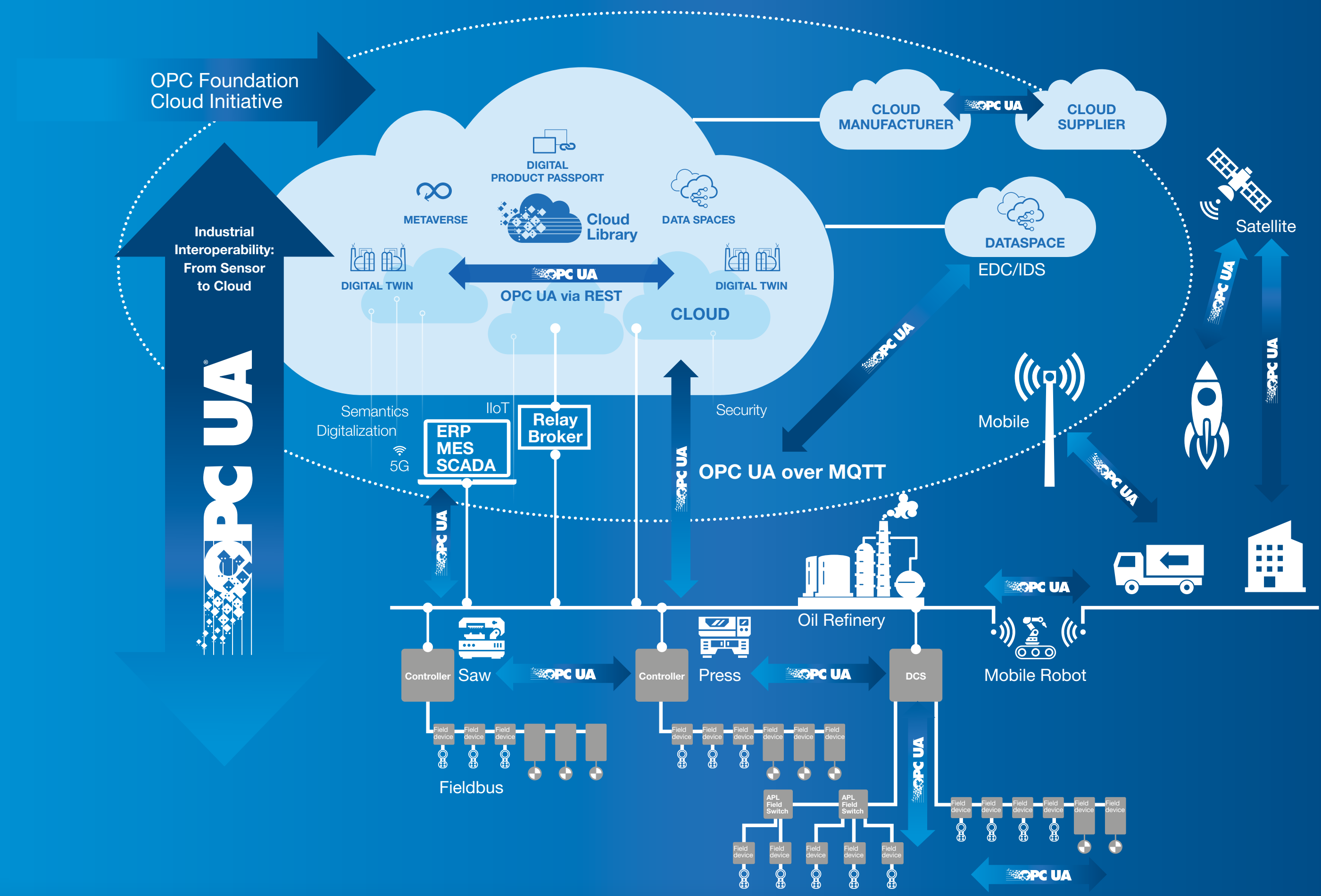
OPC Foundation Cloud Initiative
The Industrial Cloud Interoperability Standard

Version 8 // June 2026



Supporting cloud providers

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OPC UA Success Stories

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OPC UA & AI

OPC UA & Security

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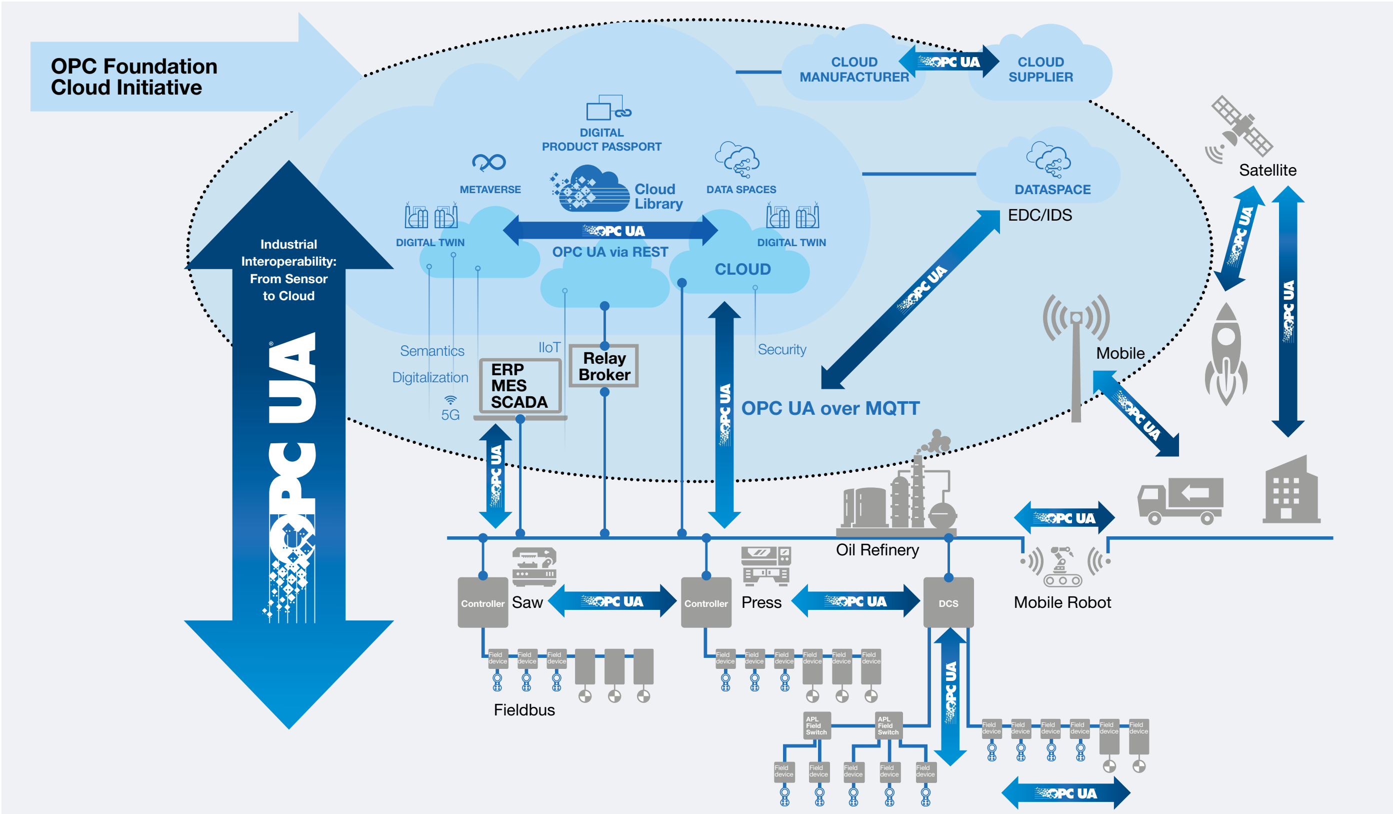
Scope:
The Industrial Cloud Interoperability Standard



OPC UA Use Cases

OPC Unified Architecture (OPC UA) is the open, globally standardized foundation for securely connecting industrial systems with modern IT and cloud platforms. It enables trusted, semantic, and scalable information exchange across OT, IT, and cloud environments – powering digital transformation, analytics, and data-driven business models.

OPC UA USE CASES:
BUILT FOR CLOUD SCALE
OPC UA is engineered for distributed, cloud-native architectures:

- Edge, on-prem, cloud, and cloud-to-cloud
- Embedded devices to hyperscale platforms
- Low-latency control and high-volume data pipelines

It supports both Client/Server and Publish/Subscribe communication, enabling real-time access as well as event-driven, many-to-many data distribution.

OPC Foundation Cloud Initiative
Executive Summary — Vision & Deliverables

The **OPC Foundation Cloud Initiative** represents a strategic, industry-wide effort to extend the proven interoperability of OPC UA from the shop floor into IT and cloud environments, enabling scalable, secure, and semantically rich industrial data exchange.

VISION OF CLOUD INTEROPERABILITY
Launched in April 2024, the initiative has rapidly gained momentum and now brings together leading cloud hyperscalers, industrial automation vendors, and global end users to address one of the most pressing challenges in Industry 4.0: standardized cloud interoperability.

AI NEEDS CONTEXT OF INFORMATION
Led by the OPC Foundation, the initiative aims to accelerate the adoption of OPC UA as the common interoperability layer for cloud use cases, including AI-driven analytics, digital twins, industrial data spaces, digital product passports, and emerging industrial metaverse applications. By extending OPC UA's information modeling and semantics into the cloud, the initiative addresses long-standing gaps between operational technology (OT), IT systems, and cloud-native services.

DELIVERABLES
A core focus of the Cloud Initiative is the development of a **cloud reference architecture** and **cloud-optimized OPC UA profiles**, providing best practices for standardized data sharing and scalable deployment across hybrid and multi-cloud environments. Complementing this architecture, the initiative will maintain OPC UA Companion Specifications directly in the cloud, ensuring that semantic context is preserved and remains consumable by modern cloud services.

THE CLOUD INTEROPERABILITY LABEL
To enable secure and trusted data exchange, the initiative is establishing a protected identity – **OPC UA Cloud eXchange (UACX)** – alongside a validation and certification program specifically designed for OPC UA cloud interoperability. These efforts are intended to reduce integration efforts, lower operational costs, and increase confidence for both providers and users.

ORGANIZATION
The steering committee reflects unprecedented cross-industry alignment, including major cloud providers, such as Amazon Web Services, Google Cloud, Microsoft, SAP, and Huawei, together with leading automation companies including ABB, Beckhoff, Honeywell, Siemens, Schneider Electric, Rockwell Automation, Mitsubishi Electric and Yokogawa.

EARLY INVOLVEMENT OF END-USERS
Equally significant is the early and active involvement of end users through the newly formed End-User Council, with participation from global manufacturers such as Renault Group, Volkswagen, Continental, equinor, JTI, Mondelez, Tetra Pak, L'Oreal Operations, Miele, Danone, and Boehringer Ingelheim. These companies are jointly defining and harmonizing real-world IT and cloud requirements, ensuring that the initiative delivers practical, scalable solutions that preserve OPC UA's semantic richness while addressing cloud scalability and performance demands.

UNIFYING THE OT AND IT WORLD
By uniting OT vendors, cloud providers, and industrial end users on neutral ground, the OPC Foundation Cloud Initiative marks a pivotal step in the evolution of industrial interoperability. It establishes OPC UA as a foundational standard, not only for connected devices and edge systems, but also for next-generation cloud-native industrial ecosystems – unlocking the full value of structured, standardized industrial data across the entire digital value chain.

Interested in joining the initiative?
Please contact us
office@opcfoundation.org

OPC UA: More Than a Protocol
Meta-Modelling Language + Transport + Security

OPC UA IS …
A RICH MODELING LANGUAGE
OPC UA delivers context-aware data, not just signals:
- Object-oriented information models
- For data and interfaces
- For devices and services
- Strong typing and validation
- 430+ free companion specifications across industries – free of charge available
- Extensible models for enterprise-specific needs

Semantics are embedded directly into the data stream – enabling scalable analytics, automated integration, and system-to-system understanding without custom mappings.








Models
- More than 430+ models (Industries, Catena-X, ..) available.
- Free of charge and commercial modelling tools available
- OPC UA library is a free of charge repository of OPC UA based information models (from OPC Foundation and worldwide contributors)
- UA Cloud Library allows to instance models, keep the instances in database and interact via Web UI and REST interface

Internationalization
- OPC UA is IEC62541 Standard
- OPC UA is local standard in China (GB/T 33863.x), Korea, Russia, Singapore

PROVIDING FLEXIBLE TRANSPORT
Native Integration with modern IT & Cloud Platforms
Support 2 communication mechanisms: Client/Server & Publisher/Subscriber
OPC UA integrates seamlessly with enterprise and cloud ecosystems:
- Publish/Subscribe over MQTT, AMQP and Kafka for cloud ingestion
- Efficient or human readable encodings
- REST and WebSocket bindings for IT and web applications
- Filetransfer
- Compatible with event streaming, data lakes, and analytic platforms

This makes OPC UA a natural backbone for IIoT platforms, AI pipelines, and digital twin architectures.

STATE-OF-THE-ART
DELIVERING SECURITY BUILT-IN BY DESIGN
Enterprise-Grade security, proven at scale
security is built-in from the ground up:
- Onboarding
- For accessing information
- For transport of information
- Fine-grained authorization down to data-point level
- Integrated audit concepts
- Verified/Validated by international experts
- Infrastructure certificate management

Based on proven IT security standards (TLS, AES), OPC UA fits naturally into zero-trust and cloud security architectures.

RELIABLE DATA FOR MISSION-CRITICAL DIGITAL SYSTEMS
OPC UA ENSURES INTEGRITY AND AVAILABILITY ACROSS UNRELIABLE NETWORKS:
- Automatic recovery and reconnection
- Data buffering to prevent loss
- Sequencing, retransmission, and redundancy support

This reliability makes OPC UA suitable for cloud-based monitoring, analytics, and operational decision-making.

Members
- 1022 Worldwide
- 60 % EMEA
- 20 % Americas
- 20 % APAC

Budget 2026
- 5,400,000,– USD
- Mostly member fees
- No public fundings

Activities
- 150+ Working Groups
- 350+ Specifications
- 430+ Models in OPC UA Cloud Library (Industries, Catena-X)
- Models are free of charge available

Supporters
- 1100+ Volunteers
- 15 Board Members
- 11 Contractors
- 0 Employees

4 Regions
- North America, Europe, China, Japan
- Hubs in France, Singapore, India and Korea

Commercial Solutions
- 21+ Toolkits
- 10+ Modelling Tools

Openness
- 17 Open-Source Projects by OPCF
- 1900 Open-Source Projects in total

Communications
- 11,000+ Followers on LinkedIn
- Marketplace with 5000+ visitors per month
- 260,000+ entries in user database for newsletters

OPC Foundation Facts & Figures

The OPC Foundation has been promoting the development and adoption of the OPC information exchange standard since 1996. As an advocate and steward of these specifications, the OPC Foundation's mission is to help vendors, end users, and software developers achieve interoperability.

MISSION
The OPC Foundation's mission is to provide the best specifications, technologies, processes, and certification to ensure interoperability between different vendors and different platforms securely and reliably from embedded systems to the enterprise cloud.

