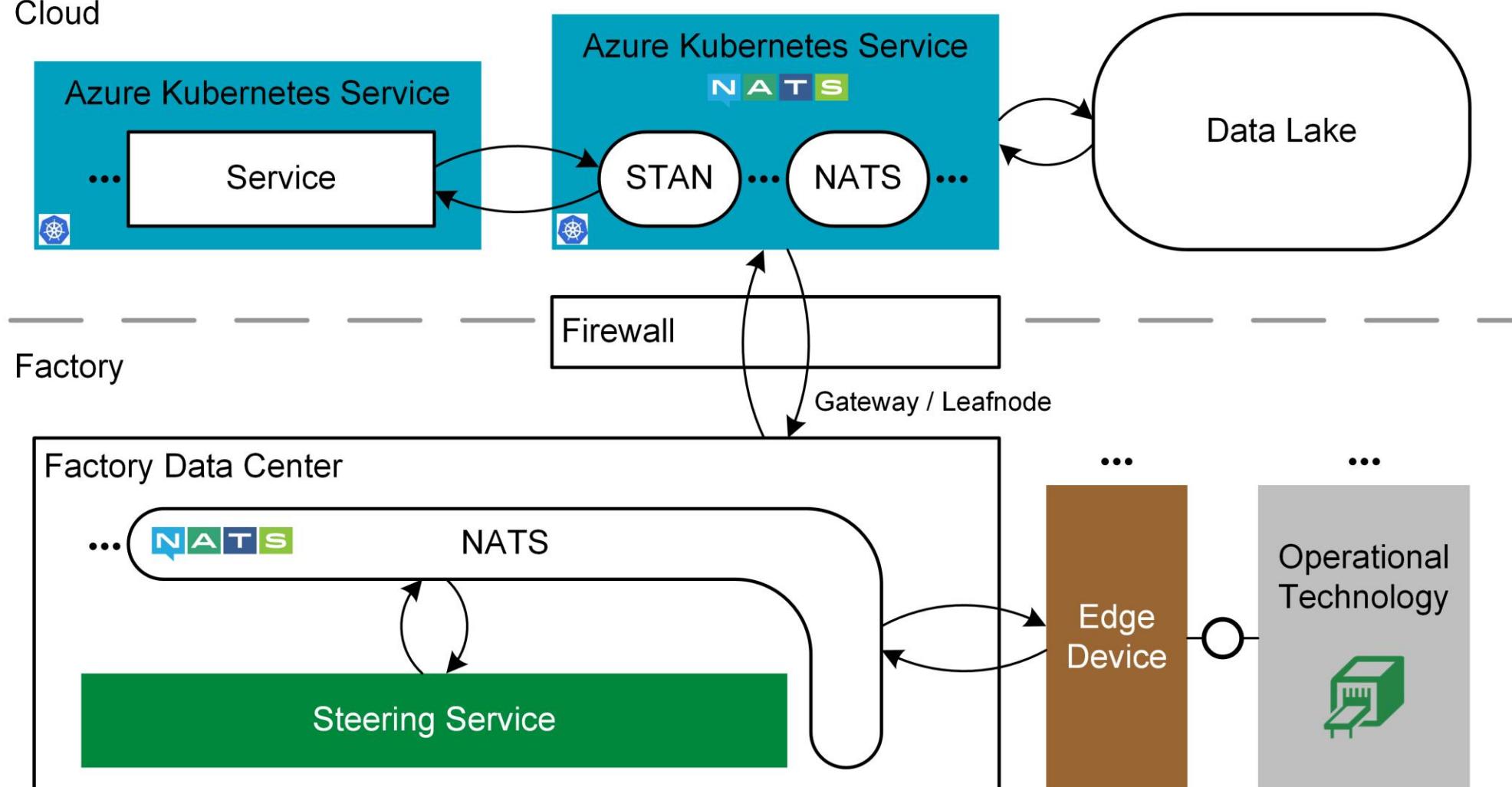


- Fast, scalable
- Easy to use
- Runs on Linux and Windows Operating Systems
- Lightweight
- Queue groups
- Provides persisting over NATS Streaming (STAN)
- Auto-Discovery automatically exchanges server topology
- Clients can failover to new servers that weren't originally configured
- NATS server clusters dynamically adjust to new or removed servers
- Rolling updates possible
-
- <https://www.cncf.io/wp-content/uploads/2019/09/NATS-CNCF-Webinar-Sep-2019.pdf>

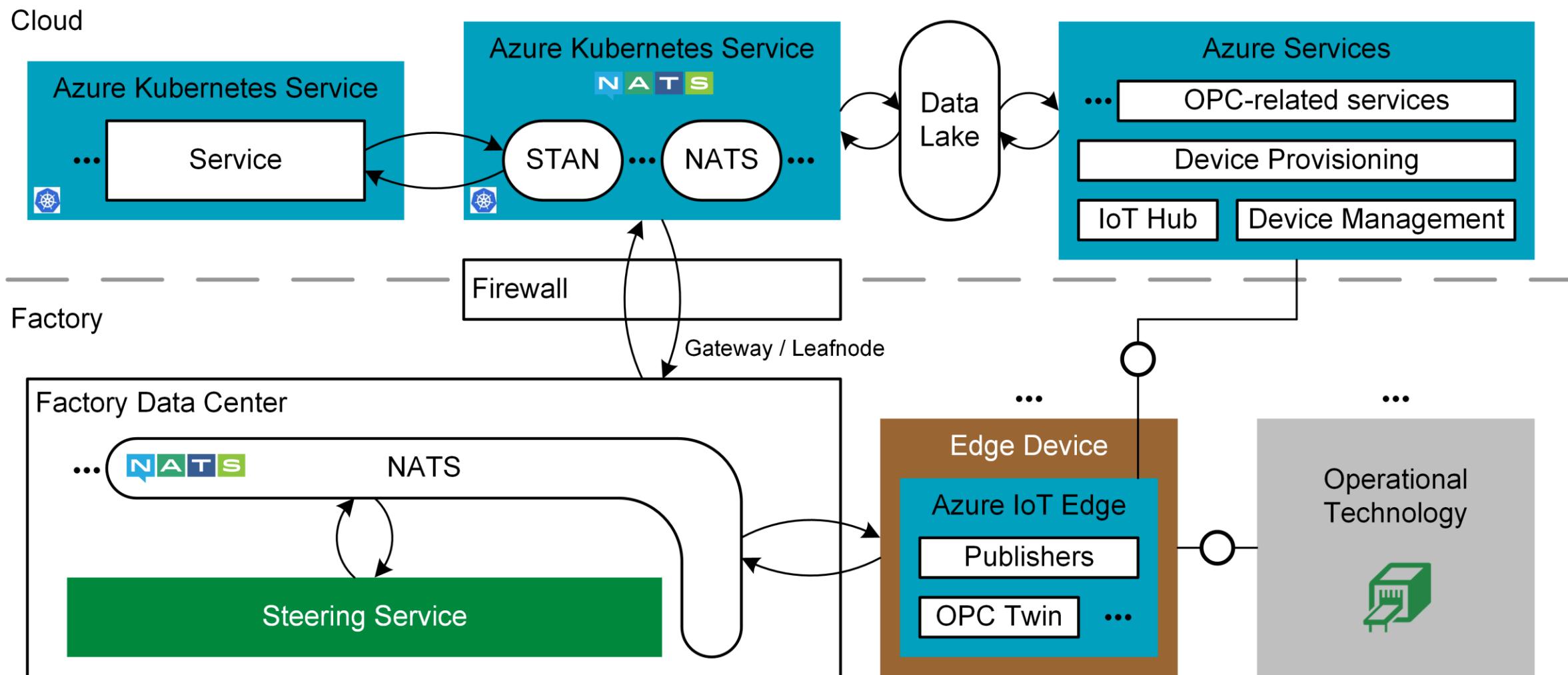
Alignment of centralized and decentralized NATS Clusters



