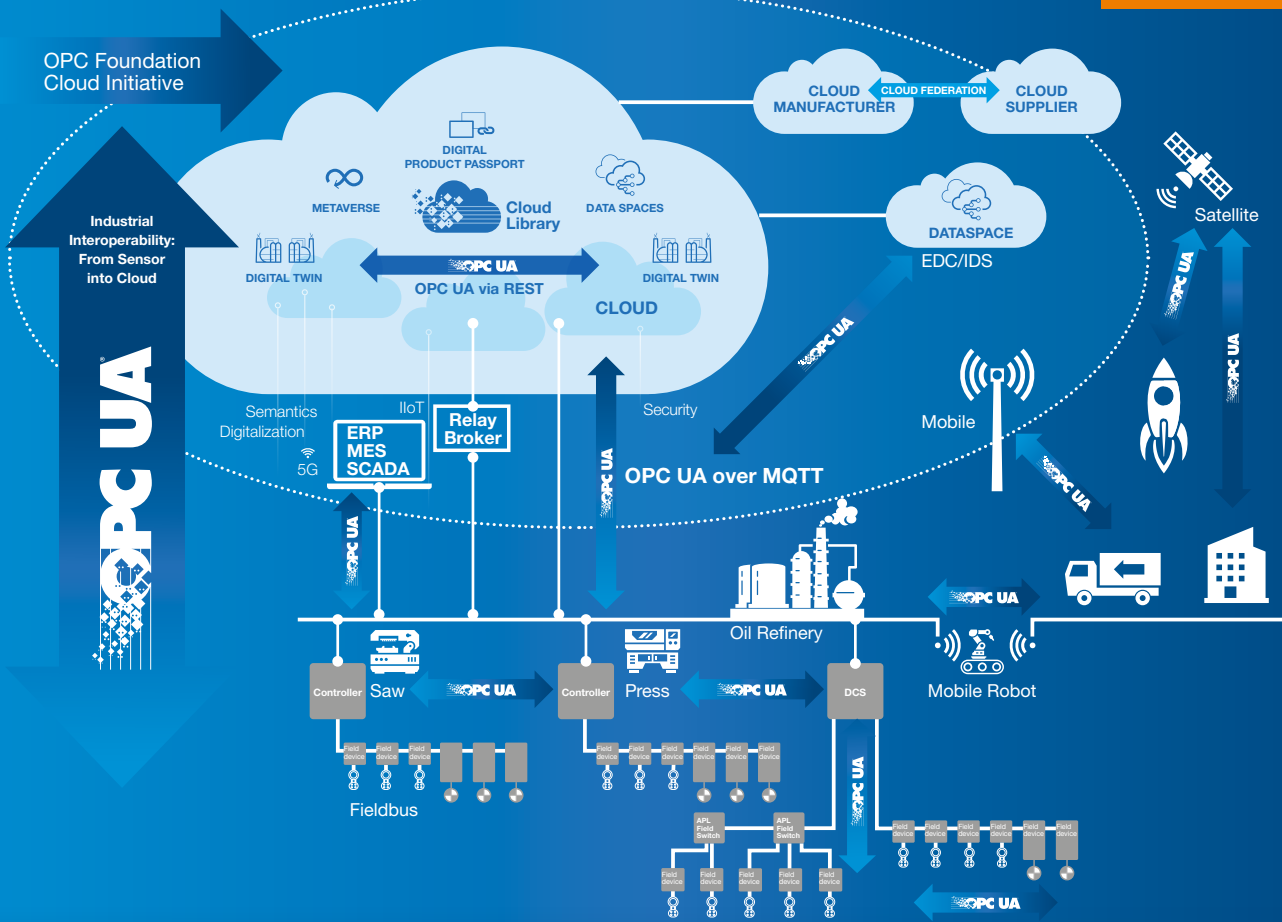


OPC Foundation Cloud Initiative

The Industrial Cloud Interoperability Standard

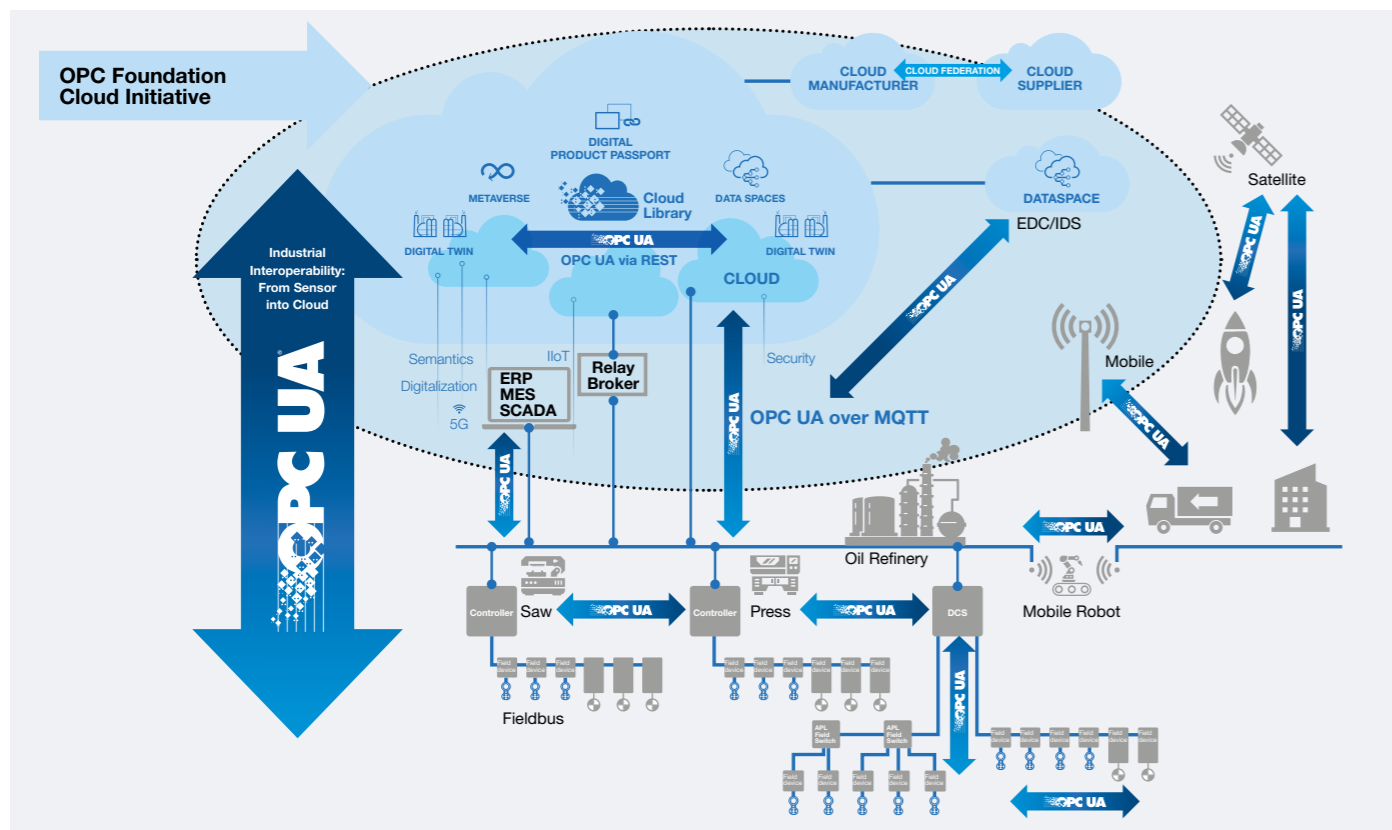
Version 3 // April 2025



Supporting cloud providers



The Industrial Cloud Interoperability Standard



Vision Building the Industrial Cloud Interoperability Standard

Goals

Digitalization in manufacturing is resulting in a world divided between those who possess and effectively utilize data and those who lack access to those resources. This is a barrier to both corporate success and macro-economic growth. Legislators (such as the EU with the upcoming Data Act) are responding to this by requiring vendors to share data among much broader eco-systems. In addition to requiring standardized data exchange in broader eco-systems, critical use-cases for traceability like the Digital Product Passport (DPP) and security aspects must be considered.

At the OPC Foundation, we believe that this creates a greater need for interoperability of end-to-end information models and standardized cloud interfaces to support these legislative demands.

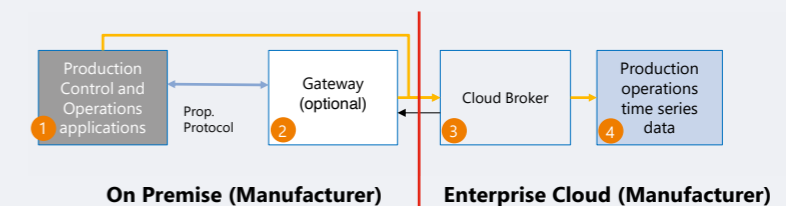
OPC UA – One harmonized Solution for OT/IT

Deliverables

- Standardized interoperability: Accelerate **interoperability of IT and cloud applications** using OPC UA, e.g. data analytics using AI, industrial data spaces, digital product passports, industrial metaverse, as well as digital twin applications.
- Semantic Data Models in the Cloud: **Maintain OPC UA Information Models (Companion Specifications)** in the cloud to utilize the context of data in cloud services.

- Best practices: Create a **cloud reference architecture** to provide best practices, increase standardized data sharing and cloud-optimized profiles for the OPC UA standard.
- Establish validation and certification for OPC UA Cloud Interoperability including a new **Protected Identity** for OPC UA Cloud eXchange "UACX".

Simplified Reference Architecture



At its core, the reference architecture consists of just a few components:

A. Secure, standardized data ingestion from on premises machine data (1) via a broker (3).

B. The time-series data is contextualized by OPC UA Information Models, adding semantic meaning (4).

Use-cases

Depending on the supported OPC UA features and scenarios, additional components such as an on-premises gateway may be required:

U1. PLCs with support for OPC UA over MQTT can communicate directly with the cloud broker for bi-directional data exchange.

U2. On factory setups, additional firewalls can be put in place by the addition of on-premises gateways (2).

U3. Some OPC UA enabled assets may not support OPC UA over MQTT yet, but an OPC UA server instead. In these cases, a (2) gateway is needed to provide translation between OPC UA over MQTT and OPC UA client/server communication. Bi-directional communication can be achieved for this, too.

U4. For asset supporting industrial protocols such as Modbus, HART, or other non-OPC UA interfaces, the market offers a many industrial connectivity software options converting the legacy interface to OPC UA. It is highly recommended to use software supporting the integration of OPC UA Companion Specifications to enable modelling the OPC UA interface with standardized data models.

Working Groups (WG) coordinated by the OPC Foundation Cloud Initiative

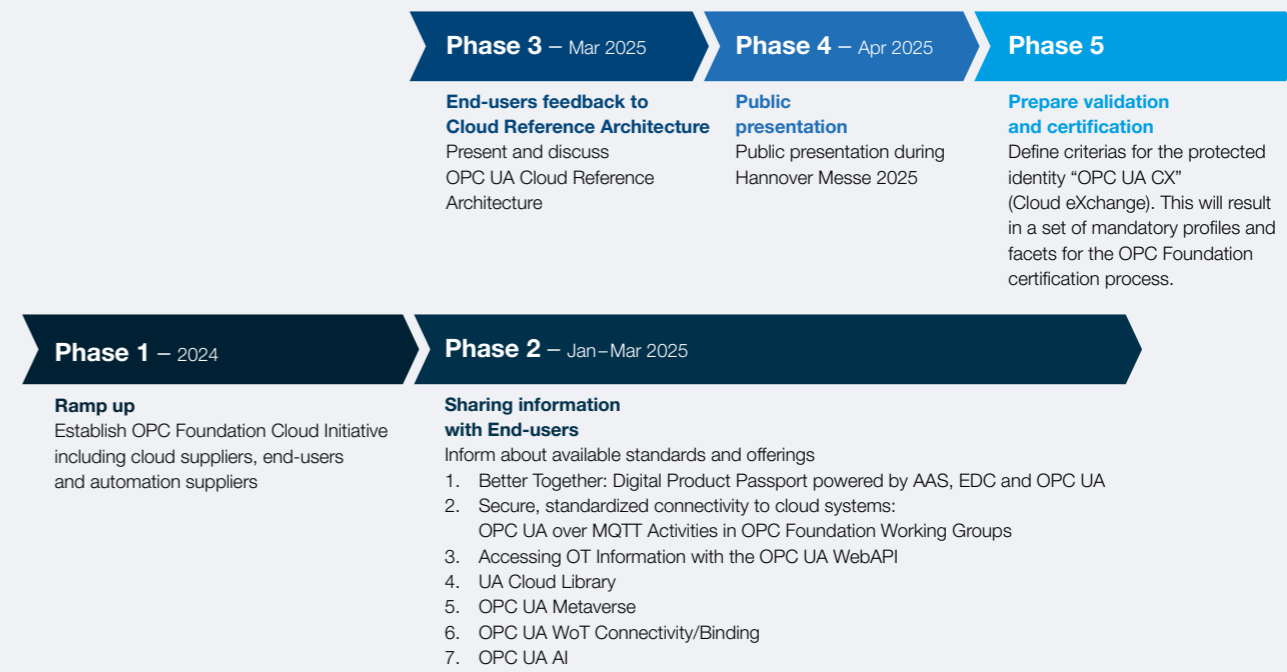
- **UA Cloud Library**
A query-able online store of OPC UA Information Models
- **OPC UA over MQTT**
Secure transport from edge to cloud and cloud to cloud, including a prototyping and a testbed group
- **OPC UA REST Interface**
Easy access to OPC UA information for the IT world via a standardized REST interface
- **OPC UA Industrial Metaverse**
Connecting the virtual and real world with OPC UA
- **OPC UA AI**
Leveraging Large Language Models for and with OPC UA
- **OPC UA Data Space (in planning)**
Provide decentralised semantic OPC UA information to central Data Spaces but keeping Data sovereignty
- **OPC UA WoT Connectivity**
Standardized industrial connectivity software configuration