MEMBERS
The Foundation supports over 1,010 members worldwide – including suppliers, end users, system integrators, academic institutions, and startups – across the fields of industrial automation, IT, IoT and IIoT, M2M, Industry 4.0, building automation, machine tools, pharmaceuticals, petrochemicals, and smart energy in achieving this goal.

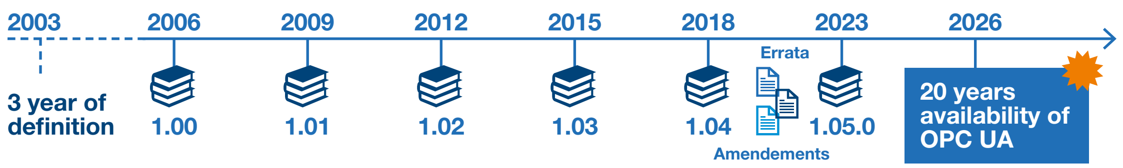
ADOPTION
Based on public analysis, there are more than 7,200 suppliers who have created more than 62,000 different OPC products used in more than 82 million applications. The estimate of the savings in engineering resources alone is in the billions of dollars.

INTERNATIONAL
- OPC UA is an international standard defined as IEC 62541, ensuring global consistency and long-term reliability. OPC UA is also recognized as a national standard in multiple countries, reinforcing its worldwide adoption like in China, Korea, Russia, Singapore
- Worldwide community of over 1,010 IT and OT members across all major industries.
- International leadership is elected annually

OPENNESS BY DESIGN – NO LOCK-IN – NO LICENSING BARRIERS
OPC UA is an open, non-proprietary standard (IEC 62541) backed by a global ecosystem of more than 1,000 IT and OT members.
- 430+ standardized information models available free of charge
- OPC UA .NET stack available as open source
- RAND-Z licensed intellectual property, ensuring open access and broad industry adoption
- Multi-vendor, cross-platform, language-independent

This openness dramatically lowers integration costs, accelerates innovation, and eliminates vendor lock-in – key requirements for enterprise IT and cloud strategies. The real long-term benefit, however, is sustainability: the technology has been on the market for more than 20 years and remains compatible with its very first release.

2026: 20-Years Availability of OPC UA
Always Backward Compatible



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 device 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 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**

Supporting cloud providers

aws, Google Cloud, HUAWEI, Microsoft, SAP

Supporting end-users

Boehringer Ingelheim, Continental ContiTech, Danone, equinor, L'ORÉAL Operations, Miele, Mondelēz International, Renault Group, JTI, Tetra Pak, Volkswagen

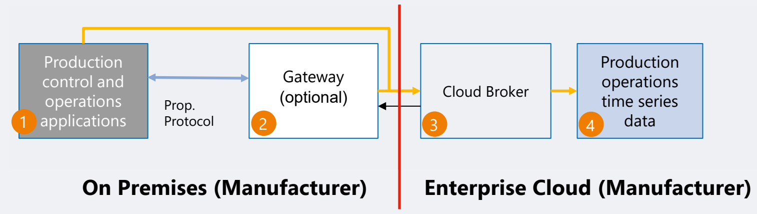
Supporting automation providers

ABB, BECKHOFF, Honeywell, Mitsubishi Electric, Rockwell Automation, Schneider Electric, SIEMENS, YOKOGAWA

Interested? Join us! www.opcfoundation.org/Cloud

Simplified Reference Architecture

The Core Building Blocks



At its core, the reference architecture consists of just a view components adressing 2 key aspects:

A. Secure, standardized data ingestion from on premises machine data 1 via a broker 3 to a time-series database in the cloud 4.

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

Use-cases

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

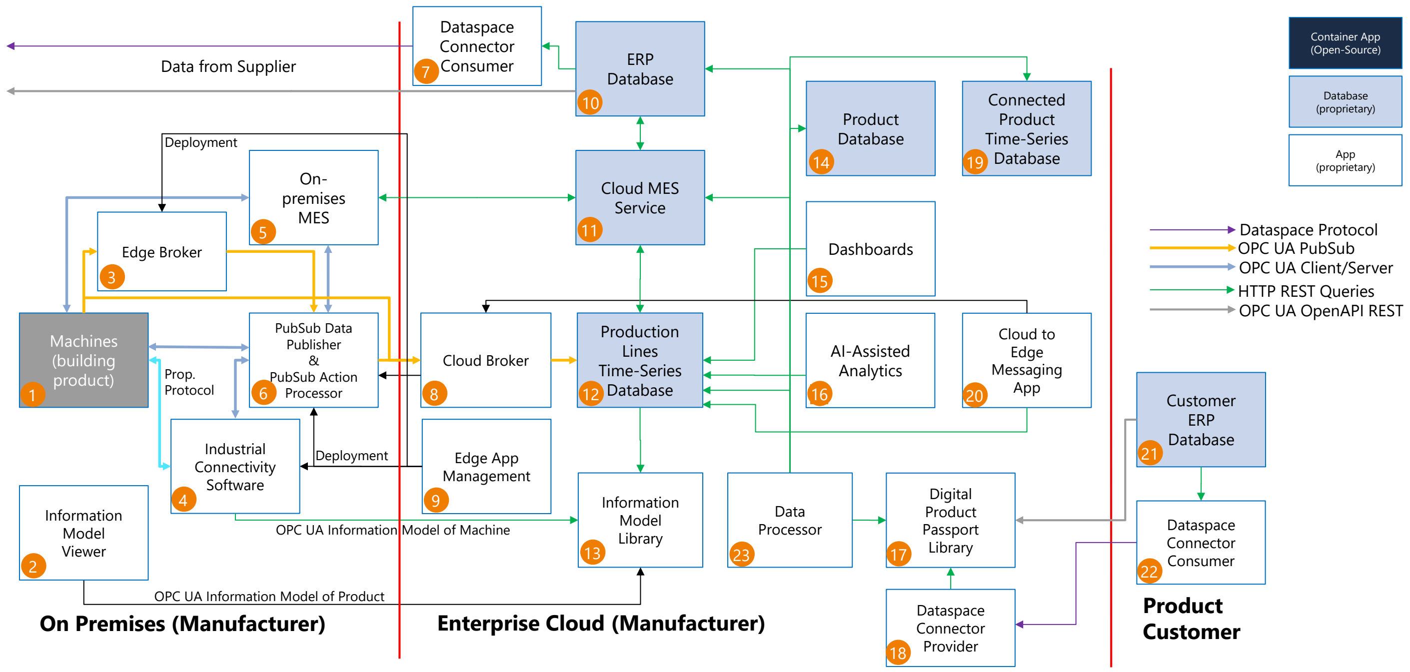
U1. PLCs with support for OPC UA over MQTT can communicate directly with the cloud broker for bi-directional data exchange.

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 Client/Server and OPC UA over MQTT 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 protocol, the market offers many industrial connectivity software options converting the legacy protocol 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.

OPC Foundation Cloud Initiative Reference Architecture – Generic



1. Machines of the Manufacturer on-premises producing the consumer good.
2. An OPC UA Information Model editor tool that can upload OPC UA Information 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 ideally supporting the OPC UA WoT-Connectivity Companion Specification.
5. The on-premises part of the Manufacturing Execution System (MES). It often includes 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 Publisher 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.

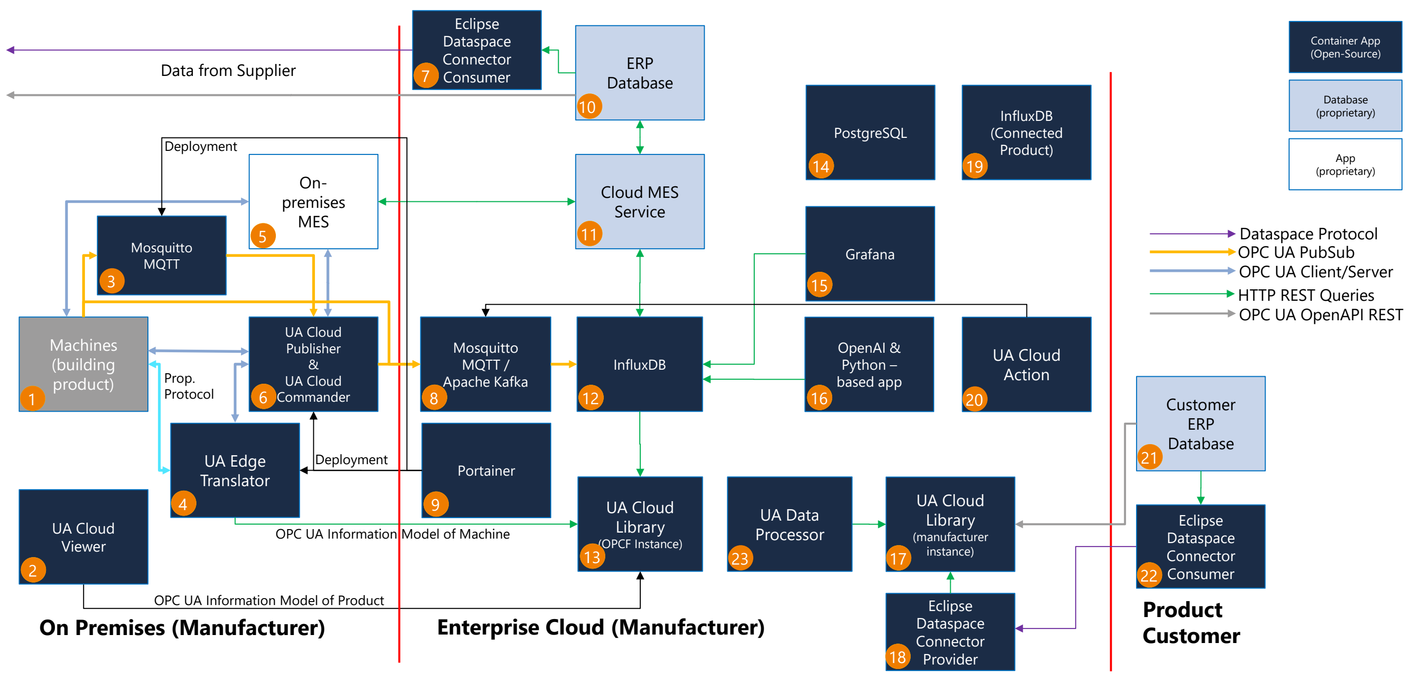
12. The time-series database receiving telemetry data from the production line via the cloud broker. It can also read order information from the MES system and OPC UA Information Model metadata from the UA Cloud Library.
13. The online store of OPC UA Information Models. This can either be the public 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 goods 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 predictions about required machine maintenance.
17. The Digital Product Passport Library stores Digital Product Passports modeled with OPC UA and provides an OpenAPI REST interface for upload and download.
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.
23. A data processor for product data stored in databases, generating Digital Product Passports for those products.

Cloud architecture components are available both as
- **commercial solutions** from leading providers like AWS, ABB, Beckhoff, Google Cloud, Honeywell, Huawei, Microsoft, Mitsubishi Electric, Rockwell Automation, SAP, Schneider Electric, Siemens, Yokogawa and as
- **open-source offerings.**

Content of the brochure:
- Detailed descriptions of the existing working groups
- a list of all commercial offerings
- URLs for the open-source reference code
- Milestones and roadmap

Download here:
www.opcfoundation.org/cloud

OPC Foundation Cloud Initiative Reference Architecture – Open-source Offerings



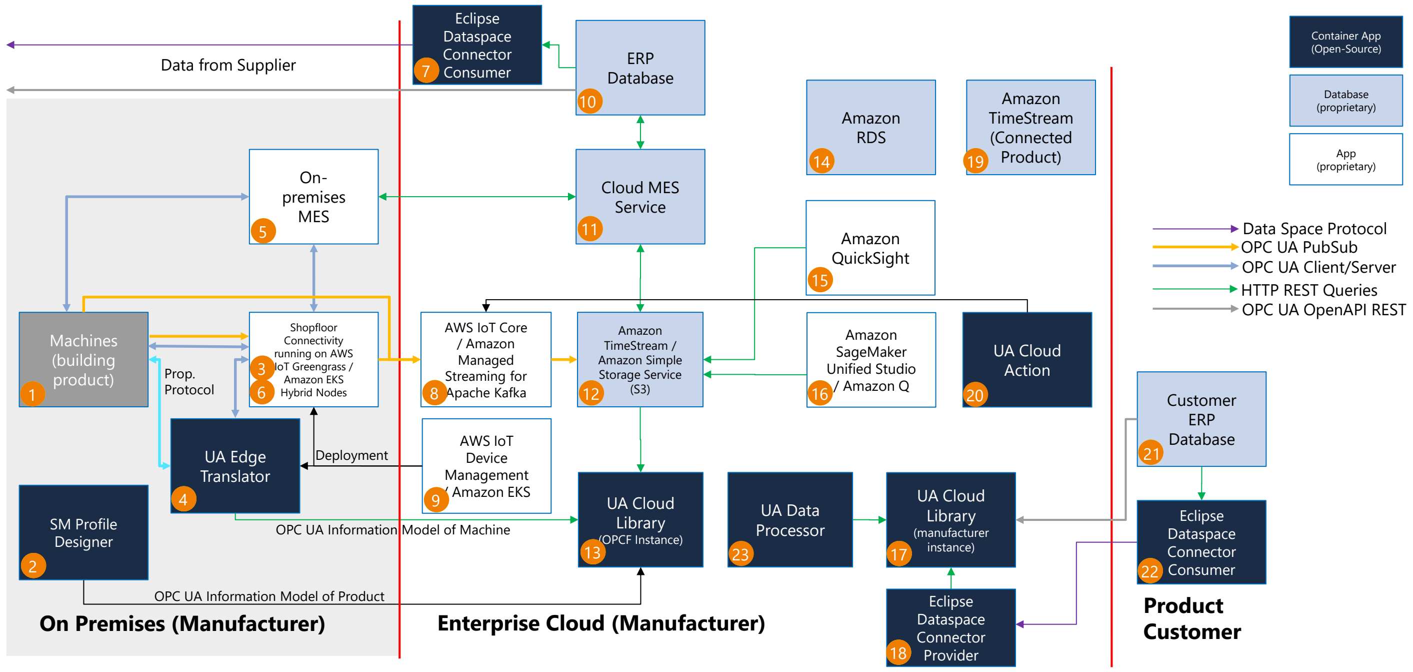
OPC Foundation Cloud Initiative Reference Architecture – Open-source Offerings

Nummer	Open-source
2	OPC Foundation SM Profile Designer Nodeset editor 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	OPC Foundation UA Cloud Library, recently extended with NodeSet viewing, uploading, downloading and editing capabilities for Digital Product Passport scenarios.
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.
23	OPC Foundation UA Data Processor for processing product data, generating Digital Product Passports and then uploading them to UA Cloud Library.