Current NATS Deployment



IoT Hub with NATS – using IoT Hub and IoT Edge for the management of devices



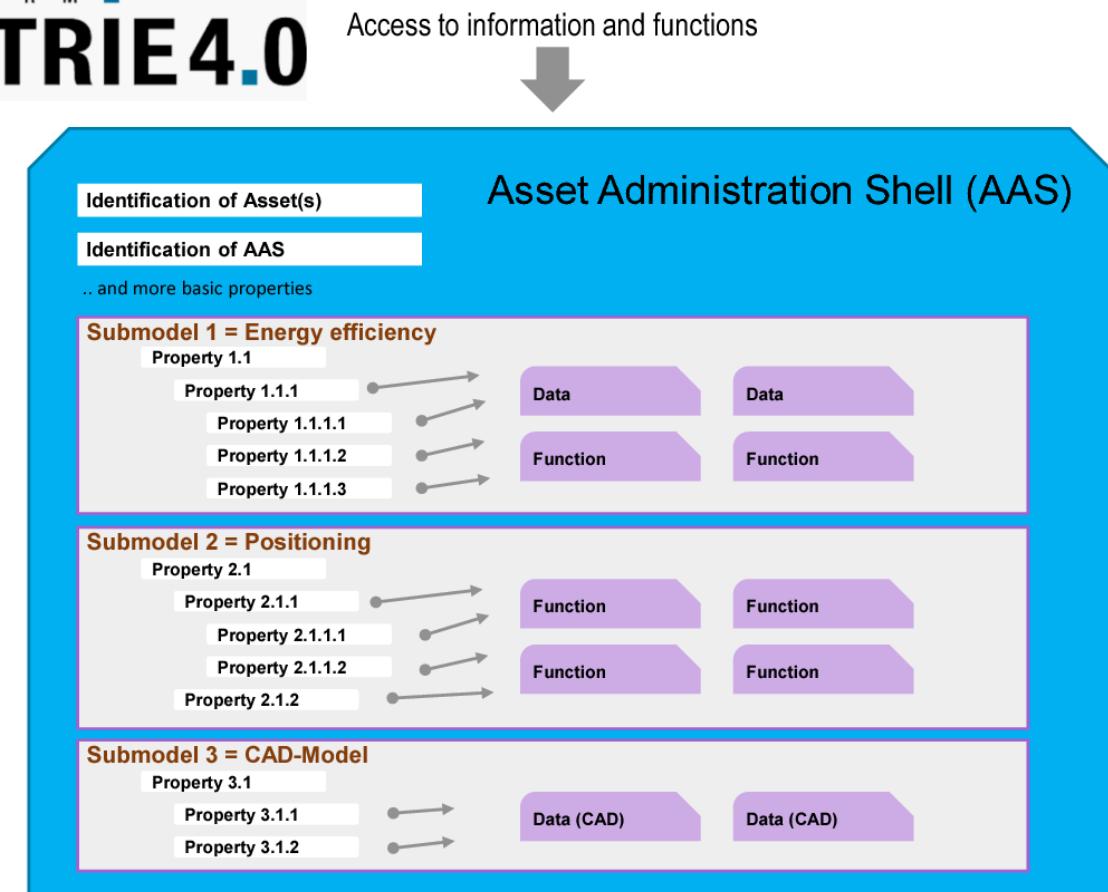
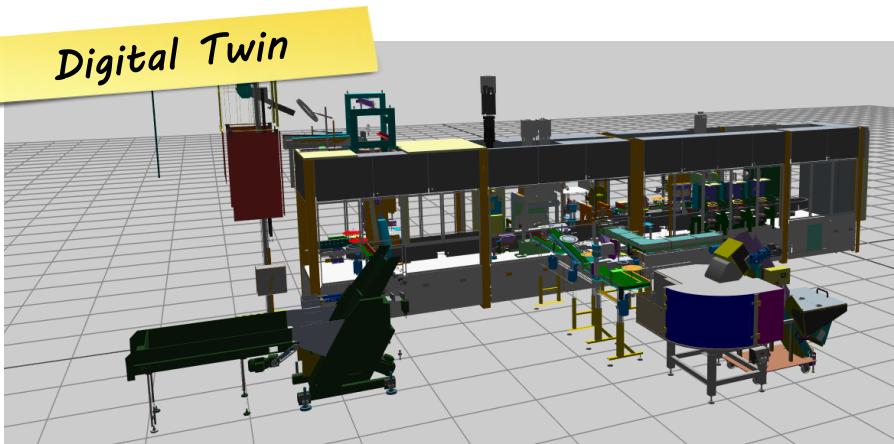
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Schaeffler Herzogenaurach,
Bearing Assembly Line

Asset Administration Shell – Realisation of a Digital Twin



Strict, standardized data format

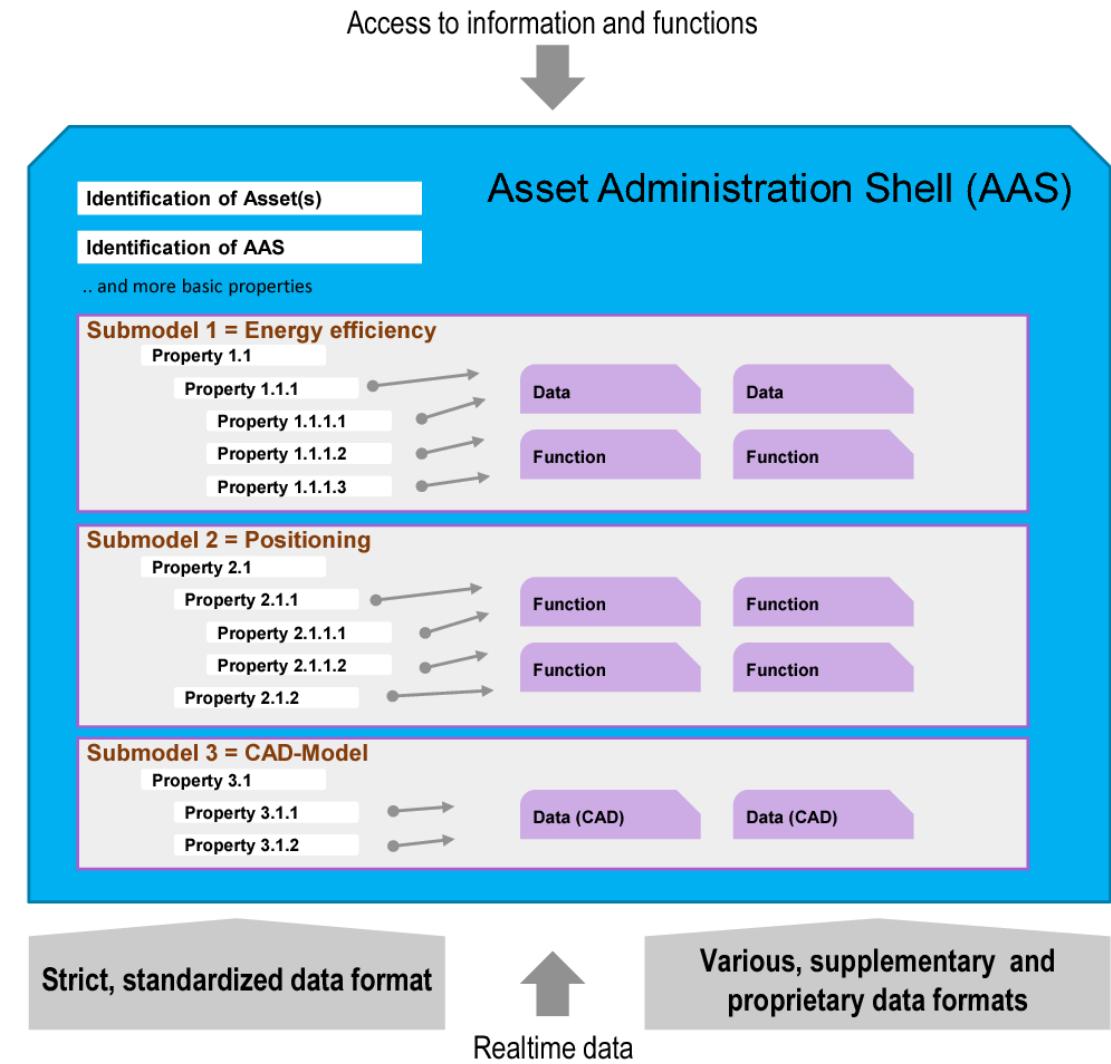
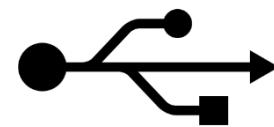
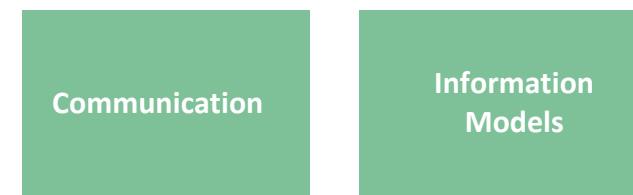
Realtime data

Various, supplementary and proprietary data formats

Open Platform Communications Unified Architecture



- ▶ Information centric architecture
 - ▶ M2M-Communication
 - ▶ Information modeling
- ▶ OPC UA is
 - ▶ Platform independent
 - ▶ Standardized in IEC 62541



Azure IIoT: Industry leading OPC UA Support



The Industrial Interoperability Standard

Microsoft is a member of the OPC Foundation since 1996

Microsoft supports OPC UA on Azure since 2016

Interoperability

Vendor, Platform and OS Independent

Open Source on GitHub (**Many Microsoft contributions**)

Discoverable Services Oriented Architecture (SOA) independent of the transport method

Owned by a Non-Profit (**OPC Foundation**)

50M installed base and exponential growth

Data Modelling

Rich data modeling preserves source context

Vendors can extend the data model of each product (Companion Specification)

Maps to field bus protocols, e.g. BACNet | PLCopen | MTConnect | ...