Detailed descriptions of the existing working groups, URLs for the open source reference code and further information can be found here:

www.opcfoundation.org/cloud

Milestones of the OPC Foundation Cloud Initiative



Supporting cloud providers

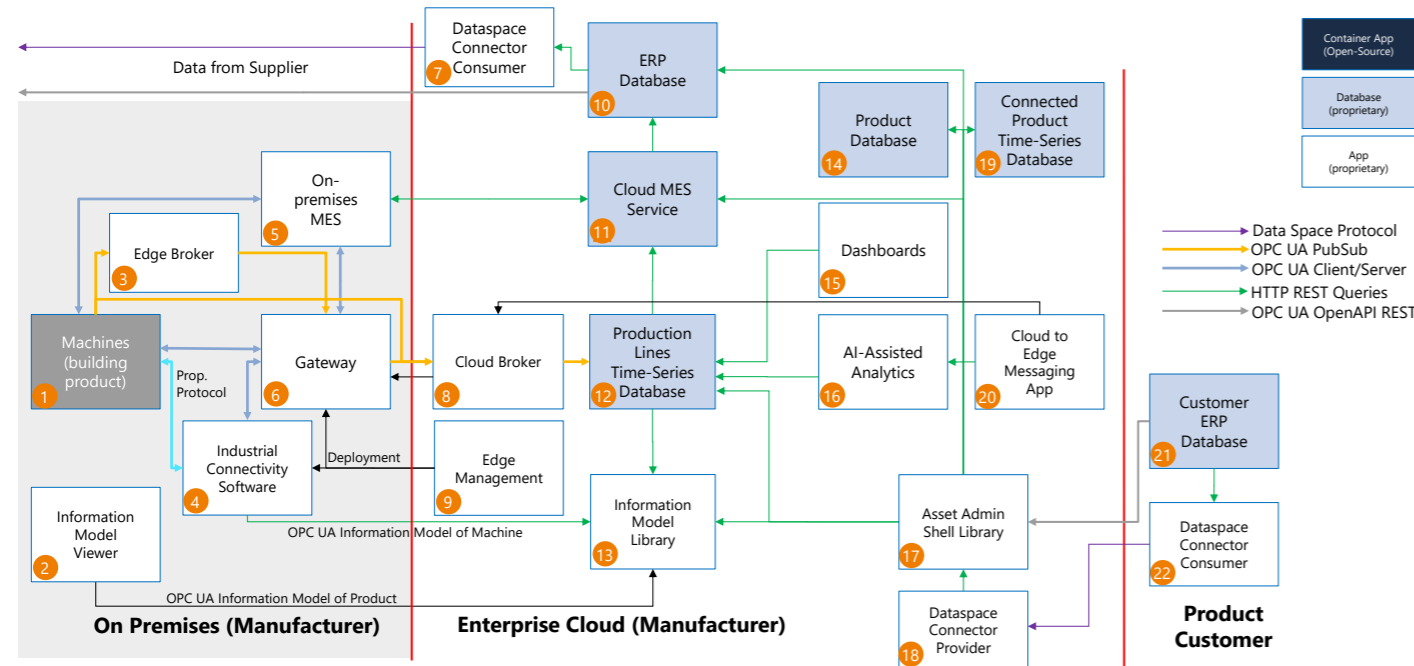
Supporting end-users

Supporting automation providers



www.opcfoundation.org/cloud

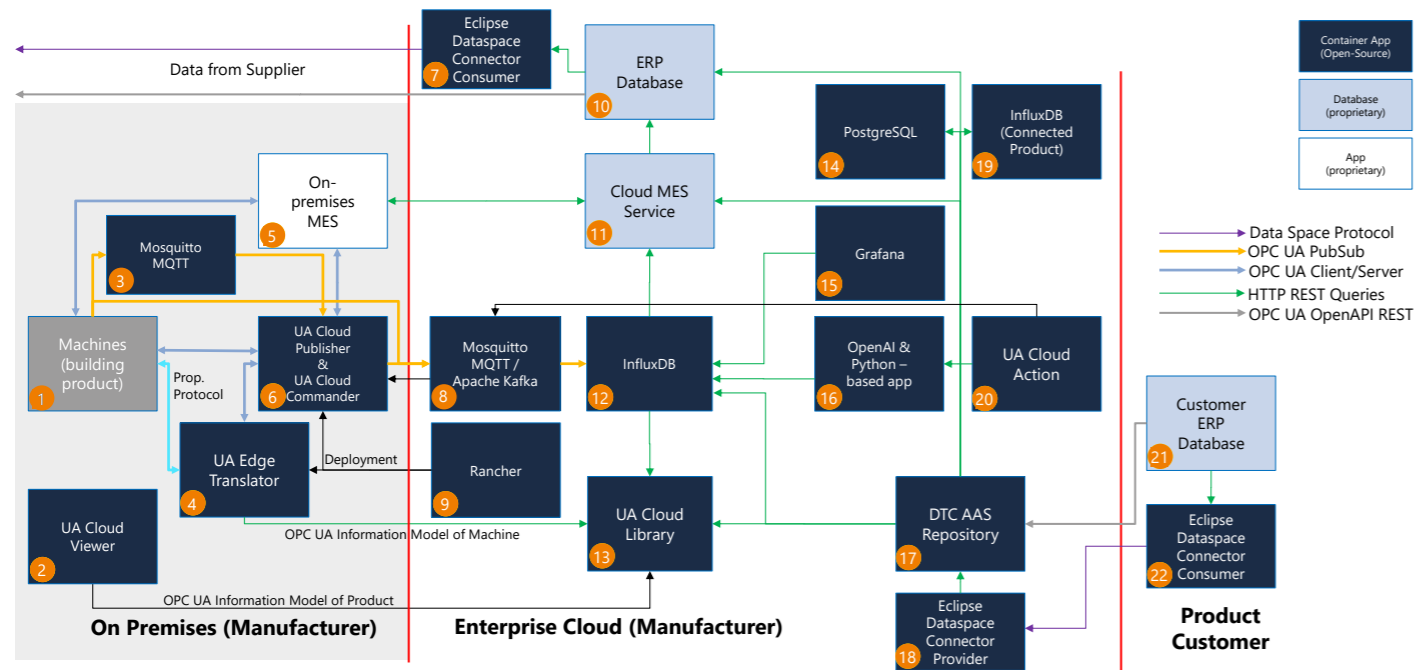
UA Cloud Initiative Reference Architecture – Generic