OPC Foundation Cloud Reference Architecture – Overview Commercial Offerings Cloud Providers

Nr.	Generic Name	aws	Google Cloud	HUAWEI	Microsoft	SAP
1	Machines (building product)					
2	Information Model Viewer			UA Cloud Viewer		
3	Edge Broker	Shopfloor Connectivity running on AWS IoT Greengrass / Amazon EKS Hybrid Nodes Greengrass	Manufacturing Connect	UA Edge Translator	Azure IoT Operations on Azure Local	SAP APM Device Connectivity
4	Industrial Connectivity Software			UA Edge Translator		SAP Production Connector
5	On-premises MES					
6	Gateway	Shopfloor Connectivity running on AWS IoT Greengrass / Amazon EKS Hybrid Nodes	Manufacturing Connect	IoT Edge	Azure IoT Operations on Azure Local	SAP APM Device Connectivity
7	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	EDS	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	IIoT	Azure Event Grid/Hubs	SAP Integration Suite – Advanced Event Mesh
9	Edge Management	AWS IoT Device Management / Amazon EKS	Manufacturing Connect (Cloud)	IoT Edge	Azure Arc	SAP Edge Lifecycle Managment
10	ERP Database				Dynamics 365 ERP	SAP S/4HANA
11	Cloud MES Service			Model Based Manufacturing	Dynamics 365 MES	SAP Digital Manufacturing
12	Production Lines Time-Series Database	Amazon TimeStream / Amazon Simple Storage Service (S3)	Cloud Storage & Big Table	GeminiDB	Azure Data Explorer	SAP Business Data Cloud
13	Information Model Library	UA Cloud Library	UA Cloud Library	UA Cloud Library	UA Cloud Library	
14	Product Database	Amazon RDS	Big Query	RDS for MySQL/RDS for PostgreSQL	Azure SQL	SAP BTP HANA
15	Dashboards	Amazon QuickSight	Looker	DataArts Insights/ Data Lake Visualization	Power BI	SAP Business Data Cloud
16	AI-Assisted Analytics	Amazon SageMaker Unified Studio / Amazon Q	Vertex AI	ModelArts	Copilot	SAP Joule
17	Digital Product Passport Library	UA Cloud Library	UA Cloud Library	UA Cloud Library	UA Cloud Library	
18	Dataspace Connector Provider	Eclipse Dataspace Connector Provider	Eclipse Dataspace Connector Provider	EDS	Eclipse Dataspace Connector Provider	
19	Connected Product Time-Series Database	Amazon TimeStream (Connected Product)	Big Table	GeminiDB	Azure Data Explorer (Connected Product)	SAP Analytics Cloud
20	Cloud to Edge Messaging App	UA Cloud Action	UA Cloud Action	UA Cloud Action	UA Cloud Action	
21	Customer ERP Database			Customer ERP Database		
22	Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	Eclipse Dataspace Connector Consumer	EDS	Eclipse Dataspace Connector Consumer	

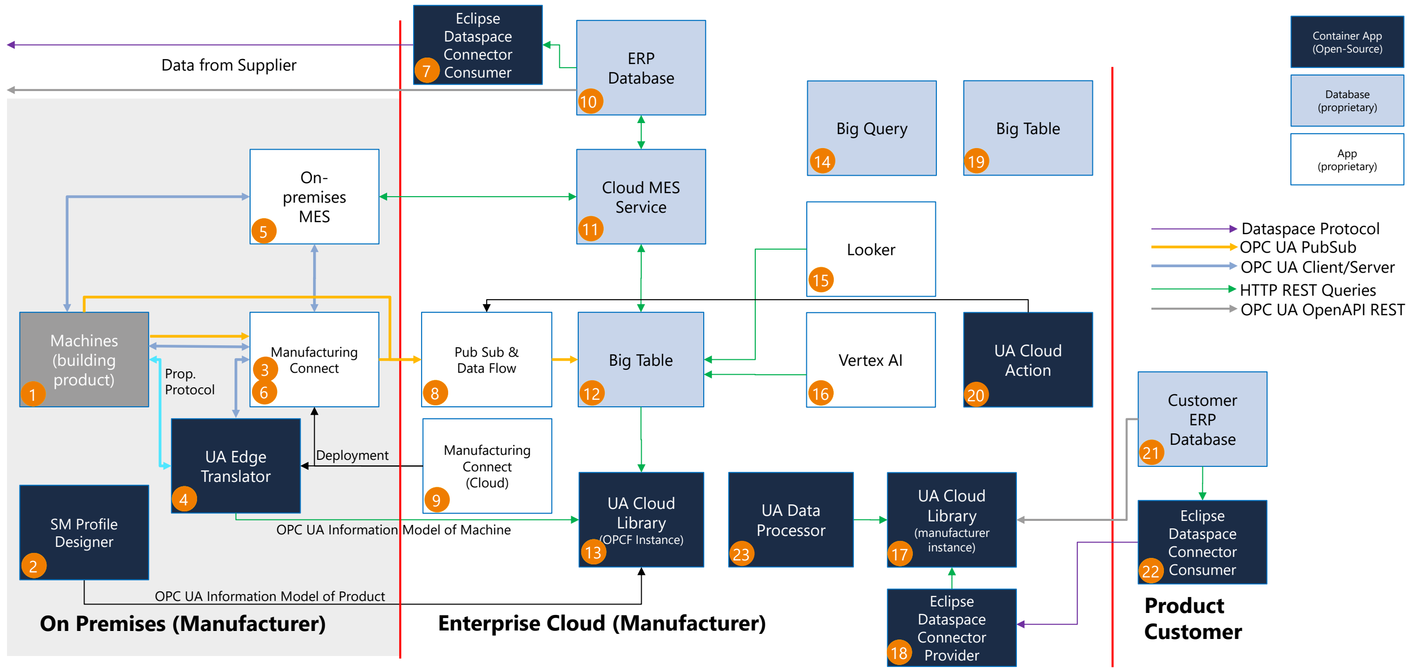
OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings AWS



OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings aws

Nummer	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	UA Cloud Library	UA Cloud Library
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

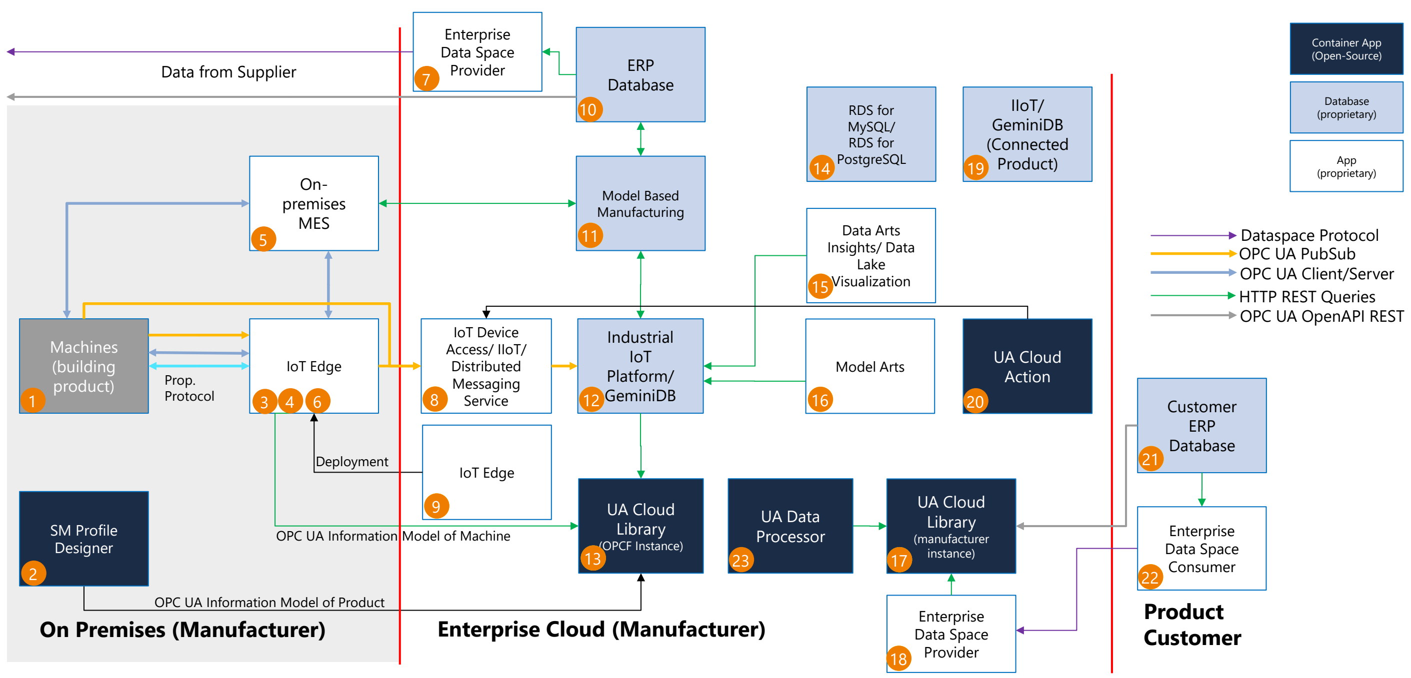
OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Google Cloud



OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Google Cloud

Nummer	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	UA Cloud Library	UA Cloud Library
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

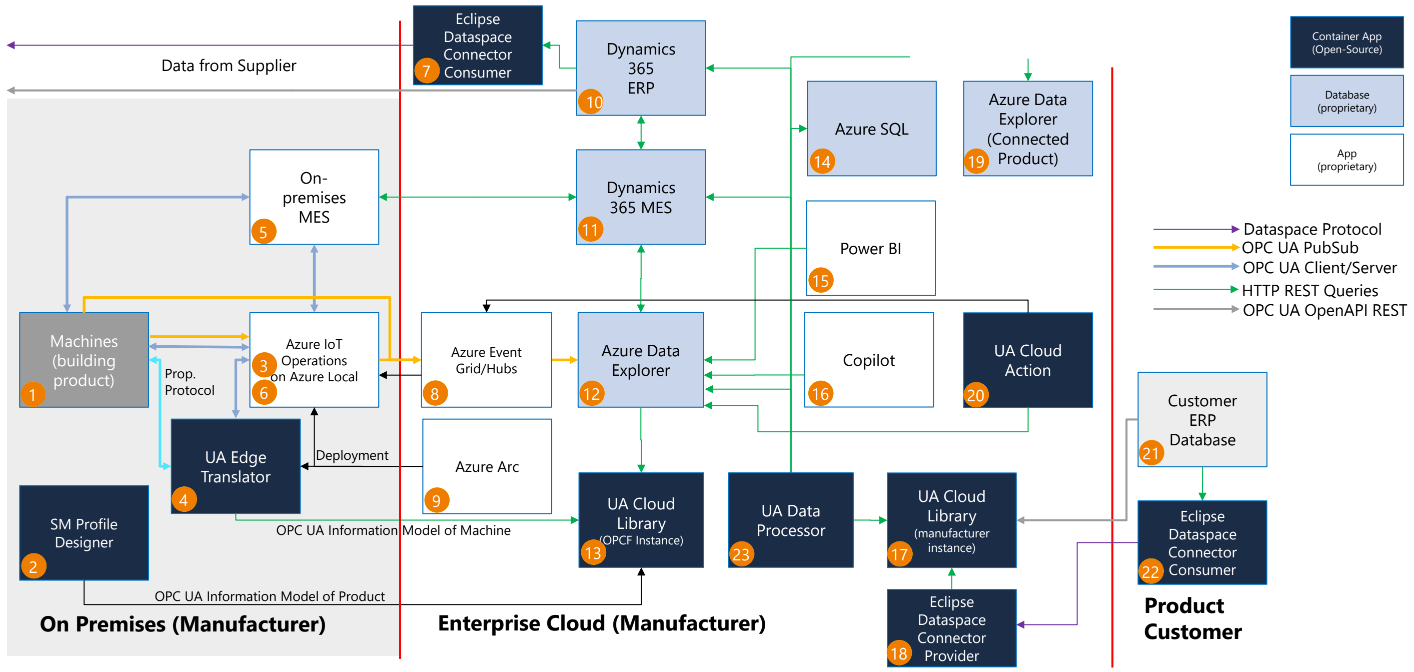
OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Huawei



OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Huawei

Nummer	Generic name	HUAWEI
1	Machines (building product)	Machines of the Manufacturer on-premises building the product.
3	Edge Broker	IoT Edge – At the edge, in close proximity to data sources or physical assets, an open platform integrating network, compute, storage, and application core capabilities, provides computing and intelligent services nearby.
4	Industrial Connectivity Software	UA Edge Translator – Open-Source
5	On-premises MES	On-premises MES
6	Gateway	IoT Edge – At the edge, in close proximity to data sources or physical assets, an open platform integrating network, compute, storage, and application core capabilities, provides computing and intelligent services nearby.
7	Dataspace Connector Consumer	EDS – The data space exchange instance is a platform for exchange and sharing that is based on protecting enterprise data sovereignty, promoting efficient data circulation within enterprises, and maximizing data value.
8	Cloud Broker	IoT Device Access (IoTDA) –The industrial IoT platform serves as a unified digital foundation for enterprises' production data, targeting the key challenges faced by manufacturing companies during the digital upgrade of their production processes. IoTDA – Provides massive device connectivity to the cloud, bidirectional messaging between devices and the cloud, batch device management, remote control and monitoring, OTA upgrades, and device linkage rules.
9	Edge Management	IoT Edge – At the edge, in close proximity to data sources or physical assets, an open platform integrating network, compute, storage, and application core capabilities, provides computing and intelligent services nearby.
10	ERP Database	ERP Database
11	Cloud MES Service	Model Based Manufacturing
12	Production Lines – Time-Series Database	GeminiDB – A multi-model NoSQL database based on Huawei's independently developed decoupled computing and storage architecture, compatible with various protocols such as Redis, DynamoDB, Cassandra, HBase, and InfluxDB.
13	Information Model Library	UA Cloud Library – Open-source
14	Product Database	RDS for MySQL/RDS for PostgreSQL
15	Dashboards	DataArts Insights/ Data Lake Visualization – The new generation of BI services provides visual, real-time, user-friendly, and secure business intelligence analysis services, enabling businesses to gain insights in the most natural and efficient way, supporting real-time and efficient decision-making.
16	AI-Assisted Analytics	ModelArts – A one-stop AI development platform for developers, enabling rapid creation and deployment of models, managing the entire AI workflow cycle, and supporting intelligent upgrades across various industries.
17	UA Cloud Library	UA Cloud Library
18	Dataspace Connector Provider	EDS – The data space exchange instance is a platform for exchange and sharing that is based on protecting enterprise data sovereignty, promoting efficient data circulation within enterprises, and maximizing data value.
19	Connected Product – Time-Series Database	GeminiDB – A multi-model NoSQL database based on Huawei's independently developed decoupled computing and storage architecture, compatible with various protocols such as Redis, DynamoDB, Cassandra, HBase, and InfluxDB.
20	Cloud to Edge Messaging App	UA Cloud Action – Open-source
21	Customer ERP Database	Customer ERP Database
22	Dataspace Connector Consumer	EDS – The data space exchange instance is a platform for exchange and sharing that is based on protecting enterprise data sovereignty, promoting efficient data circulation within enterprises, and maximizing data value.