Security

Secure Design from group-up

Based on **open security standards**

Authentication | Encryption

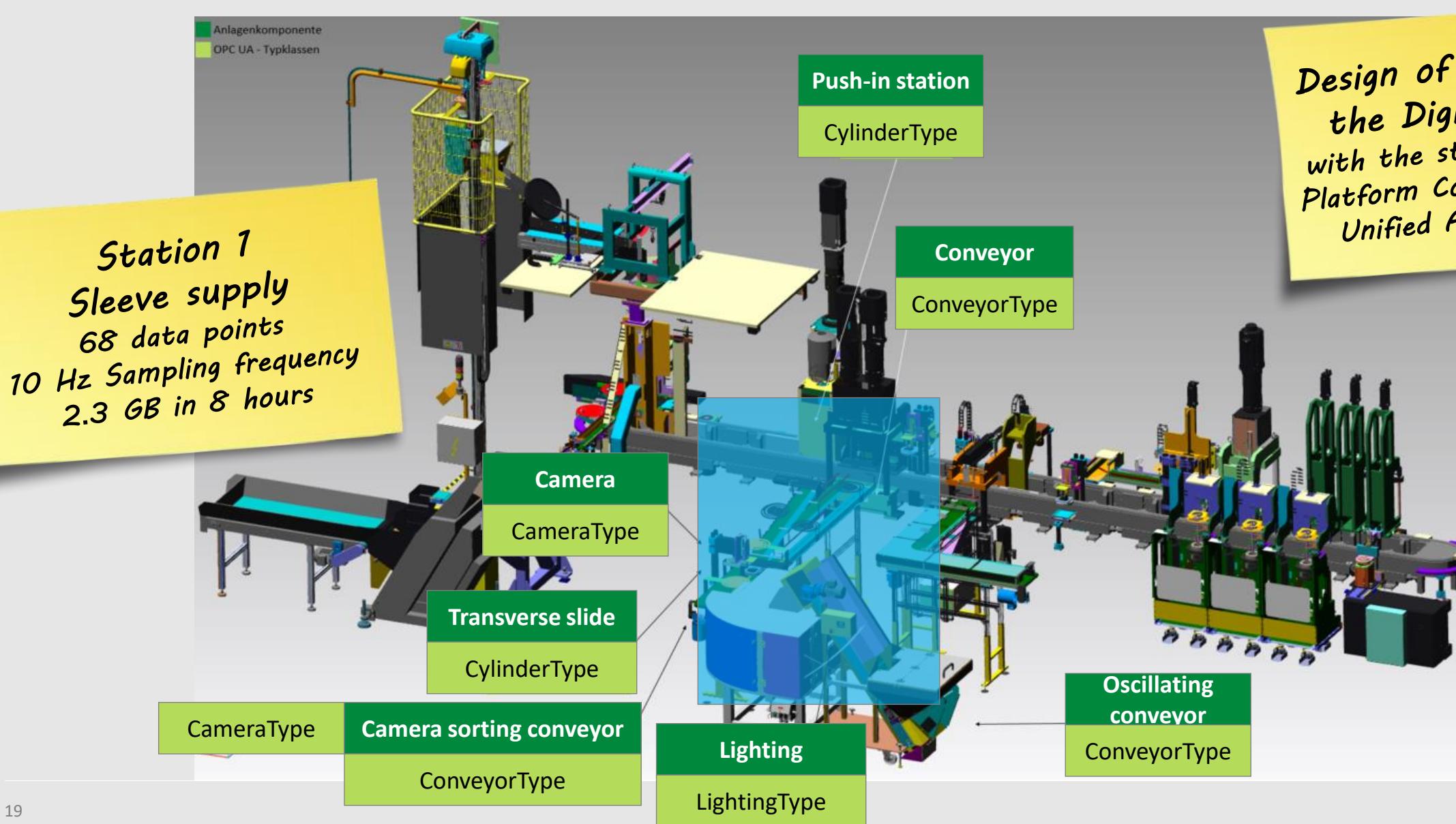
Evolves as security technologies evolve

Vendors/Users can choose level of security

Easily acceptable by IT departments

github.com/Azure?q=OPC

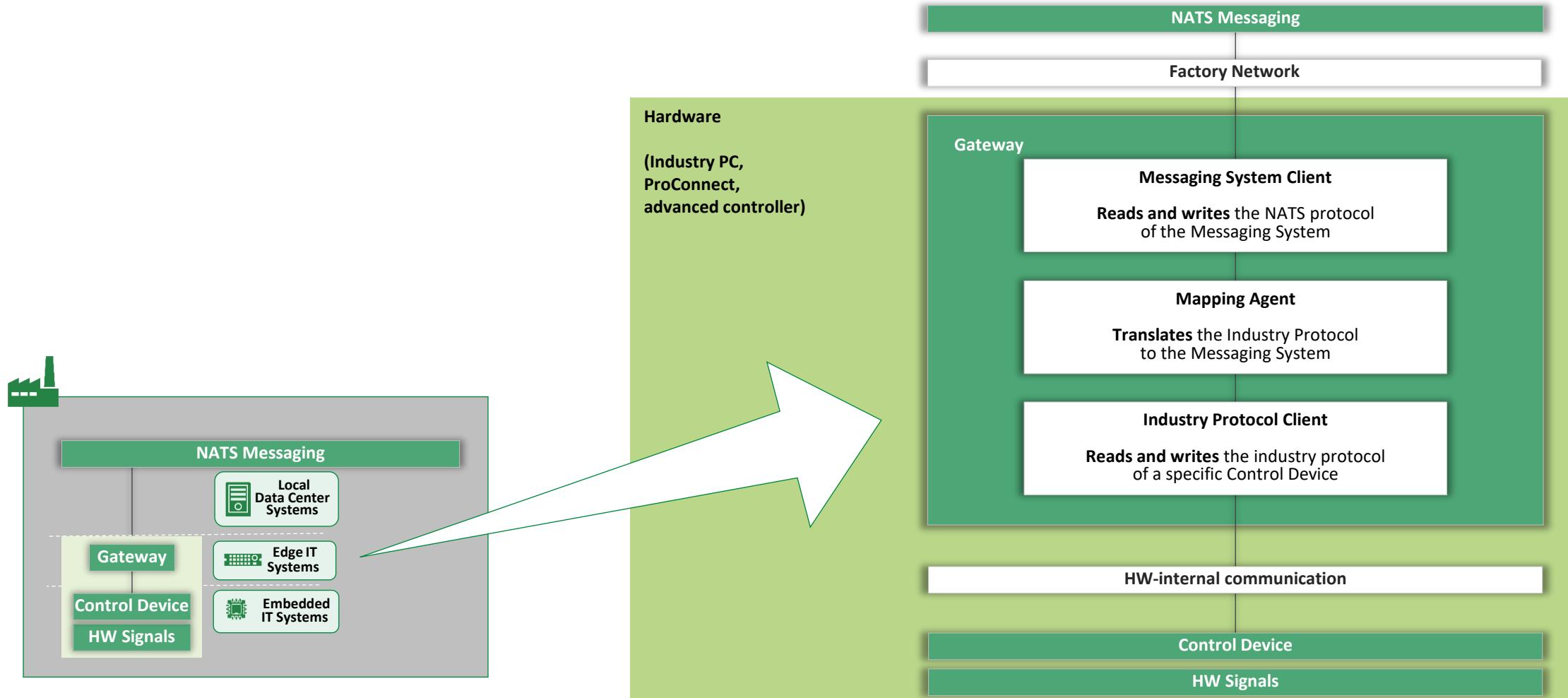
Digital Twin of an Bearing Assembly Line



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Gateways act as translators from specific industry protocols to the Messaging System





Address Space

No Highlight

Root

- Objects
 - Client
 - DeviceSet
 - RH Montage 2. Config
 - RH Master
 - DeviceManual
 - DeviceRevision
 - GlobalVars
 - 01A A2400_Band
 - 01A A2400_Hulsen
 - 01A K2400:A1
 - 01A K2400:A2
 - 01A K3100
 - 01A K3200
 - 01A K3300
 - 01A K3400_Einstosser_1
 - 01A K3500_Einstosser_2
 - 01A K3600_FuehrungEinst1
 - 01A Y0000
 - 01A Y0001
 - 01A Y0100
 - 01A Y0101
 - 01A Y0201
 - 01A Y0301
 - 01E A2400:XS4:5
 - 01E A2400:XS4:7
 - 01E B0000
 - 01E B0001
 - 01E B0050
 - 01E B0100
 - 01E B0101
 - 01E B0150
 - 01E B2450
 - 01E B3650
 - 01E B3651
 - 01E B3652
 - 01E B3653

Data Access View

OPC UA nodes to publish via the NATS Messaging System

#	Server	Node Id	Display Name	Value	Datatype	Source Timestamp	Server Timestamp
1	rh	NS4[String]...	AVO	0020	String	11:05:36.265	11:05:36.516
2	rh	NS4[String]...	Auftraqsnummer	6487625	String	11:05:36.265	11:05:36.516
3	rh	NS4[String]...	Beschreibung_Materialnr	F-349179.03.RH	String	11:05:36.265	11:05:36.516
4	rh	NS4[String]...	EAN		String	11:05:36.265	11:05:36.516
5	rh	NS4[String]...	Materialnummer	083606696-0000	String	11:05:36.265	11:05:36.516
6	rh	NS4[String]...	SollStueckzahl	300000	Int32	11:05:36.265	11:05:36.516
7	rh	NS4[String]...	F_NUMMER	F-349179.03.RH	String	11:05:36.265	11:05:36.516
8	rh	NS4[String]...	INTERNE_STOERUNGSNU...	0	Int16	11:05:36.265	11:05:36.516
9	rh	NS4[String]...	MASCHINE_STATUS	1	Int16	11:05:36.265	11:05:36.516
10	rh	NS4[String]...	PERMANENT_AUSSCHUSS	206940	Int32	11:11:01.198	11:11:01.448
11	rh	NS4[String]...	PERMANENT_EINRICHTEN	0	Int32	11:05:43.024	11:05:43.274
12	rh	NS4[String]...	PERMANENT_GESAMT	11994360	Int32	11:11:44.816	11:11:45.067
13	rh	NS4[String]...	PERMANENT_GUT	7760929	Int32	11:11:44.816	11:11:45.067
14	rh	NS4[String]...	PERMANENT_NACHARBEIT	387229	Int32	11:11:33.287	11:11:33.535
15	rh	NS4[String]...	SCHICHT_AUSSCHUSS	10	Int32	11:11:01.198	11:11:01.448
16	rh	NS4[String]...	SCHICHT_EINRICHTEN	0	Int32	11:05:43.024	11:05:43.274
17	rh	NS4[String]...	SCHICHT_GESAMT	985	Int32	11:11:44.816	11:11:45.067
18	rh	NS4[String]...	SCHICHT_GUT	952	Int32	11:11:44.816	11:11:45.067
19	rh	NS4[String]...	SCHICHT_NACHARBEIT	23	Int32	11:11:33.287	11:11:33.535
20	rh	NS4[String]...	TAG_AUSSCHUSS	6262	Int32	11:11:01.198	11:11:01.448
21	rh	NS4[String]...	TAG_GESAMT	501027	Int32	11:11:44.816	11:11:45.067
22	rh	NS4[String]...	TAG_GUT	463237	Int32	11:11:44.816	11:11:45.067
23	rh	NS4[String]...	TAG_NACHARBEIT	31528	Int32	11:11:33.287	11:11:33.535
24	rh	NS4[String]...	11A A73.6	false	Boolean	11:11:44.694	11:11:44.816
25	rh	NS4[String]...	11A A73.7	true	Boolean	11:11:44.816	11:11:45.067
26	rh	NS4[String]...	11A A74.0	false	Boolean	11:11:44.816	11:11:45.067
27	rh	NS4[String]...	11A A74.1	true	Boolean	11:11:44.816	11:11:45.067
28	rh	NS4[String]...	11A K2400	true	Boolean	11:06:18.108	11:06:18.358
29	rh	NS4[String]...	11A K2401	true	Boolean	11:06:18.108	11:06:18.358
30	rh	NS4[String]...	11E B0000	true	Boolean	11:11:44.816	11:11:45.067
31	rh	NS4[String]...	11E B0001	false	Boolean	11:11:44.816	11:11:45.067
32	rh	NS4[String]...	11E B0100	true	Boolean	11:11:44.816	11:11:45.067
33	rh	NS4[String]...	11E B0101	false	Boolean	11:11:44.816	11:11:45.067
34	rh	NS4[String]...	11E B3251	false	Boolean	11:11:44.816	11:11:45.067
35	rh	NS4[String]...	11F N3250	true	Boolean	11:06:18.108	11:06:18.358
36	rh	NS4[String]...	11M AUT	true	Boolean	11:06:18.108	11:06:18.358
37	rh	NS4[String]...	Aktuelle Schrittnummer ST10	5	UInt16	11:11:45.258	11:11:45.318
38	rh	NS4[String]...	Aktuelle Schrittnummer ST11	5	UInt16	11:11:45.030	11:11:45.067
39	rh	NS4[String]...	01A K3200	true	Boolean	11:06:31.541	11:06:37.402
40	rh	NS4[String]...	01A K3300	true	Boolean	11:06:31.612	11:06:37.402
41	rh	NS4[String]...	01A K3400_Einstosser_1	false	Boolean	11:06:31.640	11:06:37.402
42	rh	NS4[String]...	01A K3500_Einstosser_2	false	Boolean	11:06:31.726	11:06:37.402
43	rh	NS4[String]...	01A K3600_FuehrungEinst1	false	Boolean	11:06:31.743	11:06:37.402
44	rh	NS4[String]...	01E B0101	true	Boolean	11:11:36.543	11:11:36.800
45	rh	NS4[String]...	01E B0150	false	Boolean	11:11:21.757	11:11:22.007
46	rh	NS4[String]...	01E B2450	true	Boolean	11:06:37.151	11:06:37.402
47	rh	NS4[String]...	01E B3650	true	Boolean	11:11:42.060	11:11:42.311
48	rh	NS4[String]...	01E B3651	true	Boolean	11:06:37.151	11:06:37.402
49	rh	NS4[String]...	01E B3652	false	Boolean	11:11:38.301	11:11:38.552
50	rh	NS4[String]...	01E B3653	false	Boolean	11:11:43.814	11:11:44.064
51	rh	NS4[String]...	01E B3654	false	Boolean	11:11:22.758	11:11:23.009
52	rh	NS4[String]...	01E B3655	true	Boolean	11:11:43.062	11:11:43.313
53	rh	NS4[String]...	01E B3656	true	Boolean	11:11:44.314	11:11:44.566