- 1 Machines of the Manufacturer on-premises building the product.
- 2 An OPC UA Information Model viewer tool that can upload these models to the UA Cloud Library.
- 3 A message broker operated by the manufacturer on-premises, usually as part of an edge infrastructure and usually supporting the MQTT protocol.
- 4 An industrial connectivity software reference implementation providing an aggregating OPC UA server interface and supporting the OPC UA WoT-Connectivity Companion Specification.
- 5 The on-premises part of the Manufacturing Execution System (MES). It often supports an OPC UA server interface to read status information and manages the operation of the machines.
- 6 Gateways manage the bi-directional data exchange from assets the cloud services offering both, an OPC UA Client and a OPC UA PubSub supporting both the MQTT and Kafka protocol.
- 7 The Eclipse Dataspace Connector (EDC) consumer operated by the manufacturer which is used to establish trust between a supplier and the manufacturer by creating a digital contract. It also applies data sharing policies to the data received from the supplier.
- 8 The message broker operated by the manufacturer in the manufacturer's enterprise cloud. This can support either the MQTT or the Kafka protocol.
- 9 The industrial edge management software operated by the manufacturer in the manufacturer's enterprise cloud. It is responsible for deploying and managing edge applications on-premises.
- 10 The Enterprise Resource Planning (ERP) software operated by the manufacturer. It reads raw material and purchased components data from the supply chain.
- 11 The enterprise cloud part of the Manufacturing Execution System (MES). It often communicates directly with the ERP system and receives and processes production orders.

- 12 The time-series database receiving telemetry data from the production line via the cloud broker. It can also read order information from the MES system and OPC UA Information Model metadata from the UA Cloud Library.
- 13 The online store of OPC UA Information Models. This can either be the public instance operated by the OPC Foundation (mainly containing OPC UA Companion Specifications), or it can be a private instance operated by the manufacturer (containing OPC UA Information Models for the produced products), or both.
- 14 The database containing produced product information like specifications or user manuals.
- 15 Visual dashboards used to monitor the operation of the production.
- 16 AI-assisted analytics software used to calculate equipment effectiveness, make production forecasts and make predictions about required machine maintenance.
- 17 The Asset Administration Shell Repository reference implementation from the Digital Twin Consortium. It supports loading Asset Admin Shells modelled with OPC UA and provides the OPC UA OpenAPI REST interface. It provides product data to the customers of the manufacturer.
- 18 The Eclipse Dataspace Connector (EDC) provider operated by the manufacturer which is used to establish trust between a customer and the manufacturer by creating a digital contract. It also applies data sharing policies to the product data provided by the manufacturer.
- 19 The time-series database receiving telemetry data from product usage in the field.
- 20 An online reference application taking the outcomes of the production data analysis and making live modifications to the production via UA Cloud Commander (completing the digital feedback loop).
- 21 The Enterprise Resource Planning (ERP) software operated by the customer of the manufacturer. It reads product data from the manufacturer.
- 22 The Eclipse Dataspace Connector (EDC) consumer operated by the customer of the manufacturer which is used to establish trust between the customer and the manufacturer by creating a digital contract. It also applies data sharing policies to the data received from the manufacturer.

UA Cloud Initiative Reference Architecture – Open Source Offerings



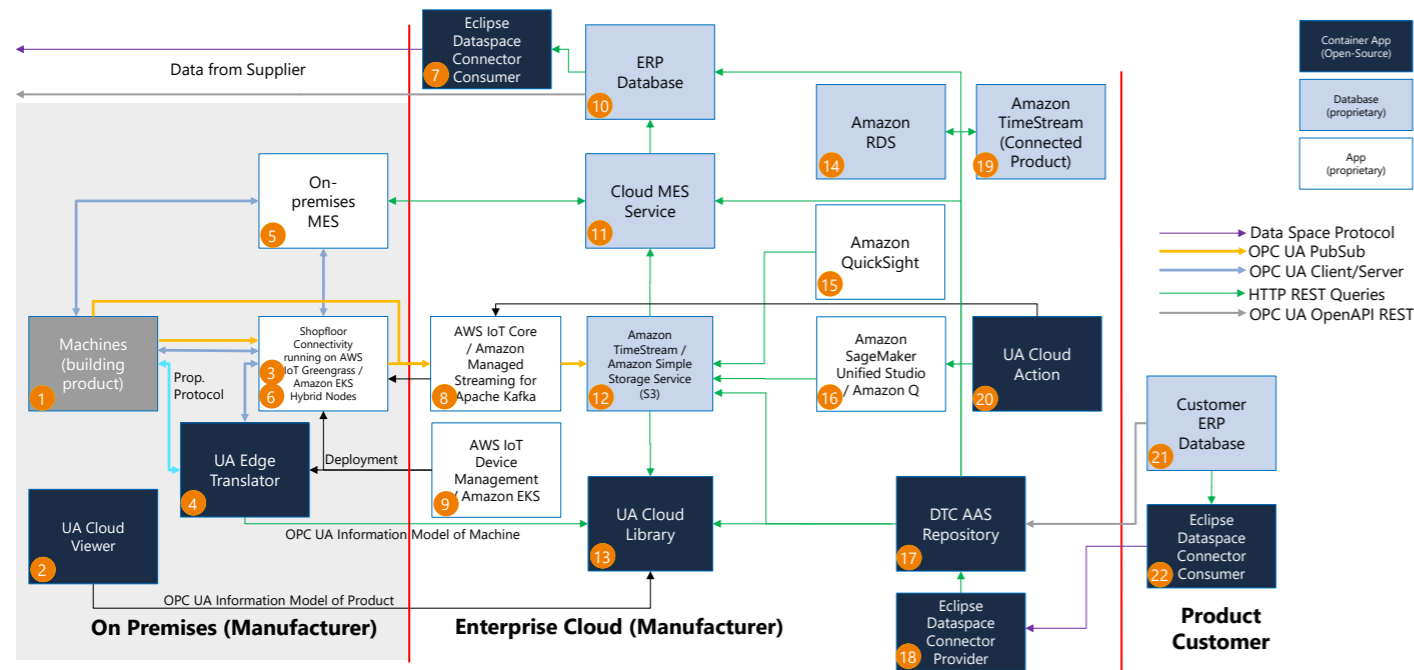
These building blocks are available as open source