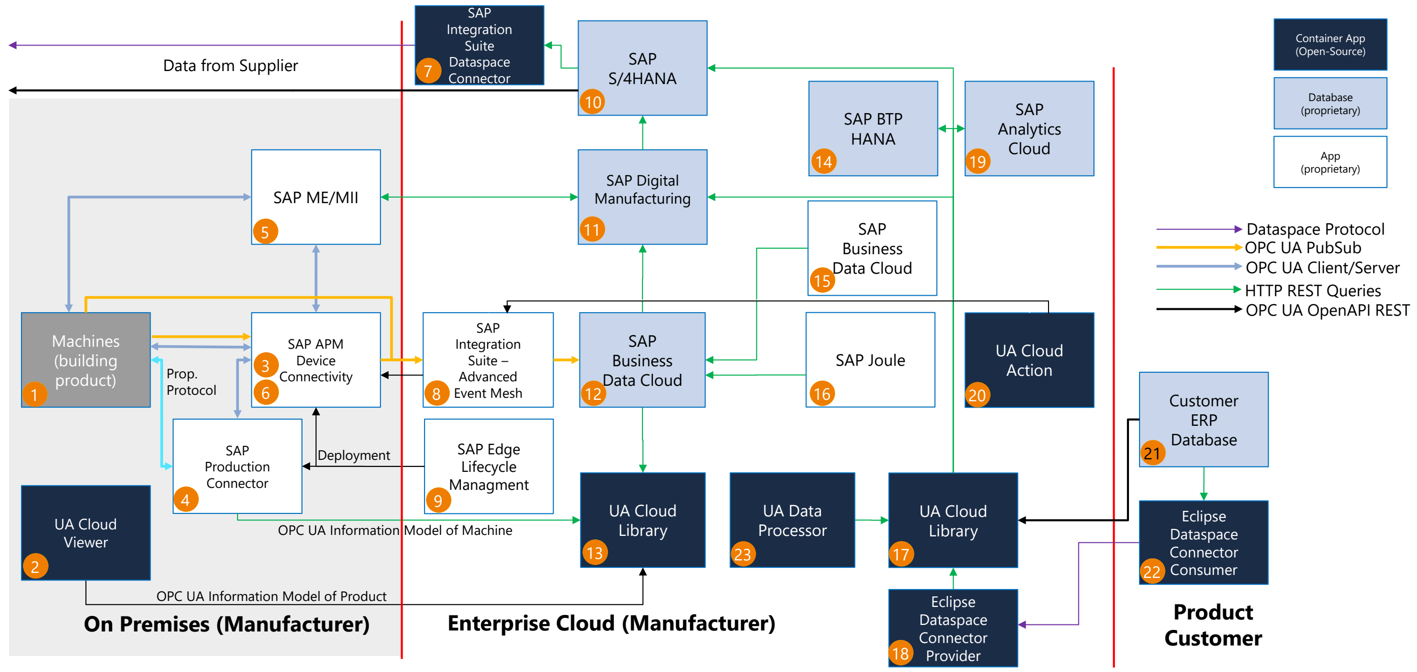
OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Microsoft



OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Microsoft

Nummer	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	UA Cloud Library	UA Cloud Library
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

OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings SAP



OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings SAP

Nummer	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 Managment
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

OPC Foundation 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 Ge-nix Industrial DataOps Express

OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings BECKHOFF

Nummer	Generic name	BECKHOFF
1	Machines	TF6100 TwinCAT 3 OPC UA includes Client/Server and Gateway. TF6105 TwinCAT 3 OPC UA Pub/Sub enables Pub/Sub communication via UDP and MQTT.
2	Editor	TE6100 TwinCAT 3 OPC UA Nodeset Editor enables integration of OPC UA companion specification
6	PubSub Data Publisher & PubSub Action Processor	TF6720 TwinCAT 3 IoT Data Agent offer OPC UA Client to OPC UA over MQTT

OPC Foundation 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

OPC Foundation 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)

OPC Foundation 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

OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Schneider Electric

Nummer	Generic name	Schneider Electric
1	Machines (building product)	OPC UA compatible modules: Modicon series controllers/EcoStruxure Machines/Foxboro DCS: 1. Modicon M580 PAC with BMENUA0100 2. Modicon M580 dPAC 3. Modicon M262 Logic/Motion controller 4. PacDrive LMC Pro motion controllers 5. Modicon M241 & M251 Micro Controller 6. Modicon Edge IO NTS 7. BMEECN0100H (Edge Compute Node module for M580 PLCs) 8. HMI solution (Harmony P6 Industrial PC and EcoStruxure Operator Terminal Expert) 9. Foxboro DCS solution 10. Ecostruxure Triconex Safety Systems
2	Information Model Viewer	Prosyst by Schneider OPC UA Modeler (based on UML modelers) to create and export information models
3	Edge Broker	AVEVA Edge through 3rd party
4	Industrial Connectivity	1. EcoStruxure OPC UA Server Expert – Aggregates OPC UA data 2. AVEVA System Platform: Offers native OPC UA server and client capabilities 3. uDC Server (Unified Data Collector) by Prosyst by Schneider: OPC UA server exposing OT Data regardless of the OT Controller protocol in OPC UA 4. uDC aggregation server used to collect OT Data from several OPC UA servers.
5	On-premises MES	AVEVA MES integrates with OPC UA and provides real-time production management and machine status monitoring.
6	Gateway	1. EcoStruxure IIoT Gateway – Supports OPC UA Client, PubSub, MQTT, and Kafka 2. AVEVA Edge 3. uDC Data Provider supporting OPC UA PubSub over MQTT and MQTTS communication – Prosyst by Schneider
8	Cloud Broker	1. EcoStruxure Platform – Edge to Cloud communication 2. AVEVA CONNECT – open, vendor-neutral and cloud-based platform
9	Edge Management	1. EcoStruxure Platform – device and app management capabilities 2. EcoStruxure Edge Apps-Manager 3. AVEVA Edge Management for provisioning and monitoring edge devices 4. uDC Plant Manager and Enterprise Monitor for remote monitoring, diagnosis and management of uDC servers deployed on premise – Prosyst by Schneider.
11	Cloud MES Service	AVEVA MES Cloud – Cloud-based MES managing production data in the cloud
12	Production Lines Time-Series Database	1. EcoStruxure Platform – supporting the EcoStruxure portfolio storing the time-series data 2. AVEVA CONNECT Data Services – Cloud-based scalable, secure industrial data management service
14	Product Database	1. EcoStruxure Platform 2. AVEVA CONNECT Data Services – Cloud-based scalable, secure industrial data management service
15	Dashboards	AVEVA Insight – Self-service dashboards and customizable alerts for optimizing operations
16	AI-Assisted Analytics	AVEVA Predictive Analytics – AI-driven insights for maintenance and performance.
18	Dataspace Connector Provider	EcoStruxure Platform – Eclipse Tractus-X Dataspace Connector for secure data sharing
19	Connected Product Time-Series Database	1. EcoStruxure Platform – supporting the EcoStruxure portfolio storing the time-series data 2. AVEVA CONNECT Data Services – Cloud-based scalable, secure industrial data management service
20	Cloud to Edge Messaging App	EcoStruxure Platform – supporting the EcoStruxure portfolio for their Cloud-to-Edge MQTT or HTTP communication
21	Customer ERP Database	Integration with customer ERP systems is supported via EcoStruxure Integration Services.

OPC Foundation Cloud Initiative Reference Architecture – Commercial offerings Siemens

Nummer	Generic name	SIEMENS
1	Machines (building product)	SIMATIC S7-1500 and ET 200SP CPU with integrated OPC UA Client/Server and OPC UA PubSub via library. SINUMERIK OPC UA Server for tool machine controllers
2	Information Model Viewer	Siemens OPC UA Modeling Editor (SiOME) – free of charge
3	Edge Broker	Siemens Industrial Edge
4	Industrial Connectivity Software	Connectivity Software for brown-/greenfield data integration – integrated into multiple products for different industries & applications – SIMATIC WinCC SCADA Systems – Industrial Information Hub: Edge-based Shopfloor integration platform – MindConnect: Insights Hub Gateway – Opcenter Connect: MES/ERP Gateway – CMS1200
5	On-premises MES	Opcenter
6	Gateway	Hardware and Software Gateways tailored to different industries and application scenarios: SIMATIC WinCC SCADA Systems, Industrial Information Hub, Opcenter Connect, IoT Gateways, SIMATIC CloudConnect 7, SIMATIC CN 4100
7	Dataspace Connector Consumer	Insights Hubs' Cross-Tenancy, Policy Based Access Control
8	Cloud Broker	Insights Hub with MindConnect MQTT and full PubSub support, Opcenter X NATS Broker with Pub/Sub and Request/Response support
9	Edge Management	Siemens Industrial Edge Management System
11	Cloud MES Service	Opcenter X
12	Production Lines – Time-Series Database	SIMATIC WinCC SCADA Systems, Insights Hub TimeSeries Services, SIMATIC Process Historian
13	Information Model Library	Asset Library in Asset Manager in sync with on-prem located Industrial Information Hub and compliant to the OPC UA PubSub model
14	Product Database	Teamcenter X
15	Dashboards	Dashboard Designer, Business Intelligence. Turn key apps for Energy-, Performance- and DriveTrain Analytics available.
16	AI-Assisted Analytics	Range from Production Copilot, custom Agents and their Skills to out of the box AI industry solutions like Quality Prediction, Senseye for maintenance, Energy Optimizer to custom AI model development and management in Predictive Learning (via Python), SiePA, gPROMS, SIMATIC easSie, Drivetrain Analyzer (DTA) X-Tools
17	Asset Admin Shell Library	Translation Service from Asset Management to AAS
18	Dataspace Connector Provider	Policy Based Access Control and cross-tenancy sharing via contracts allows to share data
19	Connected Product – Time-Series Database	Insights Hub – Timeseries Services (raw & aggregated) and Event Services based on machine data model. Including Remote Service option to securely connect to the machine for updates
20	Cloud to Edge Messaging App	MindConnect MQTT and OPC UA for messaging from the cloud to the edge via MQTT or RestAPI Opcenter Connect supports bi-directional cloud to edge communication
22	Dataspace Connector Consumer	via provided RestAPI Services Opcenter Connect, Active integration Gateway

OPC UA over MQTT – Interoperability for the Cloud Era

INTRO

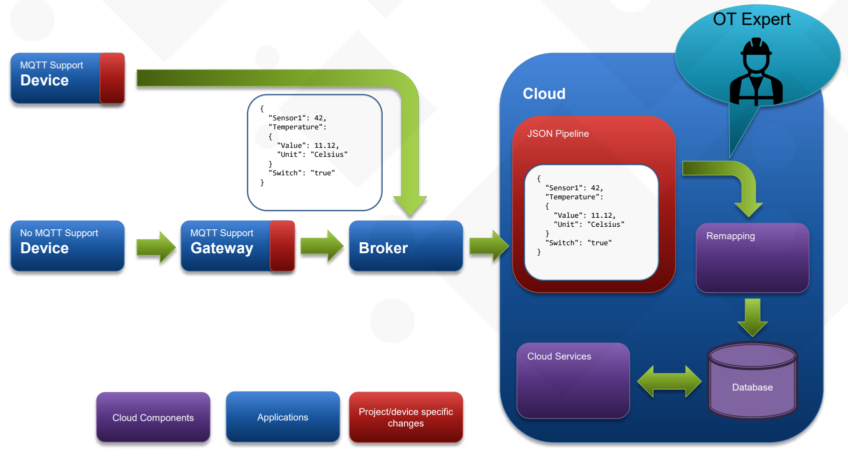
Industrial IoT projects often start with a simple goal: connect machines to the cloud. Many companies form cross-functional teams of OT experts and IT developers to bridge two worlds — operations and information technology. These teams quickly discover that connectivity and small pilots are easy, but interoperability and semantic consistency on a larger scale is hard.

MQTT is the transport of choice for many IoT architectures because it's lightweight and widely supported. However, MQTT, alone, doesn't solve the bigger problem: How do we ensure that data exchanged between OT and IT retains its meaning and context? Without a common standard, every vendor ends up defining their own payload format and topic tree, creating silos and complexity.

CHALLENGES

Many vendors today create their own MQTT payload formats and topic structures. This approach seems fast and easy but introduces severe risks:

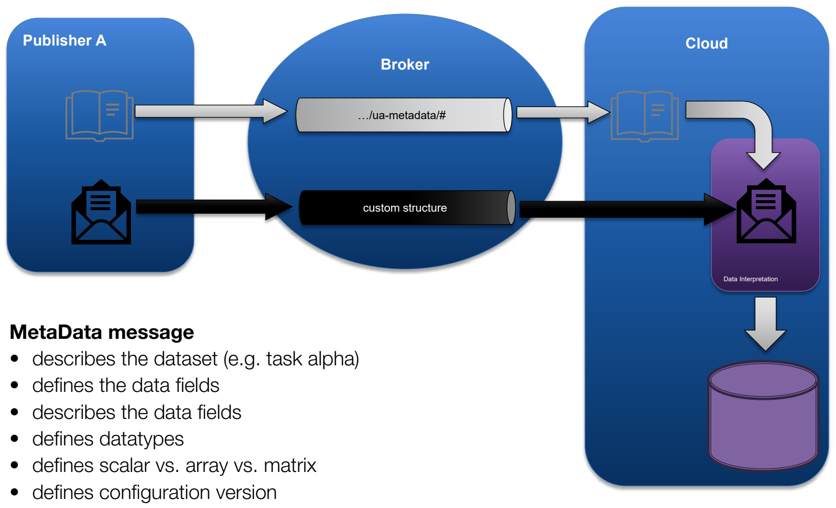
Everything is possible with JSON Pipelines



- **Vendor lock-in:** Device manufacturers, cloud providers or the system integrators dictate proprietary formats.
- **Breaking changes:** Updates to hardware, firmware, or software on either side of the OT or IT domain can disrupt integrations, requiring costly connector maintenance.
- **Lack of semantic interoperability:** Custom JSON pipelines may work, but they lack standardized meaning, making scaling and analytics difficult. In many cases, well-meaning integrators attempt to improve message structures between projects, unfortunately making every project unique, preventing cross-project interoperability.
- **Topic tree fragmentation:** Vendors often use different hierarchies, and not all follow ISA-95 strictly.
- **Loss of semantic information:** Companion specifications already define relationships and engineering context in OT systems. Customized transport payloads ignore this, forcing IT teams to "recreate" stripped-away context that was already known, which is rarely an error-free undertaking.
- **Limited availability of IT/OT experts:** Personnel who know the process and data relations, while understanding the IT systems, are scarce. Relying on them, to explain the details of every integration step to the rest of the team, slows projects and increases costs.

The result? A fragile system that is expensive to maintain and hard to scale. Don't forget what you already know. Reinventing semantics in JSON pipelines wastes effort and introduces risk.