Attributes

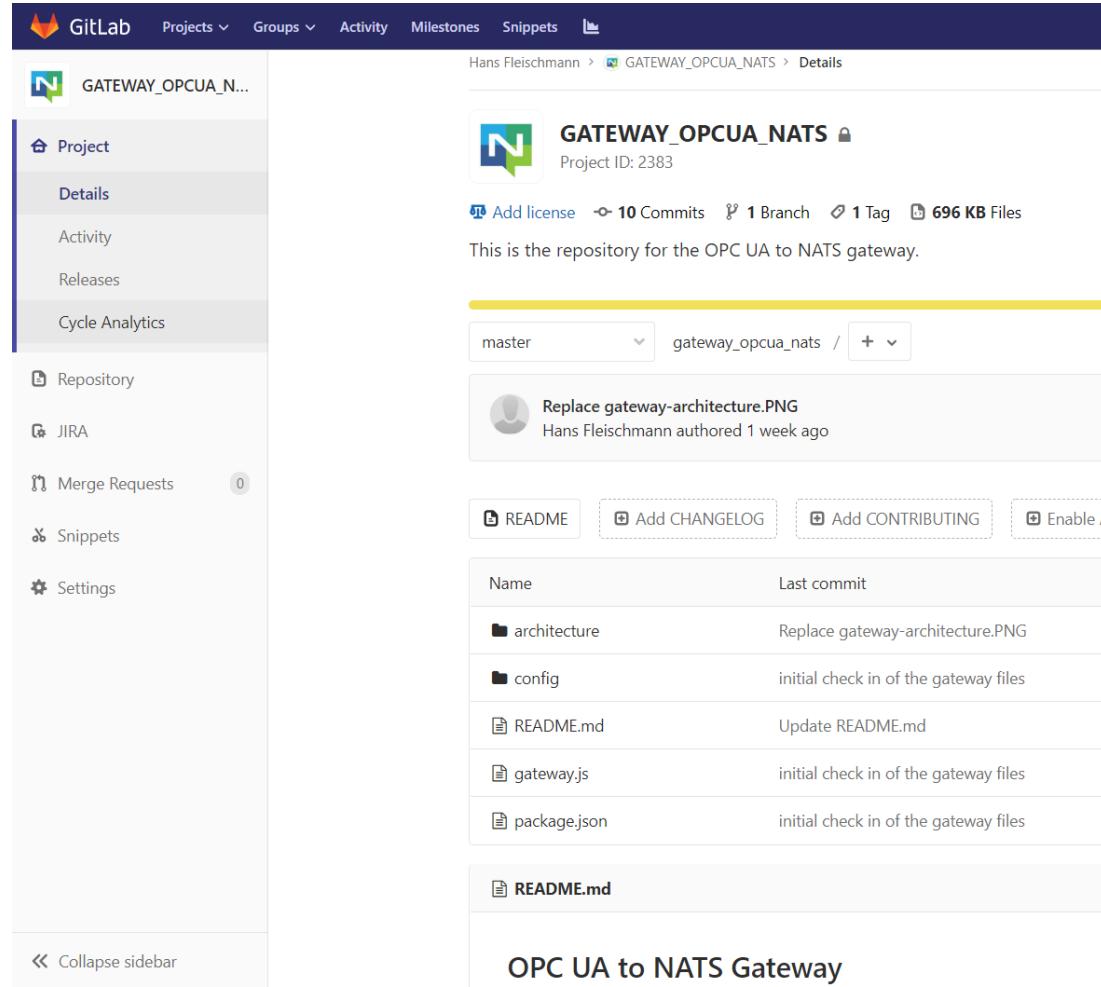
Attribute	Value
NodId	i=84 [RootFolder]
NamespaceIndex	0
IdentifierType	Numeric
Identifier	84 [RootFolder]
NodeClass	Object
BrowseName	0, "Root"
DisplayName	"en", "Root"
Description	BadAttributedInvalid (0x80350000)
WriteMask	0
UserWriteMask	0
RolePermissions	BadAttributedInvalid (0x80350000)
UserRolePermissions	BadAttributedInvalid (0x80350000)
AccessRestrictions	BadAttributedInvalid (0x80350000)
EventNotifier	None

References

Reference	Target DisplayName
HasTypeDe...	FolderType
Organizes	Views
Organizes	Objects
Organizes	Types



Gateways act as translators from specific industry protocols to the Messaging System



GATEWAY_OPCUA_NATS

Project ID: 2383

Add license · 10 Commits · 1 Branch · 1 Tag · 696 KB Files

This is the repository for the OPC UA to NATS gateway.

master · gateway_opcua_nats / +

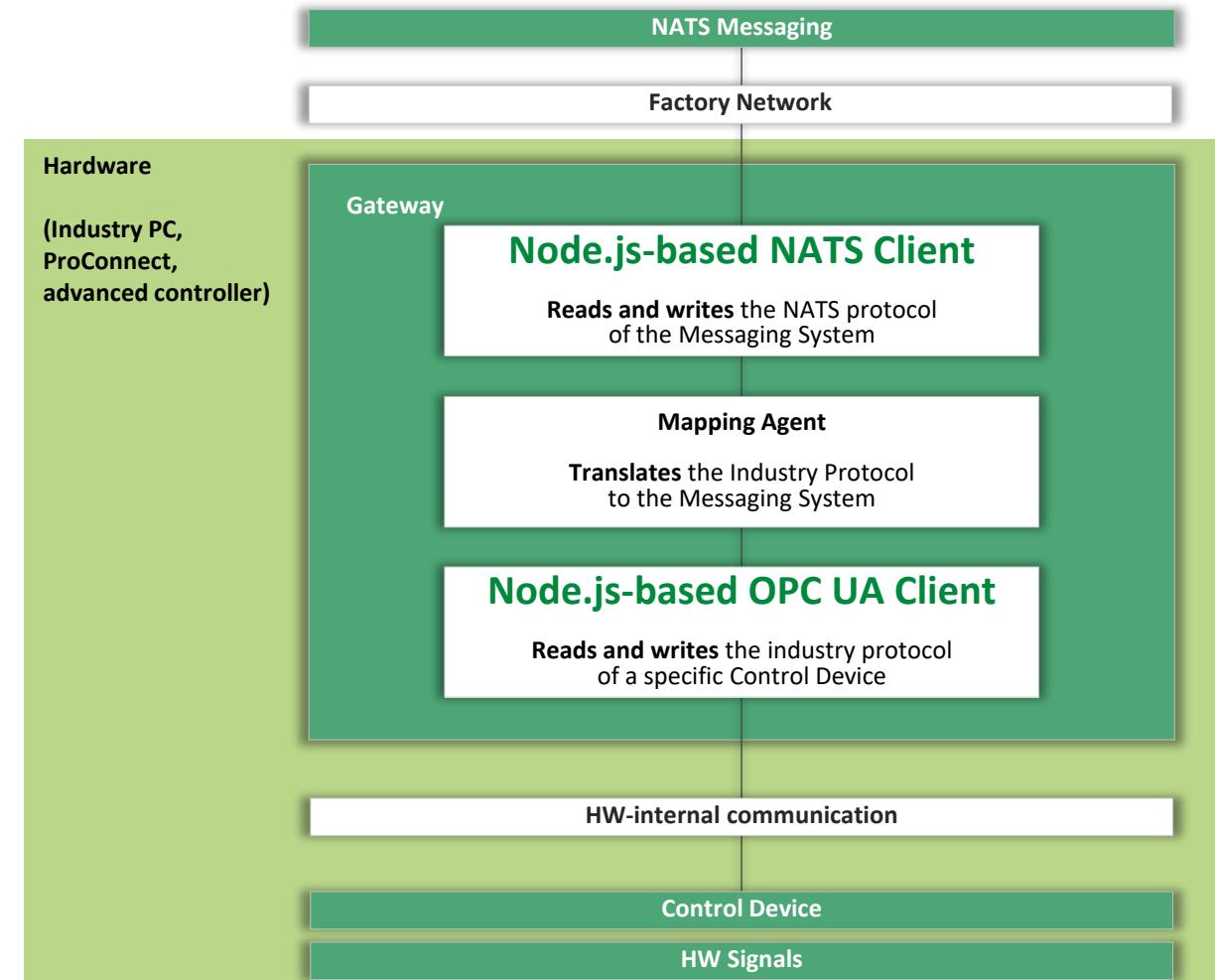
Replace gateway-architecture.PNG
Hans Fleischmann authored 1 week ago