Nummer	Open Source
2	OPC Foundation UA Cloud Viewer nodeset viewer and uploader.
3	Eclipse Mosquitto MQTT broker.
4	OPC Foundation UA Edge Translator supporting all leading industrial protocols south-bound and an OPC UA Server with WoT-Connectivity north-bound.
6	Umati UA Cloud Publisher OPC UA PubSub publisher and OPC Foundation UA Cloud Commander OPC UA PubSub subscriber supporting both the MQTT and Kafka protocol.
7	Eclipse Dataspace Connector (EDC), in consumer configuration.
8	Eclipse Mosquitto MQTT broker or Apache Kafka broker.
9	SUSE Rancher Kubernetes-based Edge application management.
12	InfluxData InfluxDB production data time-series database.
13	OPC Foundation UA Cloud Library online store of OPC UA Information Models.
14	PostgreSQL product database.
15	Grafana Labs Grafana visualization dashboards.
16	AI-assisted analytics software used to calculate equipment effectiveness, make production forecasts and make predictions about required machine maintenance.
17	Digital Twin Consortium Asset Admin Shell Repository powered by OPC UA.
18	Eclipse Dataspace Connector (EDC), in provider configuration.
19	InfluxData InfluxDB product usage data time-series database.
20	OPC Foundation UA Cloud Action for OPC UA PubSub cloud to edge messaging.
22	Eclipse Dataspace Connector (EDC) from the customer, in consumer configuration.

OPC Foundation Cloud Referenz Architecture

Nummer	Generic Name	aws	Google Cloud	Microsoft	SAP
1	Machines (building product)				
2	Information Model Viewer				
3	Edge Broker	Shopfloor Connectivity running on AWS IoT Greengrass / Amazon EKS Hybrid Nodes Greengrass	Manufacturing Connect	Azure IoT Operations on Azure Local	SAP APM Device Connectivity
4	Industrial Connectivity Software				SAP Production Connector
5	On-premises MES				
6	Gateway	Shopfloor Connectivity running on AWS IoT Greengrass / Amazon EKS Hybrid Nodes	Manufacturing Connect	Azure IoT Operations on Azure Local	SAP APM Device Connectivity
7	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	SAP Integration Suite Dataspace Connector
8	Cloud Broker	AWS IoT Core / Amazon Managed Streaming for Apache Kafka	Pub Sub & Data Flow	Azure Event Grid/Hubs	SAP Integration Suite – Advanced Event Mesh
9	Edge Management	AWS IoT Device Management / Amazon EKS	Manufacturing Connect (Cloud)	Azure Arc	SAP Edge Lifecycle Management
10	ERP Database			Dynamics 365 ERP	SAP S/4HANA
11	Cloud MES Service			Dynamics 365 MES	SAP Digital Manufacturing
12	Production Lines Time-Series Database	Amazon TimeStream / Amazon Simple Storage Service (S3)	Cloud Storage & Big Table	Azure Data Explorer	SAP Business Data Cloud
13	Information Model Library	UA Cloud Library	UA Cloud Library	UA Cloud Library	
14	Product Database	Amazon RDS	Big Query	Azure SQL	SAP BTP HANA
15	Dashboards	Amazon QuickSight	Looker	Power BI	SAP Business Data Cloud
16	AI-Assisted Analytics	Amazon SageMaker Unified Studio / Amazon Q	Vertex AI	Copilot	SAP Joule
17	Asset Admin Shell Library	DTC AAS Repository	DTC AAS Repository	DTC AAS Repository	
18	Dataspace Connector Provider	Eclipse Dataspace Connector Provider	Eclipse Dataspace Connector Provider	Eclipse Dataspace Connector Provider	
19	Connected Product Time-Series Database	Amazon TimeStream (Connected Product)	Big Table	Azure Data Explorer (Connected Product)	SAP Analytics Cloud
20	Cloud to Edge Messaging App	UA Cloud Action	UA Cloud Action	UA Cloud Action	
21	Customer ERP Database				
22	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	