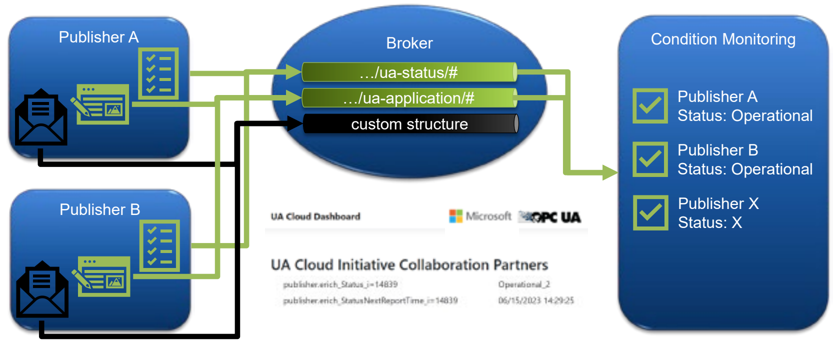
Data Discovery



MetaData message

- describes the dataset (e.g. task alpha)
- defines the data fields
- describes the data fields
- defines datatypes
- defines scalar vs. array vs. matrix
- defines configuration version

Use Case – Automatic publisher discovery



MORE INFO

Explore OPC UA over MQTT and the OPC Foundation Cloud Initiative:

OPC UA over MQTT
End-User counsel presentation

UA-IIoT Starter Kit on GitHub

OPC UA / OPC FOUNDATION SOLUTION

OPC UA over MQTT solves these issues by introducing:

- **Standardized payloads with semantic meaning:** OPC UA messages carry both data and metadata, ensuring interoperability.
- **Flexible topic tree for data messages:** Projects can define their own topic hierarchy while OPC UA mandates topic trees for essential messages like metadata, discovery, and status.
- **Message-based security:** OPC UA features data integrity and confidentiality by securing each message, end-to-end, from publisher to subscriber, reducing broker related risks.
- **Domain-agnostic design:** The same "OPC UA over MQTT" implementation works across manufacturing, process, and laboratory industries.

BENEFITS

- **Future-proof architecture:** No need for redevelopment – just reconfigure. Ease change from layered approach to UNS and back.
- **Reduced integration cost:** Eliminate custom connectors and vendor-specific mappings.
- **Scalability:** Works for small devices and large enterprise systems; and for one small project or for large systems with hundreds of sites and thousands of publishers.
- **Secure by design:** OPC UA allows for encryption, signing, and identity management beyond MQTT's TLS.
- **Interoperability across domains:** One standard for all – process, discrete manufacturing, and others, like labs.

OPC UA Web API Interface
Your Bridge from OT to IT

INTRODUCTION

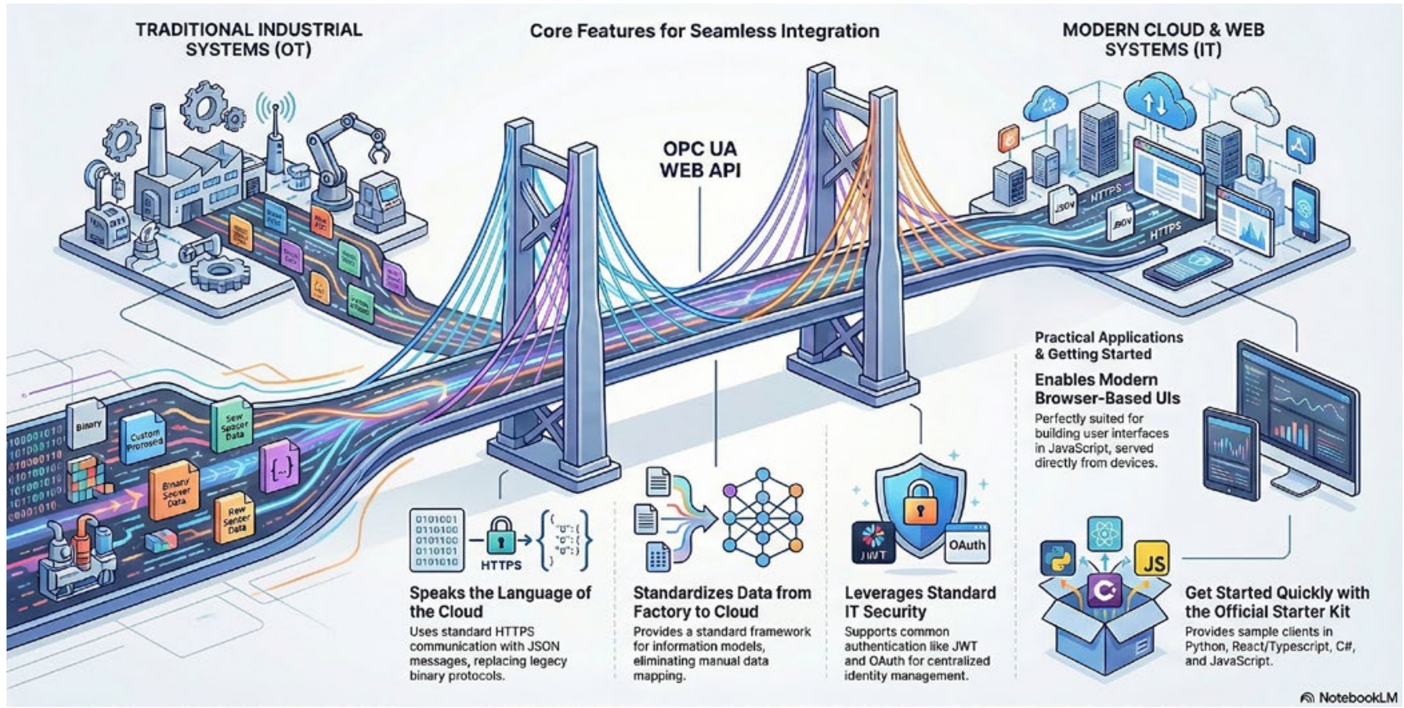
Traditional Operational Technology (OT) systems typically rely on binary network protocols to minimize network load and processing overhead. However, these protocols are often incompatible with Information Technology (IT) systems and Cloud environments.

The OPC UA Web API bridges this gap. As an IT-friendly variant of the OPC UA standard, it enables applications to communicate via HTTPS using JSON messages.

KEY ADVANTAGES:

- **Standardization:** It is formally defined with an OpenAPI schema; the industrystandard for documenting Web APIs.
- **Efficiency:** Developers can use familiar IT tooling to rapidly build and deploy OPC UA applications.
- **Connectivity:** By simplifying the integration of shop-floor data with enterprise systems, the OPC UA Web API serves as a foundational component of the Industrial Internet of Things (IIoT)

Your Bridge from OT to IT: The OPC UA Web API



END-TO-END INFORMATION MODELING WITH OPC UA

OPC UA is the only OT standard providing a unified framework for modeling information directly at its source. This model persists as data is collected and moved into higher-level systems, ensuring context remains intact throughout the information architecture and during the lifecycle.

By maintaining this “single source of truth”, the standard eliminates the need for manual data mapping once the information is stored in the cloud, significantly reducing integration time and the risk of configuration errors.

STANDARDIZING DATA STRUCTURES FOR THE CLOUD

Since most Cloud systems are optimized for JSON due to its simplicity and processing efficiency, the OPC UA Web API is designed to align OT data with modern IT requirements.

In addition to defining a JSON schema for standard services used to interact with servers, the API automatically generates JSON schemas for any DataType defined within an OPC UA information model. This provides a standardized mechanism for maintaining consistent data structures across a range of devices and manufacturers.

CENTRALIZED IDENTITY MANAGEMENT AND SECURITY

Authentication is key to the IIoT. The OPC UA Web API supports industry-standard IT authentication mechanisms, including JSON Web Tokens (JWT) and OAuth.

By leveraging these protocols, organizations can integrate OT security into centralized identity management systems. This alignment reduces the administrative overhead and costs associated with managing user identities across fragmented systems.

BROWSER-BASED UIs

The OPC UA Web API is ideally suited for developing modern, browser-based user interfaces using JavaScript. Its flexible communication architecture allows for real-time data exchange through two primary methods:

- **WebSockets:** The preferred method for high-performance subscriptions and real-time updates.
- **Long Polling:** A reliable fallback over standard HTTP for environments where WebSockets are not supported.

This versatility enables developers to build self-contained OPC UA servers that are bundled with their own web-based user interfaces, streamlining deployment and simplifying the user experience.

GETTING STARTED: THE OPC UA WEB API STARTER KIT

To accelerate adoption, the OPC Foundation has released an official Starter Kit. This resource allows developers to quickly implement and test the OPC UA Web API using simple examples.

The kit includes functional sample clients, developed in the most popular modern programming languages and frameworks:

- **Web & Frontend:** React/TypeScript and JavaScript
- **General Purpose:** Python and C#

You can access the repository and documentation here:

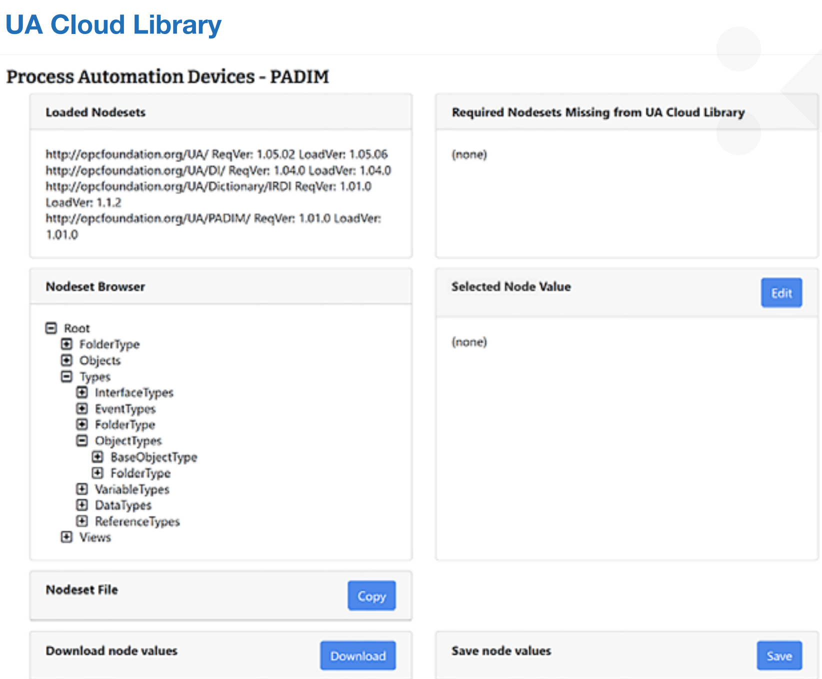
→ OPC Foundation UA-WebApi-StarterKit on GitHub
https://github.com/OPCFoundation/UA-WebApi-StarterKit

UA Cloud Library: The Semantic Backbone of OPC UA

The OPC Foundation accelerates interoperability of **OT and IT systems** using OPC UA – especially by making **OPC UA Information Models and Companion Specifications available everywhere.** UA Cloud Library is the global, queryable online repository for those models.

INTRODUCTION

Industrial data becomes truly reusable only when its meaning travels with it. OPC UA Information Models capture that meaning – assets, structure, types, relationships, and domain semantics. The UA Cloud Library brings these models into the cloud as a searchable, governed catalog, so edge or cloud applications and services can use standardized semantics across plants, vendors, and ecosystems.



SEMANTIC DATA MODELS IN THE CLOUD

Maintaining OPC UA Information Models and Companion Specifications in the cloud to utilize the context of data in edge or cloud services, is a core requirement for manufacturers. UA Cloud Library is the open, cloud-independent implementation of this requirement.

WHY SEMANTIC MODELS IN THE CLOUD MATTERS FOR OT/IT CONVERGENCE

- **Discovery happens too late, today.** Clients typically discover and learn a model only after browsing a live OPC UA server – too late for solution design and automation.
- **Onboarding & dashboards are slowed by "semantic guesswork".** Teams reverse engineer machine semantics asset-by-asset, tag-by-tag, delaying scalable edge and cloud analytics.
- **Companion Specifications are shared as files.** Sharing OPC UA Companion Specifications as files makes them hard to search, version, and reuse consistently across edge and cloud apps.
- **The cloud also needs cloud APIs.** The Cloud Initiative emphasizes cloud-scale interoperability, which also requires standardized application programming interfaces, identity, and automation – beyond what simple file downloads can provide.

THE SOLUTION

UA Cloud Library is the OPC Foundation's **standardized mechanism** to publish, find, and retrieve OPC UA Information Models on an Internet scale. It provides a mandatory **REST API** and a browser UI. The specification was developed by an OPC Foundation Joint Working Group with CESMII, and is available as an **open-source reference implementation**, as well as a **global instance hosted by** the OPC Foundation (https://uacloudlibrary.opcfoundation.org). In addition, many manufacturers host their own instance on the edge or in the cloud, leveraging the pre-built Docker container image, available free of charge from the OPC Foundation through the GitHub Container Registry.

WHAT IT ENABLES IN THE OPC FOUNDATION CLOUD INITIATIVE REFERENCE ARCHITECTURE

- **Design time semantics:** cloud apps can be configured using Companion Specifications before connecting to production assets, thus, facilitating offline engineering of the proposed instance.
- **Interoperable pipelines:** a shared model catalog supports consistent schemas and context across ingestion, storage, analytics, and AI apps in the cloud architecture.
- **Public + private ecosystems:** a public, global repository for community models and private instances for OEM/enterprise models – aligned with the OPC Foundation Cloud Initiative's openness and interoperability goals.
- **Host for OPC UA types and instances:** both OPC UA types and instances can be hosted in the OPC Foundation Cloud Initiative, paving the road for interoperability; not just for semantic metadata, but also for instances of for example, the Digital Product Passport (DPP).

BENEFITS

- **Build analytics earlier.** Set up dashboards and analytics pipelines during the design phase, well before connecting to the plant's assets for the first time.
- **Scale interoperability through reuse.** Reuse main-expert models to standardize semantics across assets, plants, partners, and cloud providers.
- **Reduce integration risk.** Simulate, test, and verify information models early—before the asset is even built.
- **Enable richer cloud context.** Full-fidelity information models in the cloud support deeper semantic enrichment than telemetry metadata alone (e.g., for time series and analytics engines).

MORE INFORMATION

- **OPC Foundation Cloud Initiative overview:** https://opcfoundation.org/cloud
- **Overview & use cases:** https://opcfoundation.org/markets-collaboration/cloudlib
- **Public instance:** https://uacloudlibrary.opcfoundation.org
- **Open-source reference implementation:** https://github.com/OPCFoundation/UA-CloudLibrary
- **Example cloud integration:** https://learn.microsoft.com/en-us/azure/iot/tutorial-iot-industrial-solution-architecture#ua-cloud-library

UA Cloud Library is one of the OPC Foundation's open, standardized building blocks – supporting cloud scale interoperability without vendor lock in.

OPC Foundation NodeSet Editor – Model. Share. Scale.

INTRO

The OPC Foundation offers the NodeSet Editor at no cost, empowering anyone to build new NodeSets and contribute to the development of standards for a rapidly expanding industry. The OPC NodeSet Editor is a web-based tool that enables manufacturers, machine builders, and system integrators to create structured information models. These models, known as NodeSets, allow for the seamless movement of "data-in-context" from the factory floor to the cloud.

WHAT CHALLENGES WILL BE ADDRESSED WITH THE NODESETS EDITOR?

The OPC Foundation NodeSet Editor, as a free-of-charge offering, enables manufacturers and system integrators alike to quickly achieve true industrial interoperability.

Today's challenges stem from the lack of a standardized semantic layer for industrial data:

1. Data Context Gap

- **Unstructured Telemetry:** Without profiles, data typically moves from the edge as "flat" streams of numbers (e.g., Tag_01: 45.2).
- **Manual Translation:** Engineers must manually document and map what each tag represents (temperature, pressure, etc.) for every single application, leading to a massive "context gap" between the source and consumption.