README · Add CHANGELOG · Add CONTRIBUTING · Enable A

Name	Last commit
architecture	Replace gateway-architecture.PNG
config	initial check in of the gateway files
README.md	Update README.md
gateway.js	initial check in of the gateway files
package.json	initial check in of the gateway files

README.md

OPC UA to NATS Gateway



File Edit Selection View Go Debug Terminal Help

default.json - gateway_opcua_nats - Visual Studio Code

EXPLORER

- OPEN EDITORS 1 UNSAVED
- default.json config M
- GATEWAY_OPNUA_NATS
 - architecture
 - config
 - default.json M
 - rh.json U
 - node_modules
 - gateway.js U
 - logfile.csv U
 - package-lock.json U
 - packagejson
 - pw.txt U
 - README.md

OUTLINE

- OPCUA-MonitoredItemParameters
 - # MonitoredItemSamplingInterval
 - # QueueSize
- OPCUA-Server
 - abc Endpoint
 - abc PW
 - abc User
 - # Namespace
- OPCUA-SubscriptionParameters
 - # DeadbandValue
 - # MaxNotificationsPerPublish
 - # Priority
 - # PublishingInterval
 - # RequestedLifetimeCount
 - # RequestedMaxKeepAliveCount
 - abc PublishingEnabled
- abc Logfile
- abc NATS-Topic
- FileLogging
- NATS-Clusters

default.json

```

config > {} default.json > {} OPCUA-Server > # Namespace
You, a few seconds ago | 1 author (You)
1 {
2   "OPCUA-Server": {
3     "Endpoint": "opc.tcp://m01009186:48010",
4     "User": "",
5     "PW": "",
6     "Namespace": []
7   },
8   "OPCUA-SubscriptionParameters": {
9     "PublishingInterval": 1000,
10    "RequestedLifetimeCount": 2400,
11    "RequestedMaxKeepAliveCount": 101,
12    "MaxNotificationsPerPublish": 1000,
13    "PublishingEnabled": true,
14    "Priority": 0,
15    "DeadbandValue": 0
16  },
17  "OPCUA-MonitoredItemParameters": {
18    "MonitoredItemSamplingInterval": 100,
19    "QueueSize": 100
20  },
21  "OPCUA-NodesToPublish": [
22    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ZEITEN_ZAEHLER.SPS_ZYKLUS_AKT",
23    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ZEITEN_ZAEHLER.SYSTEMZEIT",
24    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ASSI.MASCHINE_STATUS",
25    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ASSI.INTERNE_STOERUNGNUMMER",
26    "s=RH Montage 2. Config.RH Master.GlobalVars.10M_AUT",
27    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ASSI.Auftragsverwaltung.Auftragsnummer",
28    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ASSI.Auftragsverwaltung.Materialnummer",
29    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ASSI.Auftragsverwaltung.Beschreibung_Materialnr",
30    "s=RH Montage 2. Config.RH Master.GlobalVars.00DB_ZEITEN_ZAEHLER.STUECKZAHL.PERMANENT_GESAMT",
31    "s=RH Montage 2. Config.RH Master.GlobalVars.10A_A73.0",
32    "s=RH Montage 2. Config.RH Master.GlobalVars.10A_A73.1",
33    "s=RH Montage 2. Config.RH Master.GlobalVars.10A_A73.2",
34    "s=RH Montage 2. Config.RH Master.GlobalVars.10A_A73.3",
35    "s=RH Montage 2. Config.RH Master.GlobalVars.10A_A73.4",
36    "s=RH Montage 2. Config.RH Master.GlobalVars.10A_A73.5",
37    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B0000",
38    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B0001",
39    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B0100",
40    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B0101",
41    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B0200",
42    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B0201",
43    "s=RH Montage 2. Config.RH Master.GlobalVars.10E_B3250",
44    "s=RH Montage 2. Config.RH Master.Generic.Aktuelle_Schrittnummer_ST10"
45  ],
46  "NATS-Clusters": [
47    "nats://admin:WYeub15HpwKR3MAGvInb@ws004849:4222",
48    "nats://admin:WYeub15HpwKR3MAGvInb@ws004782:4222",
49    "nats://admin:WYeub15HpwKR3MAGvInb@ws004700:4222"
50  ]
51 }

```

Connectivity informations
for OPC UA servers

OPC UA subscription
parameters

OPC UA nodes to publish
via the NATS Messaging System

NATS Messaging

Factory Network

Gateway

Node.js-based NATS Client
Reads and writes the NATS protocol of the Messaging System

Mapping Agent
Translates the Industry Protocol to the Messaging System

Node.js-based OPC UA Client
Reads and writes the industry protocol of a specific Control Device

HW-internal communication

Control Device

HW Signals

24

SSH FILE SYSTEMS

master* 0 ▲ 0

PS C:\Users\FLEISHAS\Documents\gateway_opcua_nats>

You, 12 days ago Ln 6, Col 20 Spaces: 3 UTF-8 CRLF JSON

EXPLORER

- OPEN EDITORS 1 UNSAVED
- () default.json config M
- GATEWAY_OPCUA_NATS
 - architecture
 - config
 - () default.json M
 - () rh.json U
 - node_modules
 - gateway.js
 - logfile.csv
 - package-lock.json
 - package.json
 - pw.txt
- README.md