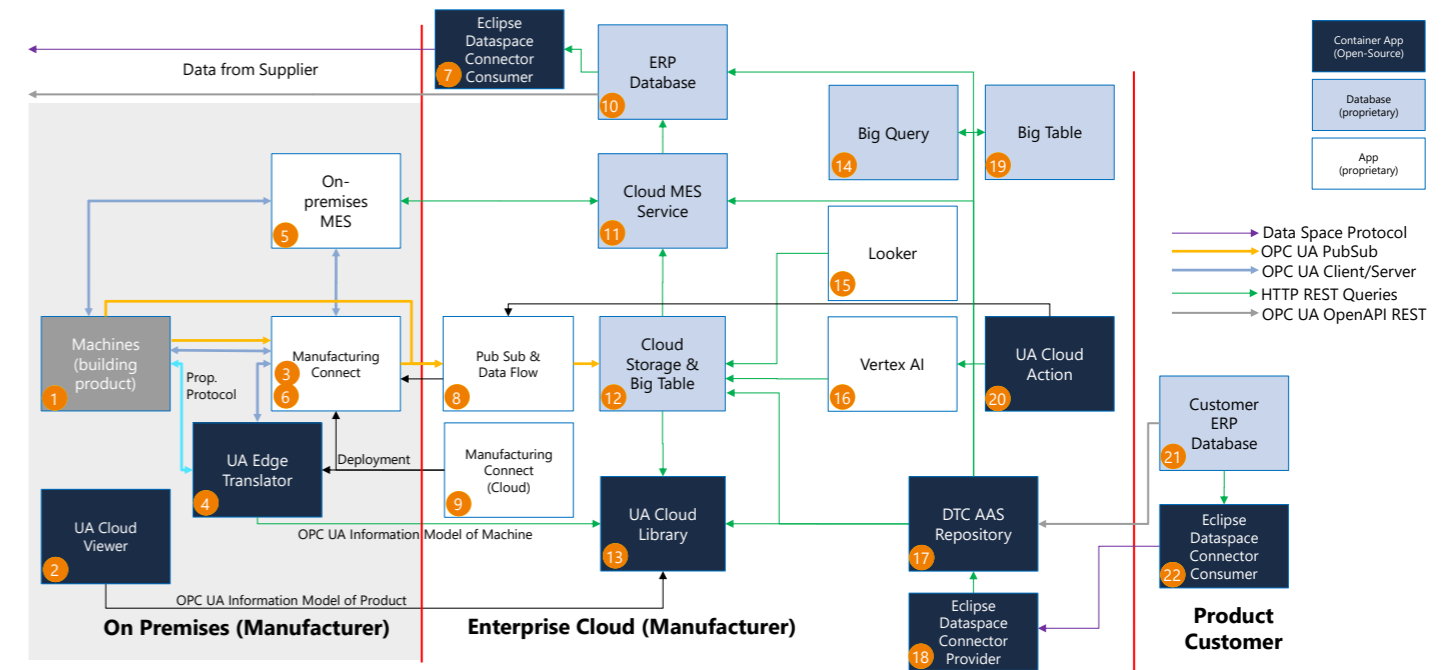
UA Cloud Initiative Reference Architecture – Commercial offerings AWS



UA Cloud Initiative Reference Architecture – Commercial offerings aws

Number	Generic Name	aws
3	Edge Broker	Shopfloor Connectivity running on AWS IoT Greengrass / Amazon EKS Hybrid Nodes Greengrass
6	Gateway	Shopfloor Connectivity running on AWS IoT Greengrass / Amazon EKS Hybrid Nodes
7	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer
8	Cloud Broker	AWS IoT Core / Amazon Managed Streaming for Apache Kafka
9	Edge Management	AWS IoT Device Management / Amazon EKS
12	Production Lines Time-Series Database	Amazon TimeStream / Amazon Simple Storage Service (S3)
13	Information Model Library	UA Cloud Library
14	Product Database	Amazon RDS
15	Dashboards	Amazon QuickSight
16	AI-Assisted Analytics	Amazon SageMaker Unified Studio / Amazon Q
17	Asset Admin Shell Library	DTC AAS Repository
18	Dataspace Connector Provider	Eclipse Dataspace Connector Provider
19	Connected Product Time-Series Database	Amazon TimeStream (Connected Product)
20	Cloud to Edge Messaging App	UA Cloud Action
22	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer

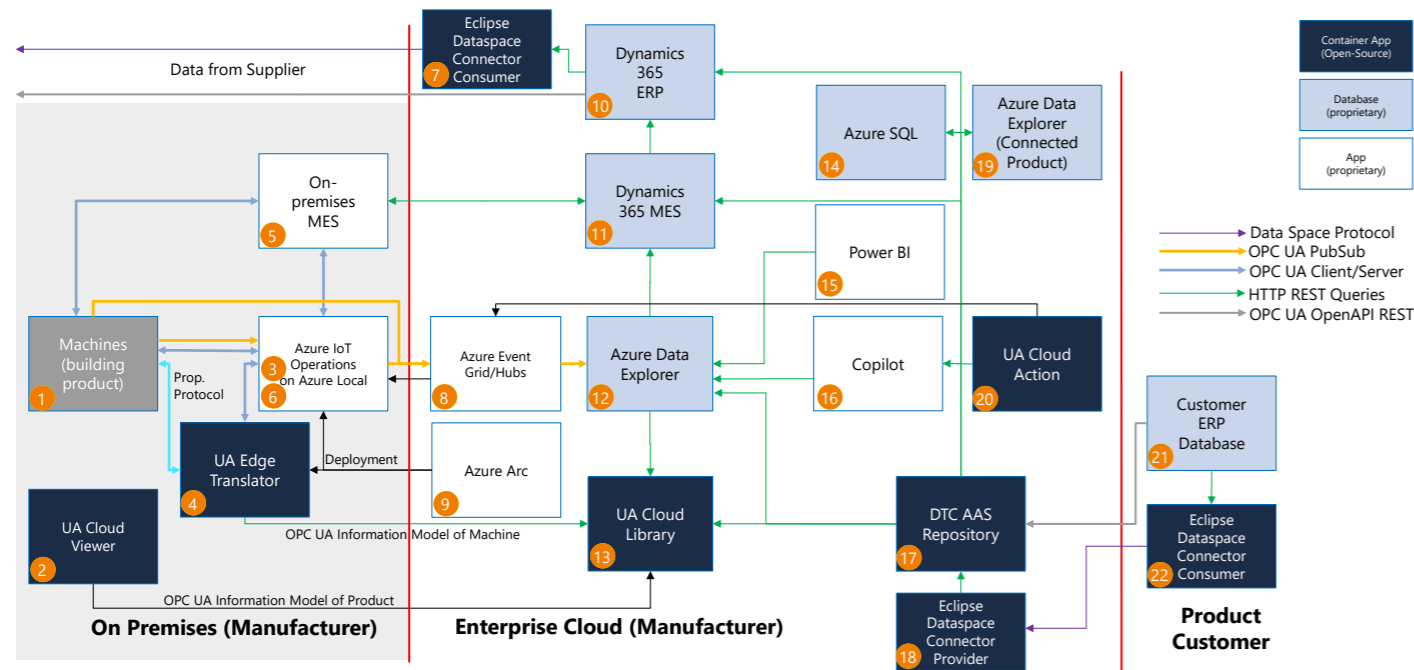
UA Cloud Initiative Reference Architecture – Commercial offerings Google



UA Cloud Initiative Reference Architecture – Commercial offerings Google

Number	Generic Name	Google Cloud
3	Edge Broker	Manufacturing Connect
6	Gateway	Manufacturing Connect
7	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer
8	Cloud Broker	Pub Sub & Data Flow
9	Edge Management	Manufacturing Connect (Cloud)
12	Production Lines Time-Series Database	Cloud Storage & Big Table
13	Information Model Library	UA Cloud Library
14	Product Database	Big Query
15	Dashboards	Looker
16	AI-Assisted Analytics	Vertex AI
17	Asset Admin Shell Library	DTC AAS Repository
18	Dataspace Connector Provider	Eclipse Dataspace Connector Provider
19	Connected Product Time-Series Database	Big Table
20	Cloud to Edge Messaging App	UA Cloud Action
22	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer

UA Cloud Initiative Reference Architecture – Commercial offerings Microsoft

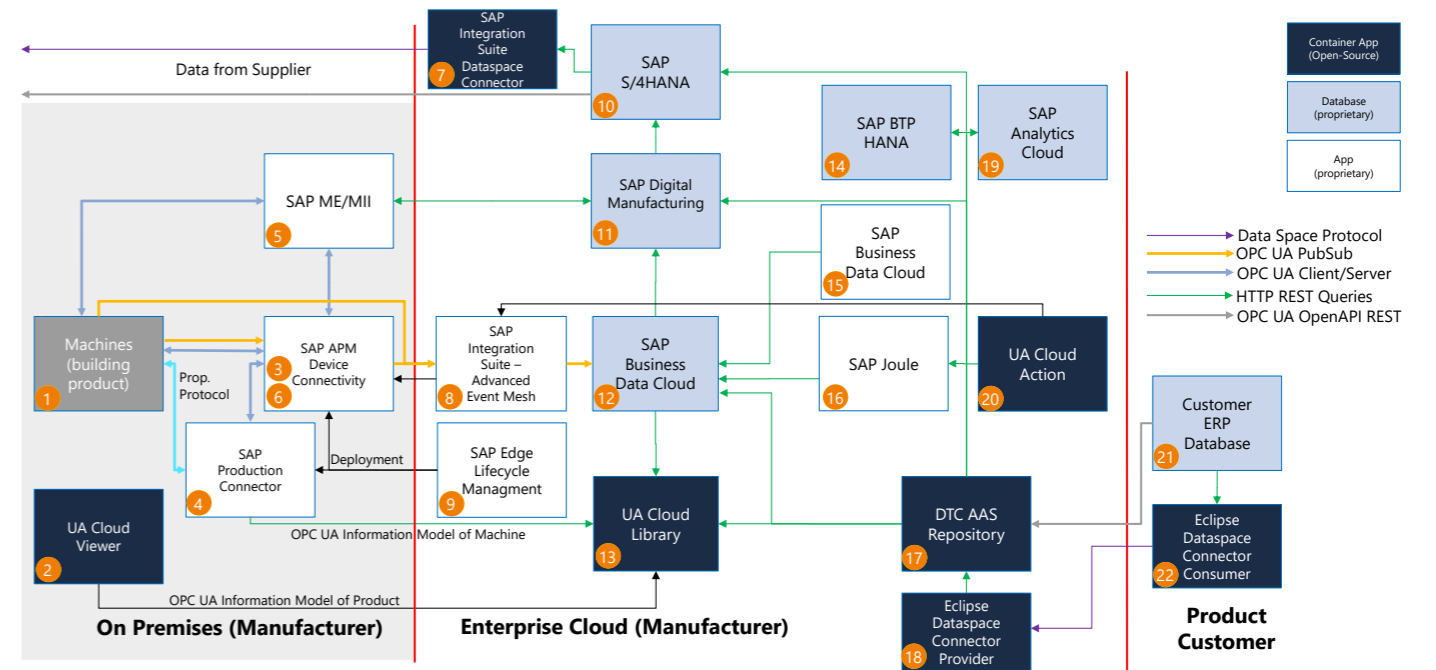


These building blocks are available as Microsoft offerings

Number	Generic name	Microsoft
3	Edge Broker	Azure IoT Operations with native OPC UA client and OPC UA PubSub support as well as an MQTTv5 broker, on Azure Local operating system.
6	Gateway	Azure IoT Operations with native OPC UA client and OPC UA PubSub support as well as an MQTTv5 broker, on Azure Local operating system.
7	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer
8	Cloud Broker	Azure Event Grid (MQTT) and Azure Event Hubs (Kafka).
9	Edge Management	Azure Arc edge infrastructure and application management.
10	ERP Database	Dynamics 365 ERP .
11	Cloud MES Service	Dynamics 365 MES .
12	Production Lines Time-Series Database	Azure Data Explorer time-series, graph and data analytics production data database.
13	Information Model Library	UA Cloud Library
14	Product Database	Azure SQL relational database.
15	Dashboards	Power BI visualization and insights platform.
16	AI-Assisted Analytics	Copilot Studio for creating Agents for your data.
17	Asset Admin Shell Library	DTC AAS Repository
18	Dataspace Connector Provider	Eclipse Dataspace Connector Provider
19	Connected Product Time-Series Database	Azure Data Explorer time-series, graph, and data analytics product usage data database.
20	Cloud to Edge Messaging App	UA Cloud Action
22	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer



UA Cloud Initiative Reference Architecture – Commercial offerings SAP



UA Cloud Initiative Reference Architecture – Commercial offerings SAP

Number	Generic Name	SAP
3	Edge Broker	SAP APM Device Connectivity
4	Industrial Connectivity Software	SAP Production Connector
6	Gateway	SAP APM Device Connectivity
7	Dataspace Connector Consumer	SAP Integration Suite Dataspace Connector
8	Cloud Broker	SAP Integration Suite – Advanced Event Mesh
9	Edge Management	SAP Edge Lifecycle Management
10	ERP Database	SAP S/4HANA
11	Cloud MES Service	SAP Digital Manufacturing
12	Production Lines Time-Series Database	SAP Business Data Cloud
14	Product Database	SAP BTP HANA
15	Dashboards	SAP Business Data Cloud
16	AI-Assisted Analytics	SAP Joule
19	Connected Product Time-Series Database	SAP Analytics Cloud