2. Fragmented Information Silos

- **Custom "One-Off" Integrations:** Systems are built using proprietary code to bridge specific hardware to specific apps.
- **Lack of Reusability:** Because these integrations are custom-coded, rather than class-based, they cannot be easily reused for different machines or across different factory sites.

3. Complex Relationship Mapping

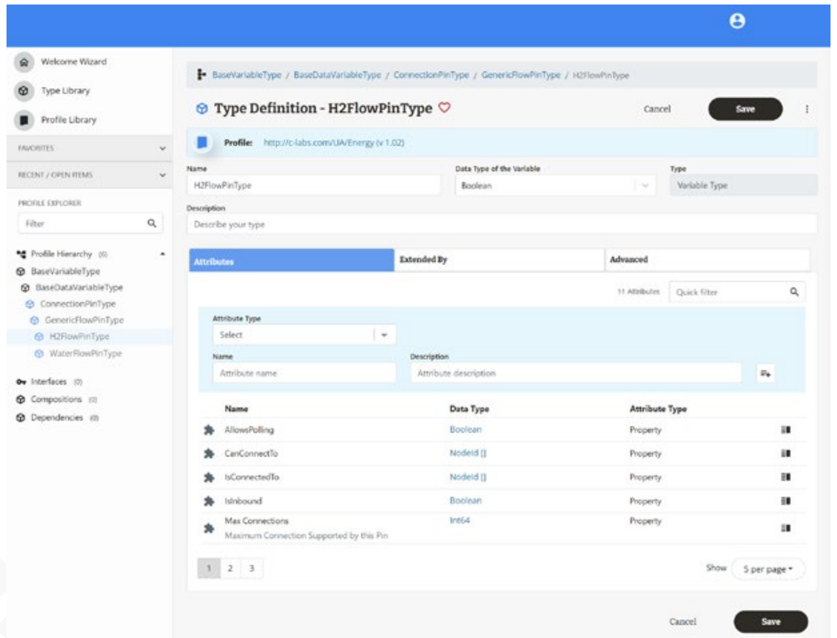
- **Flat Data Models:** Without the OPC UA-based constructs of the NodeSets (inheritance, aggregation, and dependency), it is difficult to represent complex equipment hierarchies.
- **Scale Limitations:** Modeling an entire production line or supply chain becomes exponentially more difficult when you cannot define relationships between individual machine models.

4. Vendor Lock-in and Protocol Friction

- **Interface Incompatibility:** Without universal, reusable data access interfaces, you are often limited to the specific data structures provided by the hardware vendor.
- **Programming Overhead:** Every time a new device is added, developers must build a new abstraction layer to handle communication protocols, rather than simply downloading a "driver" or NodeSet from the OPC Cloud Library

5. Limited "Plug & Play" Capability

- **Software Rigidity:** Applications cannot "learn" or adapt to changes in the hardware environment automatically.
- **Slow Deployment:** The absence of crowd-sourced, standardized NodeSet means experts must spend weeks defining asset attributes from scratch instead of building upon established OPC UA standards.



WHAT IS A NODESET?

An NodeSet is a digital twin extension – a class definition describing a piece of equipment, a process, or a manufactured good. It serves as a standardized "Contract" that allows different applications to understand and act on data without custom coding for every new device.

KEY BENEFITS

- **Eliminate Data Silos:** Move data seamlessly between the edge, the cloud, and third-party apps.
- **Rapid Integration:** Use "Plug & Play" capabilities for industrial assets.
- **Crowd-Sourced Intelligence:** Build upon existing NodeSets from the OPC Foundation or other industry leaders and an active OPC UA community.
- **Universal Reusability:** Create a NodeSet once and deploy it across multiple sites or systems.

ENGINEERED FOR PRECISION

The NodeSet Editor utilizes familiar modeling constructs to define complex manufacturing environments:

- **Object-Oriented Design:** Create relationships using inheritance, aggregation, and dependency (similar to UML).
- **Structured Attributes:** Map equipment specs, operating inputs, and measured outputs (e.g., Temperature, Vibration, Load).
- **Process Modeling:** Go beyond individual machines to model entire production lines and supply chains.

HOW THE TOOLCHAIN WORKS

1. **Design:** Use the NodeSet Editor to create or customize an information model.
2. **Publish:** Submit your NodeSet to the UA Cloud Library
3. **Implement:** Download and import NodeSet into your OPC UA Server and Client implementations.
4. **Analyze:** Connect your standardized OPC UA data and your devices and services to apps for predictive maintenance, health monitoring, and energy optimization.

GET STARTED TODAY

Join the community of innovators standardizing the future of industry.

- **Access the Tool:** https://uanodeseteditor.opcfoundation.org
- **Learn More:** Explore Technology Resources including code samples and demos.
- **Join the OPC Foundation:** Become an OPC Foundation Member and participate in working groups that define NodeSet standards.

TECHNICAL RESOURCES FOR DEVELOPERS

- **Free Open-source** https://github.com/OPCFoundation/UA-NodesetEditor
- **API Documentation:** Comprehensive guides for interacting with the OPC Foundation NodeSet Editor.
- **Sample Code:** Implementations for rapid prototyping.
- **Demos:** Real-world examples of NodeSet instances in action.

UA Edge Translator – AI-assisted, standardized connectivity for automatic asset onboarding

THE BROWNFIELD REALITY

Industrial IoT projects rarely start with a clean slate. Most plants and facilities run a heterogeneous fleet of non OPC UA assets, energy meters, drives, HVAC, PLCs, building systems, legacy machines with a simple Modbus interface, etc. Each asset usually comes with its own protocol and (too often) its own proprietary data model. The recurring pain point is the manual, tag by tag onboarding and the vendor specific configuration surfaces that slow down OT/IT convergence and create long term vendor lock in.
UA Edge Translator directly targets this bottleneck: it is an open source edge application that translates from proprietary protocols to OPC UA, so data becomes available through a standardized OPC UA information model, ideally aligned with established OPC UA Companion Specifications rather than bespoke, custom data models.

ENABLING AUTOMATIC ASSET ONBOARDING

UA Edge Translator is using W3C Web of Things (WoT) Thing Descriptions as the standardized way to describe the asset interface and its tag structure, delivered and controlled via the OPC UA WoT Connectivity Companion Specification. This design choice is intentional: It replaces all proprietary gateway configuration methods with one configuration file format built on the open WoT standard and doesn't even require a UI.

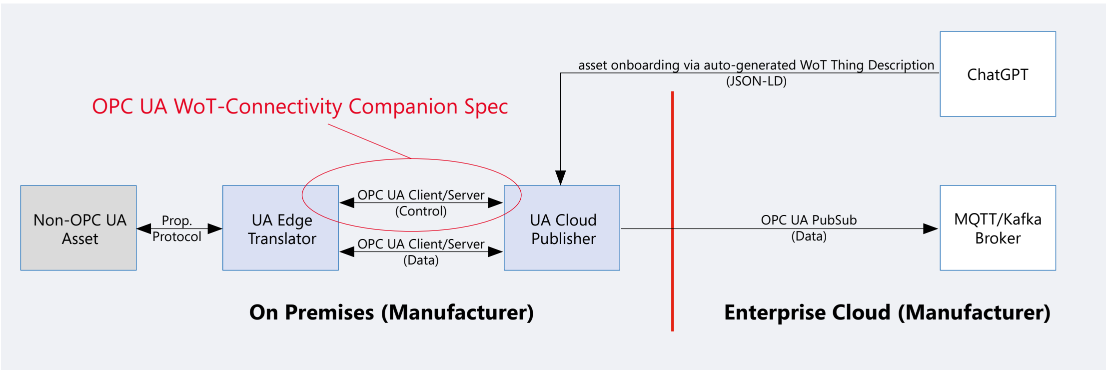
W3C WOT THING DESCRIPTIONS AS THE STANDARDIZED ASSET DESCRIPTION

At the heart of UA Edge Translator is the WoT Thing Description (TD), a JSON LD document that captures an asset's metadata: what data it exposes, how to access it (protocol endpoints), how payloads are shaped, and what security mechanisms apply. The WoT specification positions the TD as a central building block, describing the device instance and how to interact with it. Because WoT is protocol agnostic and relies on binding templates to express protocol specifics, a TD can represent any industrial protocol in a consistent properties/actions/events model.
In practical UA Edge Translator usage, the TD becomes the portable onboarding artifact: instead of configuring a gateway UI register by register, you provide a single standards based document describing the asset's tags and access details. The workflow simply becomes:

- **a. Download the asset's WoT file (or generate it using AI)**
- **b. Validate/edit it**
- **c. Onboard the asset in one shot**

WOT CONNECTIVITY: THE OPC UA CONTROL PLANE FOR STANDARDIZED ONBOARDING

A common challenge in gateway products is that, even if they expose OPC UA data northbound, the control plane (configuration, provisioning, onboarding) is often proprietary (frequently REST). UA Edge Translator takes a different approach: it uses OPC UA not only for data access, but also for configuration via the WoT Connectivity Companion Specification.
The specification defines methods such as CreateAsset, DeleteAsset, and (optionally) DiscoverAssets, CreateAssetForEndpoint, and ConnectionTest, enabling a uniform, vendor neutral onboarding API for industrial connectivity software.



HOW IT WORKS

The story is simple and repeatable:

1. Describe the asset using a WoT TD. This can be authored manually, generated by AI, or even derived from vendor documentation workflows.
2. Send the WoT TD to UA Edge Translator using the standardized WoT Connectivity OPC UA interface (e.g. CreateAsset plus the standard OPC UA file handling model defined in the specification).
3. UA Edge Translator connects to the asset and exposes its data through an OPC UA server interface, mapped to OPC UA built in types and/or types loaded dynamically from OPC UA Companion Specs.

SEMANTICS AT SCALE: OPC UA COMPANION SPECS + UA CLOUD LIBRARY

A unique strength of UA Edge Translator in the OPC Foundation ecosystem is its direct connection to the OPC UA information model landscape. The goal is not merely protocol conversion. It is conversion into an OPC UA information model that can carry semantic meaning. UA Edge Translator is part of a broader OPC Foundation Cloud Initiative reference stack and loads Companion Specs from the UA Cloud Library on demand (with options to locally load models when connectivity is constrained).

UA Edge Translator is the Cloud Initiative's standardized on ramp for brownfield assets, turning diverse protocols into a consistent OPC UA data model and interface with a standards based onboarding file and API. It connects edge onboarding to cloud ready semantics. When the edge normalizes data to recognized information models, downstream analytics pipelines can reduce costly remodeling and avoid brittle, one off transformations.

DEPLOYMENT AND PROTOCOL COVERAGE

UA Edge Translator is a containerized, MIT-licensed open source reference implementation and includes a wide set of southbound drivers (including Modbus TCP & RTU, BACnet, HTTP, IEC 61850, S7Comm, Ethernet/IP, Mitsubishi MC, Beckhoff ADS, LoRaWAN, Matter and OCPP).

KEY BENEFITS

- **Accelerated onboarding and reduced engineering effort:** Automatic asset onboarding eliminates manual tag mapping by using a standardized file format (WoT TD) and a standardized onboarding API (WoT Connectivity).
- **Vendor neutral configuration:** WoT Connectivity provides a thin interface in top of existing OPC UA server interfaces for configuring industrial connectivity software in a standardized way, accelerating industry adoption by keeping the interface minimal.
- **Semantic interoperability:** UA Edge Translator's design emphasizes mapping into OPC UA information models and Companion Specs (optionally via UA Cloud Library) so that data is normalized at the edge, close to the asset, and ready for downstream processing.
- **Unified control & data plane with OPC UA:** Schema delivery and configuration leverage OPC UA, using OPC UA for both the control plane and data plane where many other approaches rely on proprietary REST for control.

Industrial Connectivity Solutions Criteria for Industrial Gateways

OPC UA IS NOT A CHECKBOX: SPECIFY THE CAPABILITIES YOU EXPECT FROM INDUSTRIAL CONNECTIVITY PARTNERS

Industrial manufacturers often ask their suppliers and connectivity vendors a simple question: "Do you support OPC UA?" The problem is that this yes/no simplification hides the real business risk of integrating a vendor's product. In practice, OPC UA support spans a wide range of features, transports, information modeling depth, security postures, and cloud-readiness. Treating OPC UA as a checkbox often leads to costly rework later: semantic gaps, brittle integration layers, missing governance, and "UA in name only" implementations that cannot scale across plants, lines, and fleets.

The OPC Foundation Cloud Initiative exists to accelerate interoperability between OT, IT, and cloud applications, by promoting consistent use of OPC UA Companion Specifications, cloud-optimized approaches, and reuse of information models through the UA Cloud Library. When you procure industrial connectivity from a vendor, you are not buying a protocol, you are buying a set of behaviors and guarantees that determine whether you can build reliable analytics pipelines, semantically-rich applications, and cross-site data products.

WHY THE "CHECKBOX" APPROACH FAILS

A vendor can claim "OPC UA support" while still leaving you with:

- Flat, tag-only exposure with little or no semantic structure (hard to reuse across assets).
- Limited write/control capabilities, or no method invocation (no actionability).
- No support for standard domain models, leading to one-off mappings per site.
- Weak cloud alignment (no consistent way to pre-stage semantics, validate models, or onboard assets at scale).
- Integration debt: every new asset becomes a bespoke project.

The better question is: **Which OPC UA features, and which interoperability outcomes, do we require for our use cases?** One pragmatic approach is to ask vendors to answer a short, explicit capability checklist (yes/no) that aligns to your architecture and operating model.

BOTTOM LINE

OPC UA is the foundation, but interoperability is the finished building. Manufacturers that succeed will be those who require specific features (semantics, onboarding, cloud model reuse, actionability, and life-cycle operations) and hold partners accountable to those capabilities. In doing so, you move from "connected" to repeatable, secure, semantically consistent industrial data products. The core promise of the OPC Foundation Cloud Initiative.

Industrial Connectivity Software OPC UA Support

Requirement	OPC Foundation UA-Edge Translator	Beckhoff TwinCAT OPC UA	CopaData Zenon	Inray OPC Router	Inray pronubes	Kepware Edge	Matrikon Data Broker	Mitsubishi Electric Genesis	Prosys OPC Forge	Rockwell FT Optix	Rockwell FT Linx	Siemens IIH Semantics	Siemens ONEconnectivity	Softing SDEX Suite
Provide an OPC UA server interface for us for the data plane. Alternatively, OPC UA PubSub via MQTT must be supported.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secure its OPC UA server endpoint using sign & encrypt security.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Must run in a Linux Container.	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓
Map asset data tags to OPC UA for reading/ publishing tags.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Map asset data tags to OPC UA for writing tags.	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓
Map asset commands to OPC UA methods.	✓	✓	✗	✓	✓	✗	✗	✗	✓	✓	✓	✓	✗	✗
Must support both AMD64 and ARM64 CPUs	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✗	✓	✓
Setup a tag hierarchy using OPC UA folders to be able to logically group asset tags and avoid all asset tags ending up in a flat list.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
Support zero data loss on north-bound connection interruptions.	✓	✓	✓	✓	✓	✗	✓	✗	✓	✗	✗	✗	✓	✗
Supports parsing of W3C Web of Things Thing Descriptions (asset descriptions).	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗
Supports the WoT-Connectivity interface.	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗
Must map each connected asset into a separate OPC UA namespace for easy identification of "which asset tag belongs to which asset" in the Cloud.	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✗	✓	✗	✓
Must be able to map asset tags to OPC UA types defined in OPC UA Companion Specs.	✓	✓	✗	✓	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓
Supports downloading OPC UA Companion Specs from the UA Cloud Library.	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗
Must be able to map asset tags to OPC UA Complex Types (Extension Objects).	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✗	✗	✗	✓

Digital Product Passports (DPP): EU Regulations Powered by OPC UA

Across manufacturing, a new expectation is taking hold: every physical product must be accompanied by a trusted, machine-readable "digital identity" that can be shared across the value chain, from suppliers and factories to customers, recyclers, and regulators. That identity is the Digital Product Passport (DPP), introduced as part of the EU's broader push to make sustainable products the norm and to strengthen circularity, transparency, and market surveillance. For manufacturers, DPP is not just another reporting artifact. It is becoming a new digital infrastructure requirement, one that demands consistency, interoperability, data quality, and long-term maintainability across complex supply chains and heterogeneous OT/IT landscapes.