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 - # RequestedLifetimeCount
 - # RequestedMaxKeepAliveCount
 - abc PublishingEnabled
 - abc Logfile
 - abc NATS-Topic
 - FileLogging
 - [] NATS-Clusters
 - SSH FILE SYSTEMS

```
config > () default.json > {} OPCUA-Server > # Namespace
6   "Namespace":4
7     You, 12 days ago • initial check in of the gateway files
8   },
9   "OPCUA-SubscriptionParameters":{
10     "PublishingInterval":1000,
11     "RequestedLifetimeCount":2400,
12     "RequestedMaxKeepAliveCount":101,
13     "MaxNotificationsPerPublish":1000,
14     "PublishingEnabled":true,
15     "Priority":0,
16     "DeadbandValue":0
17   },
18   "OPCUA-MonitoredItemParameters":{
19     "MonitoredItemSamplingInterval":100,
20     "QueueSize":100
21   },
22   "OPCUA-NodesToPublish":[
23     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ZEITEN_ZAEHLER.SPS_ZYKLUS_AKT",
24     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ZEITEN_ZAEHLER.SYSTEMZEIT",
25     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ASSI.MASCHINE_STATUS",
26     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ASSI.INTERNE_STOERUNGSNUMMER",
27     "s=RH Montage 2. Config.RH Master.GlobalVars.10M AUT",
28     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ASSI.Auftragsverwaltung.Auftragsnummer",
29     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ASSI.Auftragsverwaltung.Materialnummer",
30     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ASSI.Auftragsverwaltung.Beschreibung_Materialnr",
31     "s=RH Montage 2. Config.RH Master.GlobalVars.00DB ZEITEN_ZAEHLER.STUECKZAHL.PERMANENT_GESAMT",