UA Cloud Initiative Reference Architecture – Commercial offerings ABB

Nummer	Generic name	ABB
1	Machines (building product)	ABB Industrial Equipments, Drives and Systems Machines support connectivity with standard protocols. Both ABB systems and Non-ABB systems are supported through Genix Industrial IoT and AI Platform Suite
2	Information Model Viewer	ABB Ability Information Model & Genix Model Viewer are components of Genix Industrial DataOps Express
3	Edge Broker	ABB Edgenius Broker is a component of Genix EdgeAI
4	Industrial Connectivity Software	ABB Genix Omni Source Integration Hub provides 200+ pre-built adapters for industrial systems ABB Edgenius Field Information Manager provides Fieldbus level connectivity to hundred plus protocols
5	On-premises MES	ABB Ability MOM
6	PubSub Data Publisher & PubSub Action Processor	Genix Data Publisher & Genix EdgeAI Orchestrator are part of Genix EdgeAI
7	Dataspace Connector Consumer	Genix Industrial DataOps Message Sync brings the functionality of Dataspace Connector Consumer and is a component of Genix Industrial DataOps Express
8	Cloud Broker	Genix IIoT Gateway is a component of Genix IIoT Hub
9	Edge Management	Genix Edge Management Portal is a component of Genix IIoT Hub
11	Cloud MES Service	Genix MES Integration Service
12	Production Lines – Time-Series Database	ABB Ability History . Also, pre integrated and supporting Azure Data Explorer , Timescale and CrateDB out of the box
13	Information Model Library	Genix Information Model Repository is a component of Genix Industrial DataOps Express
14	Product Database	Genix Industry Cognitive Model on any RDBMS
15	Dashboards	Genix Dashboard Manager is a component of Genix Analytics App Studio
16	AI-Assisted Analytics	Genix AI Express for Analytical Genix CoPilot for Generative AI
17	Asset Admin Shell Library	Genix Digital Twin Hub provides asset templates and digital twin modeler and runtime. DTC AAS Repository used for asset information registry
18	Dataspace Connector Provider	Genix Knowledge Services Hub
19	Connected Product Time-Series Database	ABB Ability History . Also, pre integrated and supporting Azure Data Explorer , Timescale and CrateDB out of the box
20	Cloud to Edge Messaging App	Genix Industrial DataOps Message Sync is a component of Genix Industrial DataOps Express

UA Cloud Initiative Reference Architecture – Commercial offerings BECKHOFF

Nummer	Generic name	BECKHOFF
1	Machines	TF6100 TwinCAT 3 OPC UA offers Client/Server and OPC UA PubSub
6	PubSub Data Publisher & PubSub Action Processor	TF6720 TwinCAT 3 IoT Data Agent offer OPC UA Client to OPC UA over MQTT

UA Cloud Initiative Reference Architecture – Commercial offerings Mitsubishi-Electric

Nummer	Generic name	MITSUBISHI ELECTRIC
1	Machines (building product)	GENESIS64 RD81OPC96 MELSEC iQ-R Series OPC UA server module FX5-OPC MELSEC iQ-F Series OPC UA server module


UA Cloud Initiative Reference Architecture – Commercial offerings Honeywell

Nummer	Generic name	Honeywell
1	Machines (building product)	ControlEdge PLC ControlEdge UOC
6	PubSub Data Publisher & PubSub Action Processor	Honeywell Enabled Services Matrikon Data Broker (MQTT Publisher)

UA Cloud Initiative Reference Architecture – Commercial offerings Rockwell Automation


Nummer	Generic name	Rockwell Automation
1	Machines (building product)	PLC Programmable Controllers Allen-Bradley US
4	Industrial Connectivity Software	FactoryTalk Linx Gateway Software FactoryTalk US
5	On-premises MES	MES Automation and Orchestration Plex FactoryTalk ProductionCentre FactoryTalk US
6	Gateway	FactoryTalk Optix FactoryTalk US
9	Edge Management	Margo - Edge interoperability for industrial automation ecosystems
11	Cloud MES Service	MES Systems: Manufacturing Execution System Software Plex
12	Production Lines Time-Series Database	FactoryTalk DataMosaix: Industrial DataOps Solution FactoryTalk US
15	Dashboards	FactoryTalk DataMosaix: Industrial DataOps Solution FactoryTalk US

UA Cloud Initiative Reference Architecture – Commercial offerings Schneider Electric

Nummer	Generic name	
1	Machines (building product)	<p>Modicon series controllers and OPC UA compatible modules :</p> <ol style="list-style-type: none"> Modicon M580 dPAC with BMENUA0100 OPC UA Embedded Module. Modicon M262 Logic/Motion controller PacDrive LMC Pro motion controllers Modicon M241 & M251 Micro Controller ATV dPAC Modicon Edge IO NTS BMEECN0100H (Edge Compute Node module for M580 PLCs) with embedded uDC Server (OPC UA Server by Prosyst by Schneider)
2	Information Model Viewer	Prosyst by Schneider OPC UA Modeler (based on UML modelers) to create and export information models
4	Industrial Connectivity Software	<ol style="list-style-type: none"> uDC Server (Unified Data Collector) by Prosyst by Schneider: OPC UA server exposing OT Data regardless of the OT Controller protocol in OPC UA uDC aggregation server used to collect OT Data from several OPC UA servers. Ecostruxure OPC UA server expert - for connection through Modicon controllers
5	On-premises MES	AVEVA MES system
6	PubSub Data Publisher & PubSub Action Processor	uDC Data Provider supporting OPC UA PubSub over MQTT and MQTTS communication - Prosyst by Schneider
9	Edge Management	<ol style="list-style-type: none"> uDC Plant Manager and Enterprise Monitor for remote monitoring, diagnosis and management of uDC servers deployed on premise - Prosyst by Schneider. Margo - Edge interoperability for industrial automation ecosystems.



UA Cloud Initiative Reference Architecture – Commercial offerings Siemens

Nummer	Generic name	
1	Machines (building product)	SIMATIC S7-1500 and ET200SP CPU with integrated OPC UA Client/Server and OPC UA PubSub via library .
2	Information Model Viewer	The free " Siemens OPC UA Modeling Editor (SiOME) " tool creates your own OPC UA information models or maps existing companion specifications to SIMATIC, SINUMERIK and CloudConnect devices.
3	Edge Broker	Siemens Industrial Edge Hub is an open, ready-to-use edge computing platform consisting of edge devices, edge apps, IT and OT connectivity, and an application and device management infrastructure. The External Databus App allows you to connect clients to the Edge Broker over MQTT.
4	Industrial Connectivity Software	Industrial Information Hub for Siemens Industrial Edge – The main data integration platform from Siemens.
5	On-premises MES	SIMATIC WinCC Open Architecture (OA) : object-oriented SCADA system for usage in the automation level right up to operation and management level. Including OPC UA and MQTT.
6	PubSub Data Publisher & PubSub Action Processor	Industrial Information Hub for Siemens Industrial Edge – The main data integration platform from Siemens.
8	Cloud Broker	Insights Hub and MindConnect MQTT – Connect your assets to the cloud, collect and explore your data.
9	Edge Management	Industrial Edge Hub Access and Industrial Edge Management enable the connection and management of Industrial Edge devices with/in the Industrial Edge Management system and access all relevant software components.



Supporting cloud providers



Supporting end-users



Supporting automation providers



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