THE REAL-WORLD CHALLENGES MANUFACTURERS FACE

Most manufacturers are already collecting a wealth of product and process data, but DPP asks for more than "data availability." It demands data readiness: structured, contextualized, and interoperable information that can be exchanged reliably across organizational boundaries.

- **Fragmented data across systems and suppliers**
  Product-relevant information is spread across engineering systems, MES, ERP, quality systems, supplier portals, and often spreadsheets. DPP requires that this data becomes discoverable, composable, and shareable in a consistent way, without forcing every supplier and customer to adopt the same proprietary platform.

- **Interoperability isn't just "format" – it's meaning**
  A major obstacle in supply-chain transparency is that the same term (e.g., "material content," "PCF," "hazardous substance") can be represented differently across domains, tools, and regions. DPP needs semantic interoperability, i.e. shared meaning, not just shared files.

- **Compliance must scale from pilots to product lines**
  Many organizations can build a DPP pilot, but few can scale it across product families and global supply chains while maintaining governance, auditability, and maintainability.

- **A "web-native" access layer is required**
  DPP ecosystems increasingly depend on web and cloud integration patterns. Traditional OT protocols alone aren't sufficient for external-facing, cross-company integration.

THE SOLUTION: DPP COMPLIANCE, DELIVERED AS AN INTEROPERABLE ARCHITECTURE

The OPC Foundation Cloud Initiative brings cloud providers, automation suppliers, and manufacturers together around a practical mission: make industrial cloud interoperability real, and do it with open, standardized building blocks. The initiative explicitly includes traceability use cases such as DPP and positions OPC UA information modeling and interfaces as the core enablers.

AT A HIGH LEVEL, THE JOINT SOLUTION FOR DPP COMPLIANCE CAN BE UNDERSTOOD AS FOUR LAYERS:

1. **Common Semantics: OPC UA Information Models**
   DPP needs consistent product semantics – what data fields mean, how they relate, and how they are validated. The Cloud Initiative uses OPC UA Information Models at "design time" so systems can be configured and aligned before connecting to production assets and enterprise workflows.

2. **Common Interfaces: OPC UA & DPP via REST**
   To integrate DPP with enterprise and cloud applications, OPC UA includes standardized REST access patterns. It is a way for applications to access OPC UA information models, supporting cloud-oriented integration. This matters because DPP implementations typically need automated data ingestion from manufacturing and supplier systems, controlled, role-based access for downstream partners, and integration with business applications and services that speak "web." In addition, DPP REST provides a standards-based bridge between industrial semantics and cloud-native consumption patterns.

3. **Common Discovery & Reuse: UA Cloud Library**
   A scalable DPP ecosystem requires not only definitions, but reusable, discoverable digital assets – the templates, data structures, and information models that can be adopted across industries and suppliers. The UA Cloud Library is the standardized mechanism to publish, find, and retrieve OPC UA Information Models at internet scale, including a mandatory REST API and reference implementation. This directly supports DPP rollouts by enabling manufacturers and suppliers to align on shared models rather than reinventing them repeatedly.

4. **Cross-Company Exchange: Dataspaces and Supply-Chain Interoperability**
   DPP is rarely a single-company problem; it is an ecosystem problem. The OPC Foundation Cloud Initiative's reference architecture explicitly situates DPP alongside data sharing patterns and dataspaces, showing DPP as part of a broader interoperable industrial cloud approach.

BENEFITS TO MANUFACTURERS: WHY OPC UA TURNS DPP FROM BURDEN TO BUSINESS VALUE

- **Faster time-to-compliance with less rework**
  By grounding DPP data in standardized information models and standardized interfaces, manufacturers reduce "one-off integration" and avoid building bespoke mappings for each customer, supplier, or regulatory channel. The OPC Foundation Cloud Initiative's focus on reference architectures and cloud interoperability is designed to accelerate adoption and reduce duplication.

- **Higher data quality and auditability through semantics**
  DPP requires trust. Data must be attributable, consistent, and interpretable. OPC UA information models provide structured context – helping ensure that the meaning of a reported value remains consistent across systems, rather than being lost in translation between documents and portals.

- **Interoperability that scales across multi-cloud and multi-vendor ecosystems**
  Manufacturers rarely operate in a single-vendor world – especially across global supply chains. The OPC Foundation Cloud Initiative is explicitly oriented toward vendor-neutral interoperability for IT and cloud applications using OPC UA.

- **Lower integration costs by using web-native standards without losing industrial rigor**
  OPC UA and DPP REST allows cloud and enterprise developers to use familiar web patterns while still consuming industrial-grade semantics and metadata.

- **Better customer experience: transparency without exposing IP**
  A well-designed DPP must provide different views for different roles – customers, recyclers, regulators, partners – without exposing sensitive internal know-how. DPP's "information access" requirement becomes far easier to manage when product data is consistently structured and delivered through standardized interfaces that can be integrated with governance and access control approaches used in enterprise and cloud environments.

OPC Foundation & Catena-X: Turning Industrial Data Sharing into a Competitive Advantage

Manufacturers are entering an era where trusted, machine-readable product data isn't just "nice to have" anymore. It's becoming a market expectation, especially with EU-driven requirements, like the Digital Product Passport (DPP). In that context, the strategic collaboration between Catena-X Automotive Network and the OPC Foundation is a practical way to accelerate standardized, cross-company data sharing, without forcing companies to rip-and-replace what already works.

At a high level, this partnership connects two proven ecosystems: Catena-X, which provides a collaborative dataspace approach for the automotive supply-chain and the OPC Foundation's OPC UA modelling language and tools. The aim is straightforward: make industrial data exchange simple, trustworthy, and ready for upcoming compliance and supply-chain demands.

THE BIG PROMISE: FROM "DATA EXISTS" TO "DATA DELIVERS"

The Catena-X + OPC Foundation collaboration is defined to make data sharing actionable by focusing on four concrete cooperation areas: semantic integration, open-source implementations, reference architecture alignment, and industrial ecosystem enablement. This reduces the friction that typically slows down cross-company data sharing, so manufacturers can move faster from pilots to production value.

WHAT'S HOLDING MANUFACTURERS BACK TODAY?

- **"We can exchange data… but can we trust and understand it?"**
  In real supply chains, "interoperability" fails most often at the semantic layer. Different definitions, different structures, different interpretations. The partnership explicitly targets this with semantic integration, combining OPC UA information modelling with Catena-X semantic templates to create interoperable, machine-readable models and support automated DPP generation from production data.

Catena-X and OPC Foundation Whitepaper

Download Whitepaper here:

See Webinar here:

- **"Shopfloor data isn't dataspace-ready"**
  Manufacturers don't just need data transfer. They need data that's structured and contextualized. "We do more than just provide data for the data space. We model it… From the shop floor to the cloud – a seamless data modelling experience using open standards." This brings OT reality to supply-chain scale.

- **"Scaling onboarding across suppliers is the real cost"**
  Dataspace leaders acknowledge that the biggest challenge is often adoption and support, not raw infrastructure. Cost is frequently more about manpower and supporting users than infrastructure optimization. This collaboration directly answers that pain-point via reusable semantics and open-source building blocks, designed to lower the effort for onboarding at scale.

THE JOINT SOLUTION

Semantic Integration:
"One model you can reuse everywhere"
The collaboration first unified modeling strengths: OPC UA's information modeling plus Catena-X semantic templates, creating a strong foundation for interoperable, machine-readable models and automated DPP generation. A key enabler here is the UA Cloud Library, the OPC Foundation's standardized mechanism to publish, find, and retrieve OPC UA Information Models on an Internet scale, including a standardized REST API and browser UI. This matters because it turns models into reusable digital assets rather than one-off project artifacts.

Open-Source Reference Implementations:
"Faster starts; lower risk"
The partnership commits to jointly developing and providing open-source reference implementations for key dataspace and interoperability components, making it easier to integrate OPC UA-based systems into the Catena-X data ecosystem. This accelerates adoption velocity: give implementers something tangible to build on.

Reference Architecture Alignment:
"Deploy from shopfloor to supply chain with a clear blueprint"
The collaboration aligned the OPC Foundation Cloud Initiative reference architecture with Catena-X dataspace architecture so deployments can be streamlined from the shopfloor to the supply chain. Data spaces are now part of a broader industrial cloud interoperability standardization effort.

Industrial Ecosystem Enablement:
"Use what you already have, and meet what's coming"
Finally, the partnership enables companies to leverage their existing OPC UA tools and infrastructure to meet regulatory requirements (especially DPP), while reducing integration costs and accelerating time to compliance. This is a "value unlock" message manufacturers understand: preserve past investments while meeting future obligations.

THE BENEFITS FOR MANUFACTURERS

✅ **Compliance readiness that doesn't feel like a compliance tax**
The partnership is explicitly framed around supporting DPP requirements by enabling trusted, machine-readable product data across value chains. With semantic alignment and architecture guidance, the intent is to move toward repeatable, governed data exchange, rather than ad-hoc evidence collection.

✅ **Less friction, fewer errors, more confidence**
Simplifying data integration and reducing reporting errors by aligning OPC UA modeling with Catena-X governance and infrastructure is a strong promise for any manufacturer trying to standardize supplier reporting.

✅ **A practical bridge from OT data to cross-company value**
OPC UA is a key modeling tool for Catena-X and industrial data spaces, enabling a seamless modeling experience using open standards from shopfloor to cloud. That's the difference between "we have data" and "we can use data across partners."

From Interoperability to Data Sovereignty: OPC UA for Industrial Data Spaces

INTERNATIONAL DATA SPACES ASSOCIATION

INTRO

OPC UA has become the standard for platform independent interoperable industrial digitalization, connecting assets from the shop floor to enterprise and cloud systems. Its success is based on three core principles: rich semantic information modelling, extendable transport, and built-in by design cybersecurity (for both access of information and transport). Today, millions of industrial devices expose structured, machine-readable data via OPC UA, using standardized Companion Specifications across industries.

As digital transformation progresses, industrial data is no longer consumed only within a single factory or company. Increasingly, value is created when data is shared across organizational boundaries – between manufacturers, suppliers, service providers, customers, and regulators. Typical use cases include supply-chain transparency, condition-based services, Digital Product Passports, sustainability reporting, and AI-driven optimization across value networks.

This shift introduces new requirements that go beyond connectivity and semantics. Companies must be able to share data without losing control, define usage conditions, and establish trust across heterogeneous ecosystems. This is where Industrial Data Spaces come into play.

The groundwork for data spaces has been shaped significantly by the International Data Spaces Association (IDSA), whose consensus-driven framework established widely recognized principles for trustworthy, sovereign and interoperable data sharing.

From an OPC UA perspective, data spaces are not a replacement for existing industrial standards. Instead, they complement OPC UA–based infrastructures by providing the governance and trust structures needed when data sharing extends beyond a single organization.

CHALLENGES

OPC UA already solves many core interoperability challenges in industrial systems. However, when OPC UA-based data leaves the boundaries of a single organization, new challenges arise:

1. **Cross-company data sharing at scale**
   OPC UA enables standardized access to data, but traditional client/server or cloud ingestion approaches assume a single legal environment. When multiple independent companies are involved, additional mechanisms are required to establish rules for data sharing dynamically and at scale.

2. **Data sovereignty beyond access control**
   Industrial stakeholders often need more than simple read/write permissions. They must specify how data may be used, for what purpose, for how long, and by whom. These requirements go beyond classic security models and are not addressed by information exchange technologies like OPC UA alone.

3. **Platform-neutral data exchange**
   While OPC UA provides platform-independent semantics, data is often consumed within specific cloud platforms or applications. Cross-platform, ecosystem-wide data exchange requires a neutral framework that prevents vendor lock-in while preserving OPC UA semantics.

4. **Regulatory and ecosystem requirements**
   Initiatives such as Digital Product Passports, Manufacturing-X, and sustainability reporting require standardized, traceable, and auditable data sharing across entire value chains. Implementing these requirements manually for each partner does not scale.

These challenges are not limitations of OPC UA itself, but rather indicators that an additional architectural layer is needed when OPC UA data is shared beyond enterprise boundaries.

SOLUTIONS

Data Spaces as an extension to OPC UA architectures

Building on the data space principles established by IDSA, a data space is a federated data-sharing framework that governs how data is exchanged between independent participants.

In this architecture, OPC UA continues to provide:

- standardized information models,
- semantic context via Companion Specifications or information model templates provided by specific data space verticals like the automotive industry
- secure and reliable data access from devices, machines, and systems.

The data space layer adds:

- sovereign data sharing, ensuring data owners retain control,
- usage policies, attached to data
- enforced technically through trusted connectors, enabling peer-to-peer exchange without central data ownership.

OPC UA as the semantic foundation of data spaces

Data spaces rely on meaningful, machine-interpretable data. OPC UA provides exactly this through its information modeling framework. By sharing OPC UA-modeled data within a data space, participants ensure that data consumers correctly understand structure, meaning, and context—across vendors, industries, and domains.

This semantic consistency is essential for automated data processing, cross-company analytics, AI and machine learning, digital twin federation, and regulatory reporting.

Without OPC UA semantics, data spaces would risk becoming mere file or payload exchange mechanisms. OPC UA turns them into interoperable industrial ecosystems.

Integration into the OPC Foundation Cloud Initiative

The OPC Foundation Cloud Initiative integrates the concepts and characteristics of data spaces as defined by IDSA into a cloud-native OPC UA reference architecture. OPC UA over MQTT, and OPC UA REST/Open Web API Interfaces enable scalable data ingestion from edge and enterprise systems, while dataspace connectors manage cross-company exchange.

In this model:

- OPC UA remains the authoritative source of industrial truth,
- cloud platforms process and analyze OPC UA data,
- data spaces govern who can access which OPC UA data and under which conditions.

This separation of concerns preserves existing OPC UA investments while enabling new ecosystem-level use cases.

Enabling new industrial business models

By combining OPC UA with data spaces, companies can safely participate in multi-partner data ecosystems. This enables collaborative optimization across supply chains, data-driven services without exposing sensitive know-how, and monetization of high-quality industrial data and compliance with emerging regulatory frameworks.

Importantly, this approach is inclusive: SMEs can participate using the same OPC UA standards already deployed on their machines, without the need for proprietary platforms or learning new tools.