32     "s=RH Montage 2. Config.RH Master.GlobalVars.10A A73.0",
33     "s=RH Montage 2. Config.RH Master.GlobalVars.10A A73.1",
34     "s=RH Montage 2. Config.RH Master.GlobalVars.10A A73.2",
35     "s=RH Montage 2. Config.RH Master.GlobalVars.10A A73.3",
36     "s=RH Montage 2. Config.RH Master.GlobalVars.10A A73.4",
37     "s=RH Montage 2. Config.RH Master.GlobalVars.10A A73.5",
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39     "s=RH Montage 2. Config.RH Master.GlobalVars.10E B0001",
40     "s=RH Montage 2. Config.RH Master.GlobalVars.10E B0100",
41     "s=RH Montage 2. Config.RH Master.GlobalVars.10E B0101",
42     "s=RH Montage 2. Config.RH Master.GlobalVars.10E B0200",
43     "s=RH Montage 2. Config.RH Master.GlobalVars.10E B0201",
44     "s=RH Montage 2. Config.RH Master.GlobalVars.10E B3250",
45     "s=RH Montage 2. Config.RH Master.Generic.Aktuelle Schrittnummer ST10"
46   ],
47   "NATS-Clusters": [
48     "nats://admin:WYeub15HpwKR3MAGvInb@ws004849:4222",
49     "nats://admin:WYeub15HpwKR3MAGvInb@ws004782:4222",
50     "nats://admin:WYeub15HpwKR3MAGvInb@ws004790:4222"
51   ],
52   "NATS-Topic": "rh-test-topic",
53   "FileLogging": true,
54   "LogFile": "logfile.csv"
55 }
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

Windows PowerShell

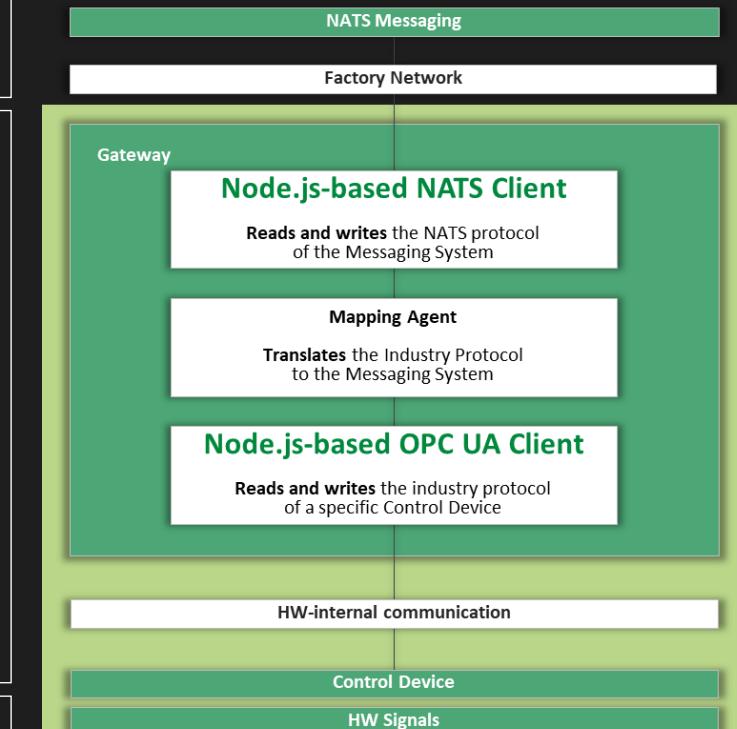
Copyright (C) 2016 Microsoft Corporation. Alle Rechte vorbehalten.

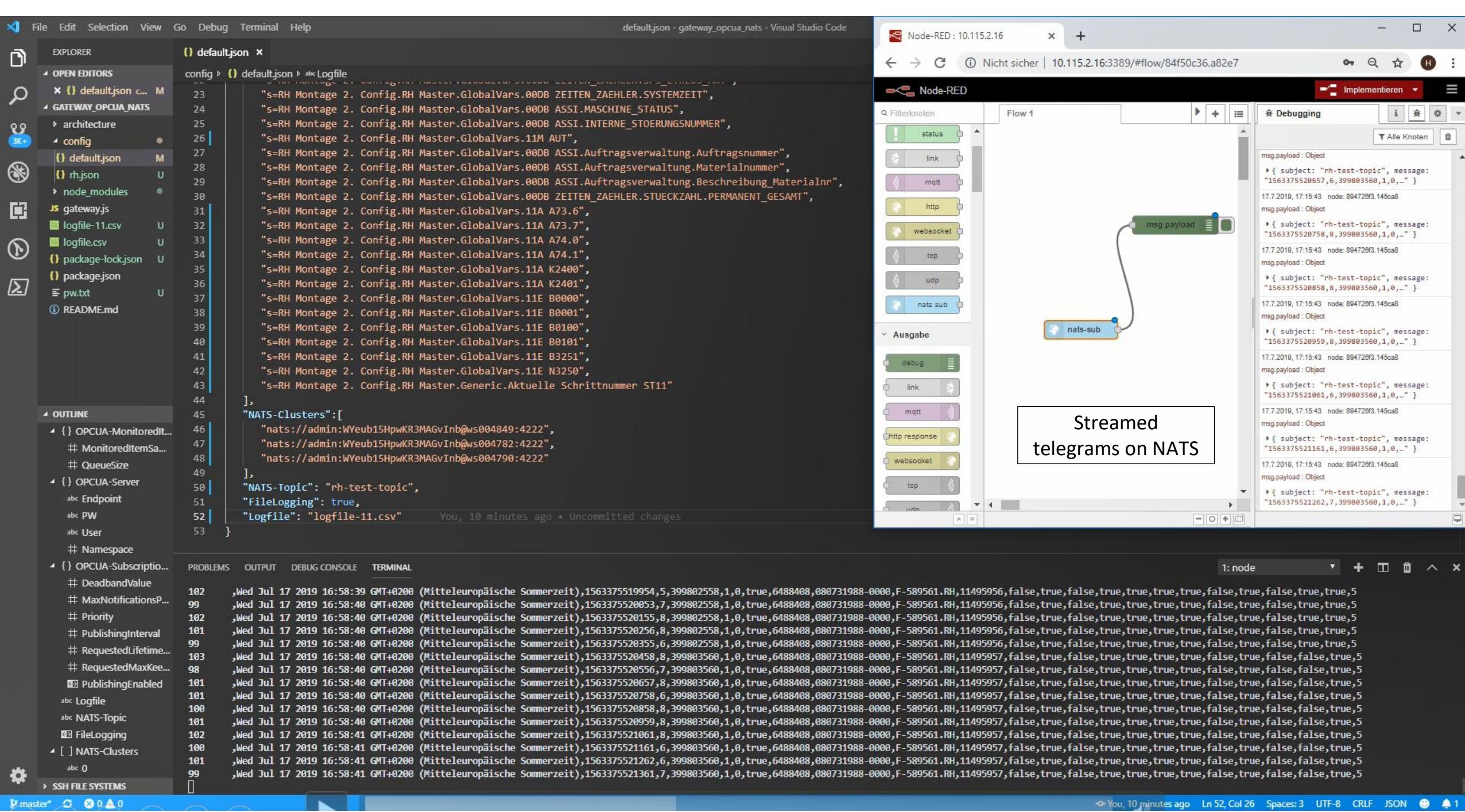
PS C:\Users\FLEISHAS\Documents\gateway_opcua_nats>

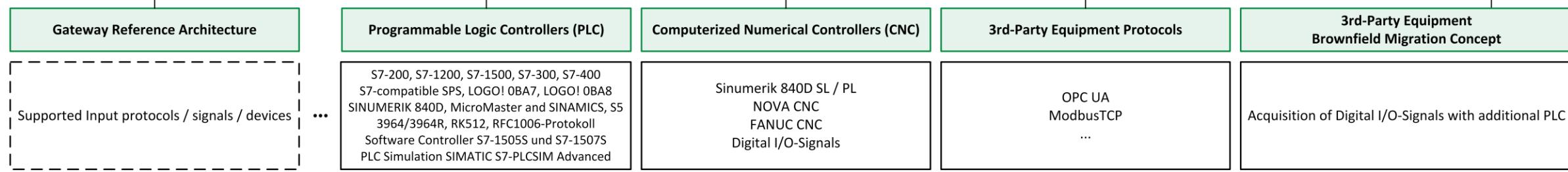
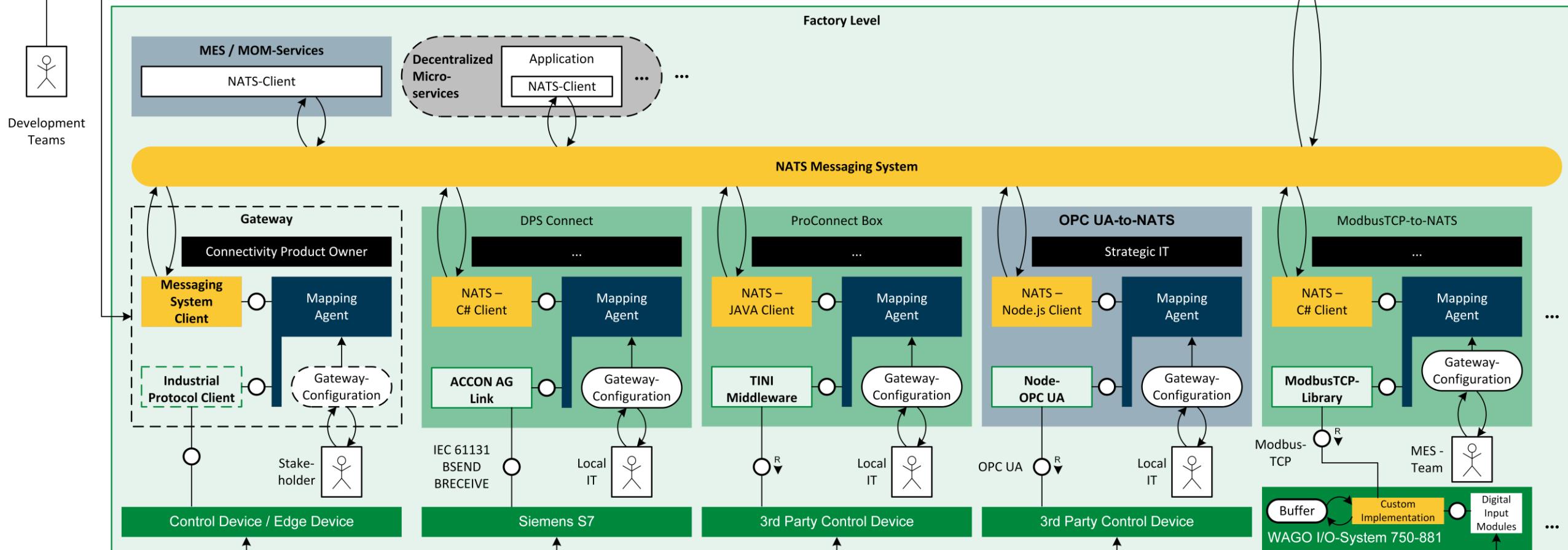
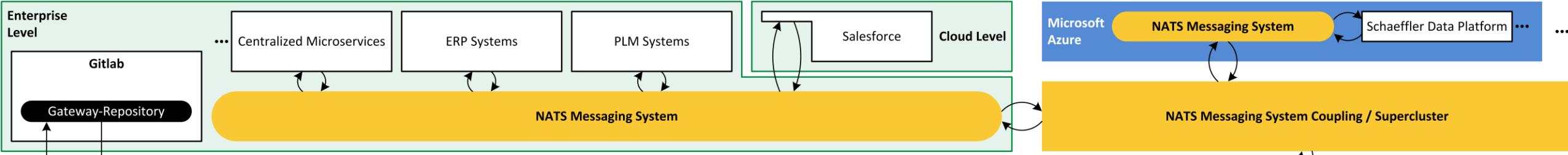
OPC UA subscription parameters

OPC UA nodes to publish via the NATS Messaging System