LINKS

- **OPC Foundation Cloud Initiative**
  https://www.opcfoundation.org/cloud
- **OPC UA and IDSA:**
  Interview with Lars Nagel, CEO IDSA
  https://opcfoundation.org/resources/podcast/
- **International Data Spaces Association (IDSA)**
  https://internationaldataspaces.org

From Hype to Reliability: How OPC UA Enables AI in Industrial Automation

INTRO

Recent advancements in Artificial Intelligence and, specifically, the creation of Generative AI and Large Language models, indicate that these technologies can be useful in industrial and process automation. To reliably produce correct results, AI needs additional domain-specific information and the semantic interoperability that OPC UA provides is the missing piece of information that helps to create reliable and useful AI systems to interact with production equipment. AI can also help accelerate the adoption of OPC UA by supporting software development and data analysis.

CHALLENGES

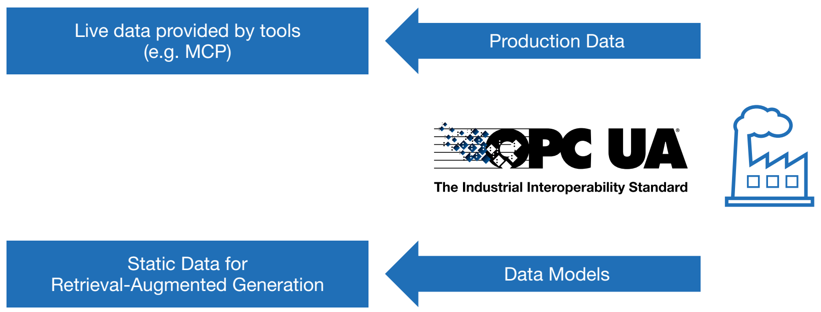
Generative AI, Large Language Models, and interactive consumer applications like ChatGPT have convinced the public that true Artificial Intelligence is now commercially available and, by passing tests such as the Turing test and even complex academic examinations, have created the appearance of superhuman capabilities available for free, or for a small monthly fee. But at the same time, challenges in reliability have surfaced, ranging from amusing errors in image generation and text production to convincing but wrong answers in critical areas such as legal or medical advice. While new and more capable models are created at an amazing pace, users in critical areas such as factory automation remain hesitant to rely too much on AI.

Especially in the domain of software engineering, code-generating AI systems have already proven to be useful under human supervision, e.g., for supporting experts in tedious tasks such as generating simple code pieces for interacting with existing APIs, rewriting and updating legacy code bases, or transforming software systems from one programming language to another.

While industrial automation is a domain with similar challenges, the existing models lack the deep domain knowledge needed to interact with automation systems. They also lack knowledge about the typical use cases in factory automation as these are not well represented in existing training datasets that focus more on other domains such as web sites or cloud computing. This is reflected in the programming languages such as JavaScript that are best supported by AI models.

To address these challenges, the working group has started to develop documentation and software examples that allow AI models to understand OPC UA and to facilitate the interaction between AI applications and OPC UA Servers.

Use of OPC UA in AI applications for acquiring data from production systems



BENEFITS

Providing machine readable versions of the OPC UA Specifications allows AI models to be informed about OPC UA

- OPC Foundation Specifications provided in simple markdown text formats can be used to train or retrain language models based on generative AI. This enhances the quality of the results produced by these models
- As part of retrieval-augmented generation, relevant sections of OPC Specifications can be identified and added to the context window of LLMs, thereby informing the models about specific parts of the specification that should be taken into account when answering specific questions. As information contained in the context has a higher probability to be used in generating the answer, this increases overall response quality.
- Providing AI applications with methods to access OPC UA based data sources through access mechanisms such as the Model Context Protocol (MCP) allows these applications to not only use static documentation but also request current information from running OPC UA servers, e.g. to answer questions about the current state of an industrial automation system. With the semantic augmentation provided by the OPC UA companion specifications, this enables models to answer domain-specific questions in the terminology of the domain.
- For example, if the OPC UA server queried by the AI application implements a companion specification for weighing technology (OPC 40200), the operator can ask about the "current weight". The specification includes the object type "ScaleDeviceType" that contains the data field "CurrentWeight". The AI model can now infer that the operator is referring to this data field and can emit a query via MCP to browse the OPC UA Server of a scale device for matching objects and then gather this information and return it to the operator.

MORE INFO

Explore OPC UA for AI working group:

- **Working Group Artificial Intelligence**
  https://opcfoundation.org/about/working-groups/view/94

- **OPC Day international video presentation**
  https://www.youtube.com/watch?v=F4kUZGIEOaQ

Testimonials

»Since 2017, Renault has chosen OPC UA, believing in its capacity to standardize within the highly diverse industrial environment. Today, thanks to a massive deployment with over 2,200 OPC UA servers and 15,000 connected devices, we are able to gather industrial data in a structured and standardized way. However, to enable data storage in the cloud and address scalability challenges, Renault had to make the decision to reduce the semantic richness of the OPC UA data. We strongly believe in the importance of the OPC Foundation Cloud Initiative, as it represents the final step toward OPC UA standardization in the cloud. We are confident that the outcomes from this working group will enable the preservation of the model structuring logic even within the cloud layer, address the scalability challenge, and, thus, achieve the vision of a fully structured and standardized data collection chain.«

Thierry Daneau,
Metaverse Industrie & Qualité, Expert Leader Industrie 4.0, Renault-Group

»OPC UA has established itself as the industrial interoperability standard in on-premises, OT environments, field-level communication, as well as industrial edge applications. Therefore, it is not surprising that OPC UA users want to leverage their existing investment in OPC UA Information Models and communication patterns and also utilize it in IT and cloud applications by enhancing secure, interoperable cloud architectures for advanced data analysis, digital twins, and AI.«

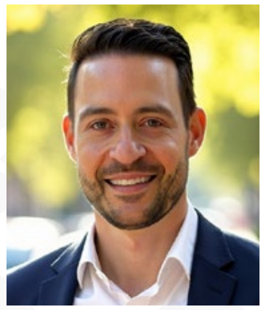
Stefan Hoppe,
President and Executive Director OPC Foundation

»Seamless semantic structures are becoming an essential driver of industrial value creation. When data remains consistently interpretable from the shop floor all the way to cloud-based applications, it forms a reliable basis for collaboration, efficiency and technological scalability. A key contribution comes from the OPC UA Companion Specifications, whose established models can now be fully utilized in cloud environments. For the mechanical engineering sector, this represents tangible progress: standardized data flows, reduced integration effort and greater transparency across complex supply chains.«

Andreas Faath,
VDMA, OPCF Board Member

»As the original creator and chair of the OPC Foundation Cloud Initiative, it fills me with great pride to see how far we have come in two short years! In no other place in the world are so many cloud providers, automation companies and end users gathered under a single roof, building interoperable solution architectures. Not to mention all the free-of-charge open-source offerings the Cloud Initiative has produced already. This allows manufacturers of any size to get started quickly and mix and match services from different cloud providers to create their solutions. This is a requirement I hear very often and the Cloud Initiative delivers it.«

Erich Barnstedt,
Senior Director & Architect Industrial Standards, Corporate Standards Group, Microsoft Corporation



»The OPC Foundation Cloud Initiative gives industry the open, multi-cloud blueprint it needs, extending OPC UA's secure, semantic interoperability from the shop floor into IT and the cloud with a reference architecture, cloud-optimized profiles, and the UA Cloud Library to power governed data exchange for AI, digital twins, industrial data spaces, and Digital Product Passports. This direction aligns directly with SAP's commitment to open, cloud-independent ecosystems and networks such as Catena-X, enabling customers to deploy once, scale globally, and realize value faster.«

Matthias Hollenders,
VP Product Management Manufacturing SAP SE,
OPCF Board

»Regional (European) technical sovereignty could be interpreted as isolation from other regions. On the other hand, global manufacturers will need global standards to keep costs in check. These principles do not need to be incompatible to each other. The OPC Foundation Cloud Initiative is a tangible project that helps create more cloud and IIoT sovereignty, while ensuring that international standards remain available across the globe.
No other platform provides such a direct pre-competitive collaboration between Microsoft Azure, Google Cloud, Amazon Web Services, SAP, and Huawei Industrial Cloud; focusing to reduce vendor lock-in and increase user mobility in the manufacturing, industrial IoT, and dataspace sectors. Very relevant activities under the OPC Foundation Cloud Initiative umbrella are: The integration of OPC UA as the semantically rich framework for information modelling and transmission to the MCP (Model Context Protocol) servers, as well as the connection of OPC UA as the manufacturing knowledge language to the new IT infrastructure and European trust framework being deployed at Catena-X and the upcoming projects under the Manufacturing-X umbrella. One very interesting use case to keep an eye on is the Battery Digital Product Passport powered by OPC UA.«

David Tobon,
Huawei Technologies Co., Ltd.

Open-Source Offerings from OPC Foundation

INTRO
OPC UA-based interoperability is driven not only by strong and convincing specifications and a stable legal framework, but also by a broad ecosystem of commercial offerings – including toolkits and training – and, most notably, by an exceptionally large open-source landscape.

- More than 1,900 open-source projects related to OPC UA can be found across the web
- 17 open-source projects are directly supported by the OPC Foundation – please review the examples listed here:

TECHNOLOGY REPOSITORIES

1. **UA-.NET Standard**
   This repository provides a .NET Standard implementation of the OPC UA specifications, enabling cross-platform development of OPC UA applications. The library supports various features such as secure communication, data access, and event handling, making it a comprehensive library for developers working with OPC UA in .NET environments.
   https://github.com/OPCFoundation/UA-.NETStandard

2. **UA-NodeSets**
   This repository contains UA NodeSets and other normative files released with its respective specification. These files define the structure and semantics of data in OPC UA applications and are essential for ensuring interoperability between different OPC UA implementations.
   https://github.com/OPCFoundation/UA-Nodeset

3. **UA-ModelCompiler**
   This repository provides the OPC UA ModelCompiler, a tool that converts OPC UA information models, defined in XML, into code. The ModelCompiler supports generating code in C#, facilitating the integration of custom information models into OPC UA applications.
   https://github.com/OPCFoundation/UA-ModelCompiler

4. **Open API Libraries**
   These repositories have the .NET, Python and TypeScript classes generated from the OpenApi schema definition for the OPC UA WebApi, a REST-like API designed for use in IT applications.
   .NET: https://github.com/OPCFoundation/opcua-webapi-dotnet

   Python: https://github.com/OPCFoundation/opcua-webapi-python

   Typescript: https://github.com/OPCFoundation/opcua-webapi-typescript

5. **UA Cloud Library**
   The UA-Cloud Library repository hosts the OPC UA Information Model database with REST interfaces. It allows users to store, manage, and retrieve OPC UA information models in a centralized cloud-based repository.
   https://github.com/opcfoundation/UA-CloudLibrary.

SAMPLES REPOSITORY
Comprised of several repositories, which demonstrate cloud use cases, like the UA-CloudCommander, UA-CloudViewer, UA-EdgeTranslator, UA-CloudDashboard, UA-Cloud-Action, and the UA-Cloud Metaverse.

1. **IIoT Starter Kit**
   A set of quick-start samples for OPC UA over MQTT. This repository contains samples and tutorials for building OPC UA Pub-Sub applications in Industrial Internet of Things (IIoT) scenarios. The starter kit demonstrates how to use OPC UA for secure and reliable communication between industrial devices and systems. It is designed to help developers quickly prototype and deploy IIoT solutions using OPC UA.
   https://github.com/opcfoundation/UA-IIoT-StarterKit

2. **UA-WebApi-StarterKit**
   A set of sample applications used to demonstrate the OPC UA WebApi based on OpenAPI definitions.
   – UaWebApiGateway
   – UaWebApiClient
   – OpenApiGenerator
   https://github.com/OPCFoundation/UA-WebApi-StarterKit

3. **UA Cloud Twin**
   Digital Twin adapter for OPC UA PubSub data from the Digital Twin Consortium
   https://github.com/digitaltwinconsortium/UA-CloudTwin.

4. **UA Cloud Metaverse**
   OPC UA Industrial Metaverse reference implementation leveraging Unity.
   https://github.com/OPCFoundation/UA-Cloud-Metaverse

5. **UA Cloud Viewer**
   An online viewer for OPC UA Information Models
   https://github.com/opcfoundation/UA-Cloud-Viewer.

6. **UA Edge Translator**
   An industrial connectivity edge application translating from proprietary protocols to OPC UA leveraging the W3C Web of Things (WoT) thing descriptions.
   https://github.com/opcfoundation/UA-EdgeTranslator.

7. **UA Cloud Commander**
   The OPC Foundation UA Cloud Commander is an open-source project that simplifies the deployment and management of OPC UA infrastructure in cloud and hybrid environments. This is a cross-platform OPC UA cloud command & control implementation leveraging MQTT and Kafka. It runs in a Docker container and executing commands, reads and writes on on-prem OPC UA servers from the cloud. It enables secure discovery, registration, and lifecycle management of OPC UA applications across distributed systems.
   https://github.com/opcfoundation/UA-Cloud-Commander.

8. **UA Cloud Action**
   OPC Foundation UA Cloud Actions is an open-source project that enables event-driven automation based on OPC UA data and events. This cloud-based app trigger an action for the UA Cloud Commander. It enables developers to trigger cloud-native workflows and actions when defined conditions in OPC UA systems are met. This makes it easy to connect industrial OPC UA environments with modern IT and cloud services in a scalable and secure way.
   https://github.com/OPCFoundation/UA-Cloud-Action.

9. **UA Cloud Dashboard**
   OPC Foundation UA Cloud Dashboard is an open-source web application for OCP UA PubSub data that provides a centralized view of OPC UA assets and services registered in cloud environments. It enables users to discover, monitor, and manage OPC UA applications through an intuitive, browser-based interface. By visualizing OPC UA ecosystems across sites and clouds, it improves transparency and operational control.
   https://github.com/opcfoundation/UA-Cloud-Dashboard.

10. **UA DataProcessor**
    Data processor for the UA Cloud Initiative, deployed as a Docker container. It ingests data from connected data sources (see DataServices) and generates OPC UA NodeSet files for publication in the UA Cloud Library.
    The current implementation provides a Product Carbon Footprint (PCF) processor based on the Greenhouse Gas (GHG) Protocol calculation methodology.
    https://github.com/OPCFoundation/UA-Data-Processor

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OPC® FOUNDATION

OPC FOUNDATION NORTH AMERICA
16101 N 82nd Street 3B
Scottsdale, Arizona
AZ 85260-1868
United States
office@opcfoundation.org

OPC FOUNDATION EUROPE (HQ)
OPC Federation AISBL
Cantersteen 47
1000 Brussel
Belgium
office@opcfoundation.org

OPC FOUNDATION CHINA
Room 102-104, 1st Floor
Fengheng Building, Kandan Street
Fengtai District, Beijing 100070
P.R. China
opcchina@opcfoundation.org

OPC FOUNDATION JAPAN
c/o Microsoft Japan Co., Ltd.
2-16-3 Konan, Minato-ku
Tokyo 108-0075
Japan
opcjapan@opcfoundation.org

FRANCE
opcfrance@opcfoundation.org

INDIA
opcindia@opcfoundation.org

ASEAN
opcasean@opcfoundation.org

KOREA
opckorea@opcfoundation.org