NATS public cluster settings







Agenda

- 1 IT@Schaeffler-Framework
- 2 NATS.io Messaging System
- 3 Open Platform Communications Unified Architecture
- 4 Gateway Development
- 5 Workshop Results
- 6 Digital Production System

SCHAEFFLER

Microsoft Azure



Applications that **Solve Business Problems**, services for **Specific Use Cases**
Data-driven identification of behavior models of automated production plants

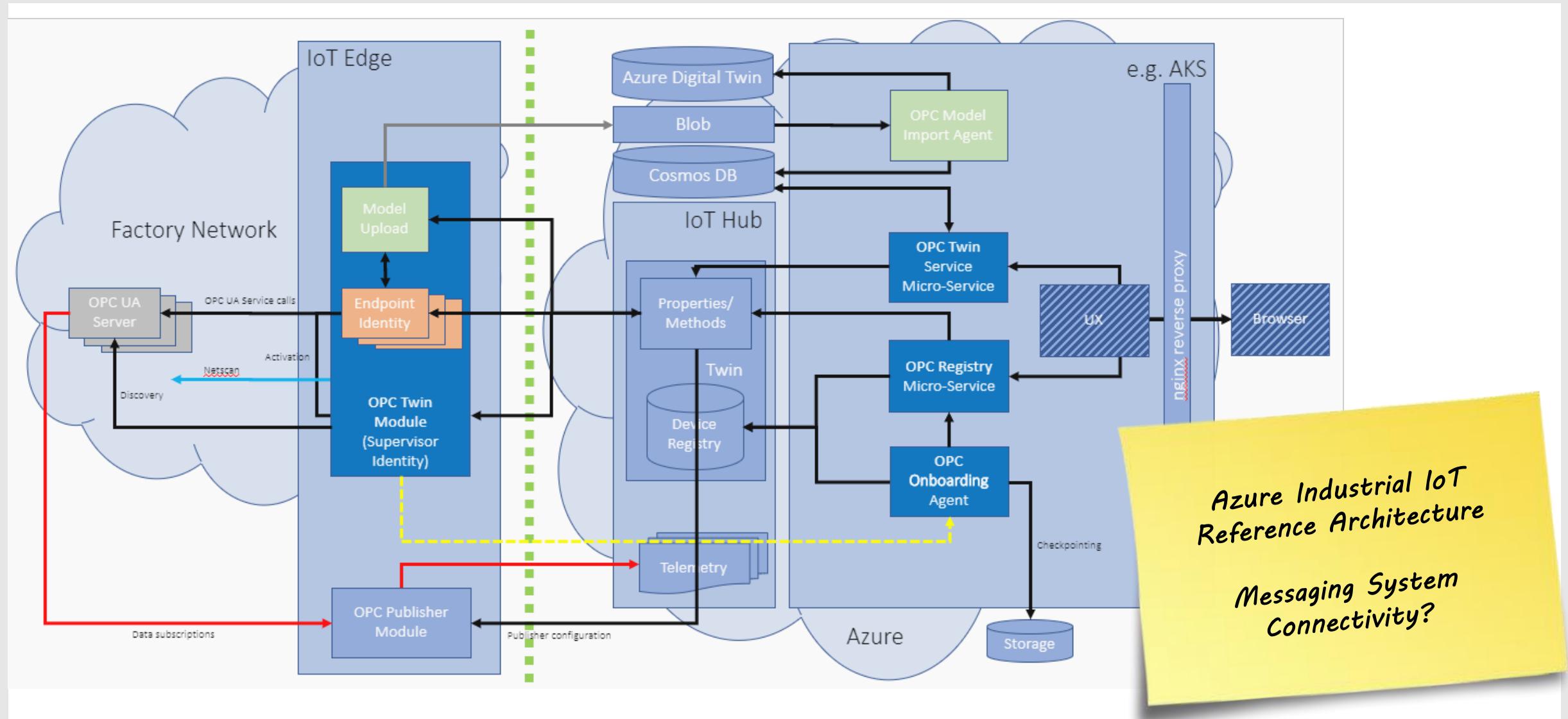
Connectivity and Data Processing modules

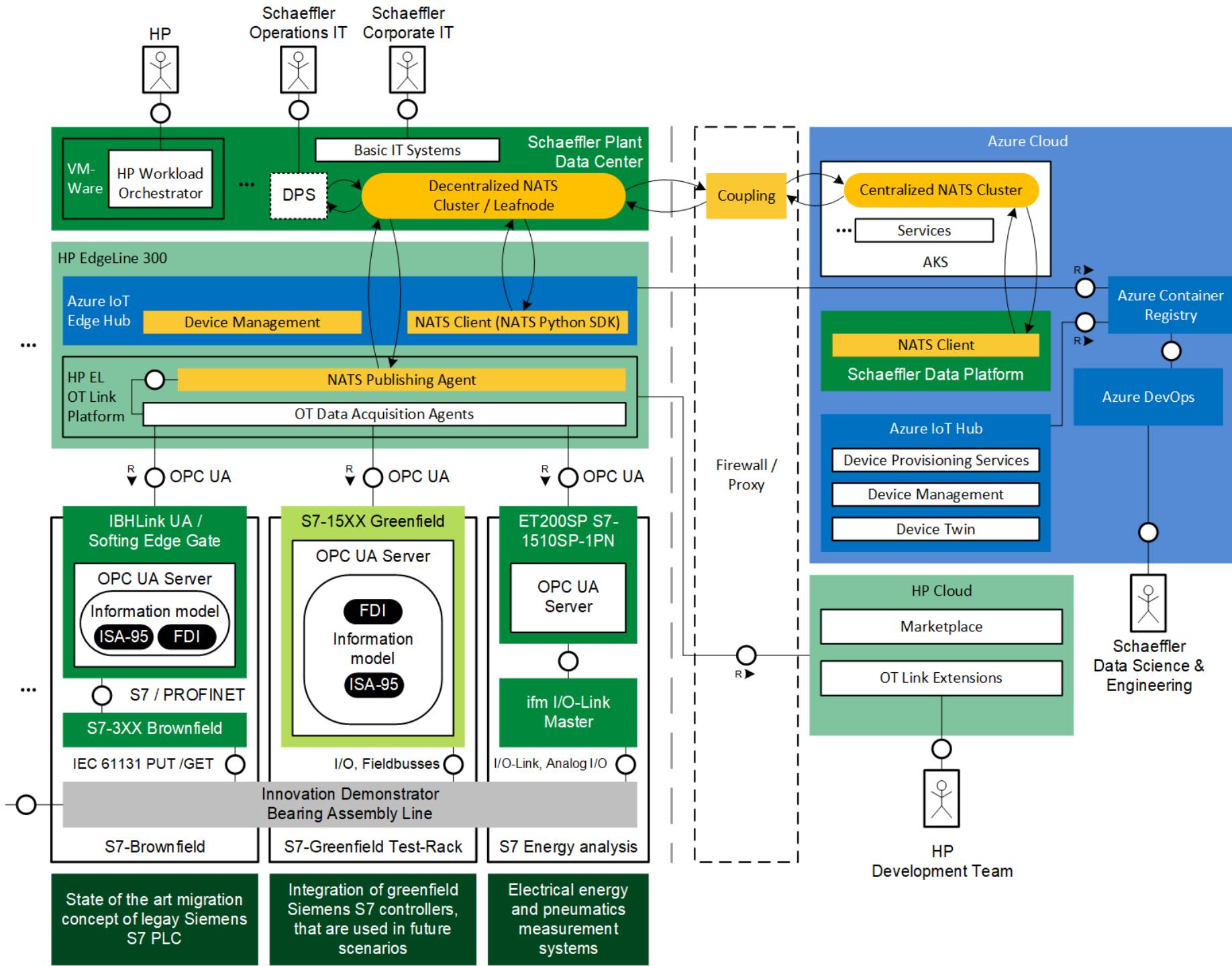
Scalable Services for Manufacturing Interoperability and Data Modeling
Open Industrial IoT Reference Platform based on **Industrial Standards (OPC UA)**

Scalable, Managed Services for Common Patterns (PaaS)
IoT Edge, IoT Hub, Stream Analytics, Data Lake, Azure Functions, AzureML, ...

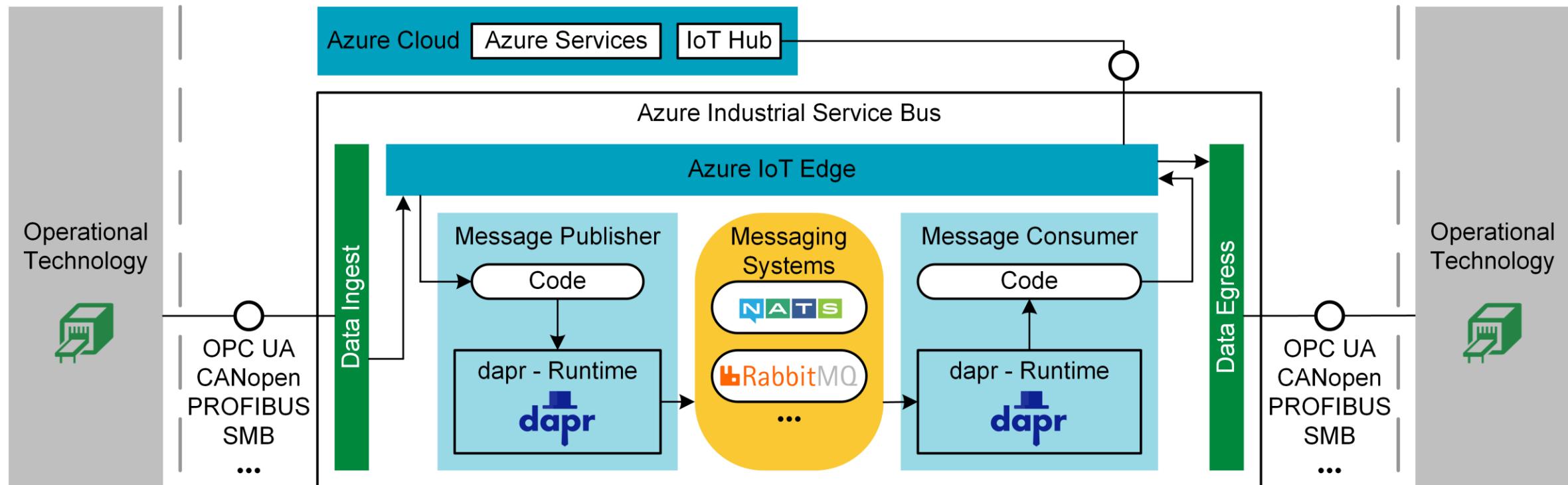
Globally Available Edge/Private/Public Cloud Infrastructure (IaaS)
Kubernetes Service, KeyVault, Azure Active Directory, Resource Manager, Azure Portal, ...

Build solutions on your terms





Outlook: Advancement of Azure IoT Edge to an Industrial Service Bus (ISB)

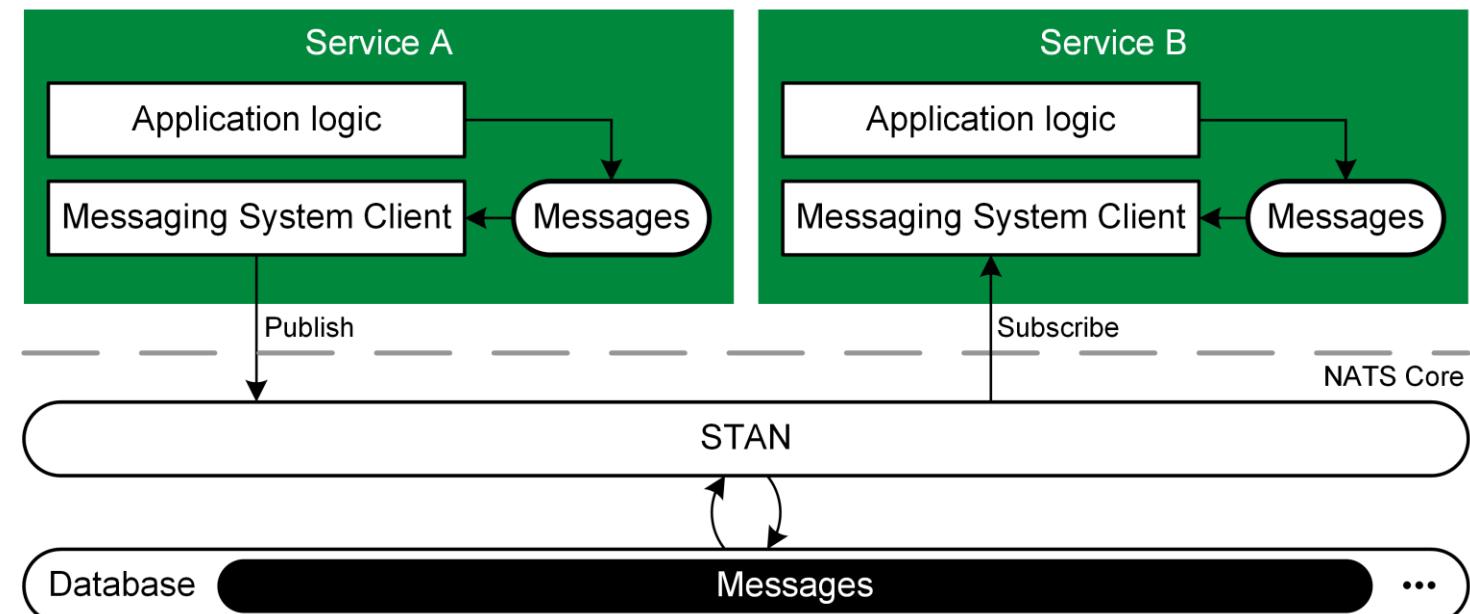


Agenda

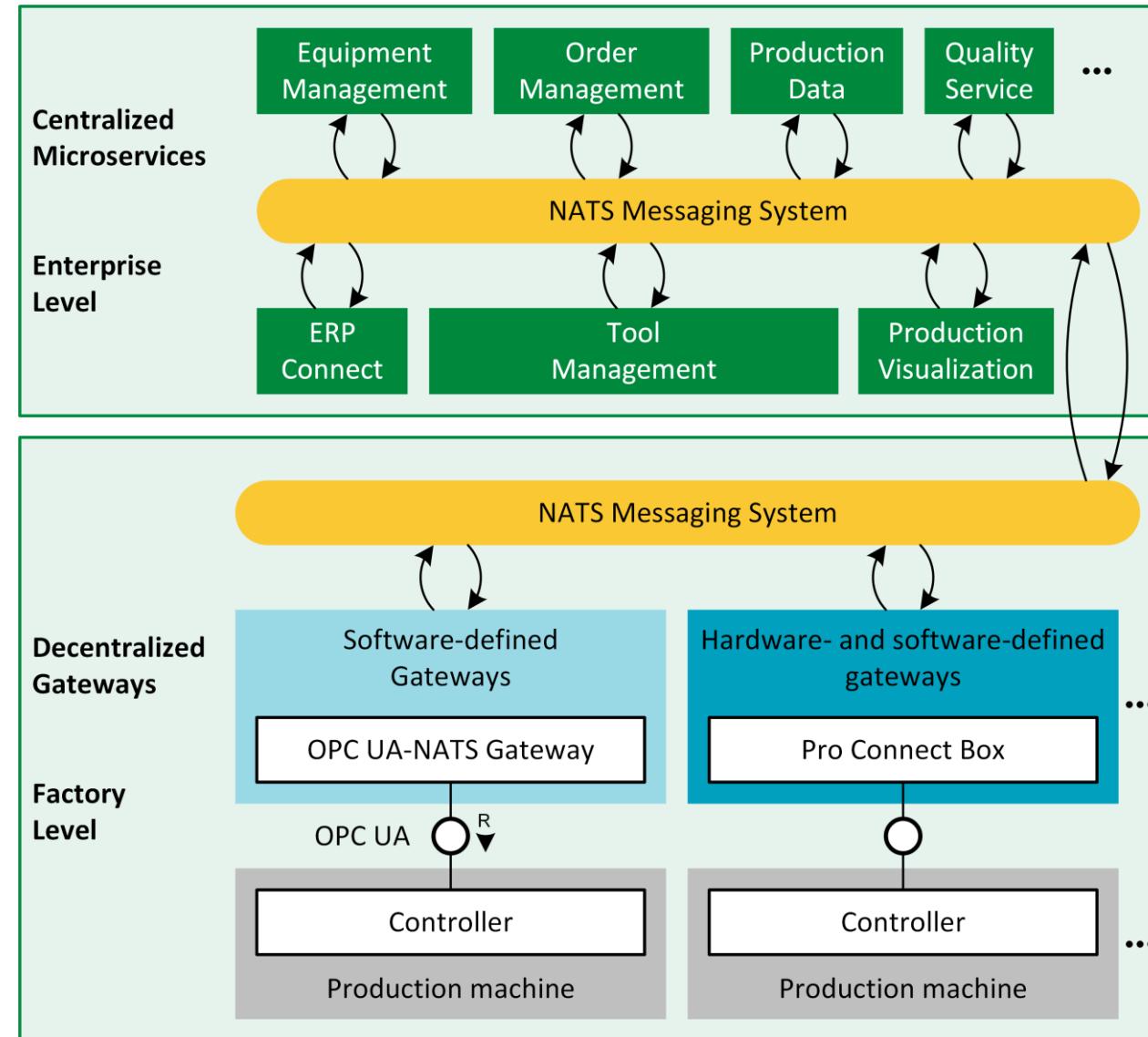
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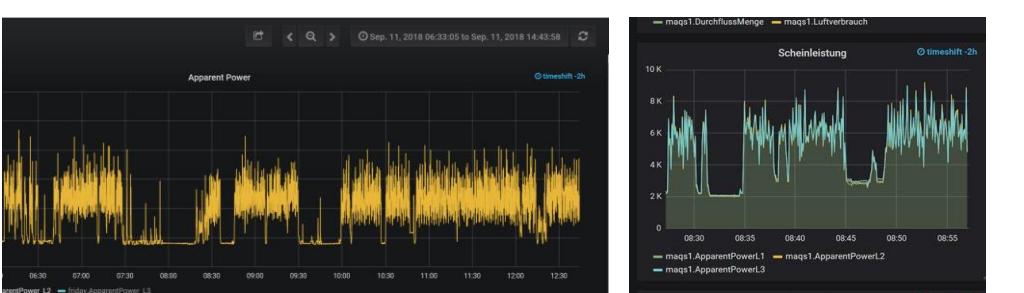
Digital Production System @ Schaeffler

- Implementation of services for custom use cases
- Production systems handle almost similar data -> reusable components
-> Microservices architecture
- Based on Microservice Messaging Pattern
- Implemented with NATS Streaming



Digital Production System Architecture





Thank
you.

