OPC UA & Smart-ready Factory

황철상

BridgeWare
All about Data Connectivity Solutions
ISA 95 Model by International Society of Automation

Level 4
Enterprise Resource Planning

Level 3
Manufacturing Execution Systems

Level 2
SCADA and HMI

Level 1
Controllers (PLCs and Devices)

Level 0
Sensors and Actuators
OPC UA Target Applications
Real-time Manufacturing Data
- Producers (L0 Sensors & Actuators)

Sensors and other equipment are connected to the analog and digital I/O of an industrial device or a controller.

- **Signal Outputs**: 4-20mA, 1-5V, 0-24V

A controller has a CPU to process and store data from connected equipment.
Real-time Manufacturing Data
- Producers (L1 PLCs & I/O Devices)

PLC (Programmable Logic Controller)
- Siemens, ABB, Schneider Electric
- Rockwell Automation, GE
- Mitsubishi, Omron
- LS산전

DCS (Distributed Control System)
- Honeywell, Emerson, Yokogawa
- GE, Siemens

IED (Intelligent Electronic Device)

PAC (Programmable Automation Controller)

DDC (Direct Digital Control)
Real-time Manufacturing Data

– Consumers (L2, L3 & L4)

HMI/SCADA (Human Machine Interface / Supervisory Control And Data Acquisition)

- Wondoerware InTouch (AVEVA/Schneider Electric)
- WinCC (Siemens)
- FactoryTalk View (Rockwell Automation)
- iFIX (GE)
- ETAP, Cimon

Historians

- OSI PI System, dataPARC
- Honeywell PHD, Aspen InfoPlus.21
- Wonderware Historian, GE Historian
- Kepware Historian, ibaPDA, Canary Historian

Databases

- MS SQL Server, MS Access, PostgreSQL
- Oracle, MySQL, Tibero

MES (Manufacturing Execution System)

IoT & Big Data Platforms (ThingWorx, MS Azure, SAP, Splunk, GE Predix, Siemens MindSphere, etc.)
Real-time Manufacturing Data – the Middle-man

**OPC Server**: Software application for Interoperability & Data Exchange. ("the Middle-man")

Data Consuming Applications

Data Producing Devices

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Data Flow: Sensor to OPC Server

Register 43250 Value: 72.5

Read Request in “Protocol X” for Register 43250

Temperature Sensor

CPU Memory

Analog Input 4-20mA

72.5

Register 43250
Modbus Packet Capture over Ethernet

Data payload format for an Ethernet-encapsulated Modbus Serial read of registers 400001 through 400006

Device ID = 01
Function Code = 03
Starting Register = 00 00
Number of Registers = 00 05
Checksum = 85 C9
Data Flow: OPC to Applications

- ODBC
- OPC DA/UA
- OPC HDA

Big Data/Analytics

REST/MQTT

SNMP
Before OPC

Each application requires communication driver for each Device.

Toolkits or APIs to develop a driver.

Slow to Deploy

High Cost, Less Efficiency

No Security
After OPC

No Need to know Machine Protocols

Reduced Complexity, Increased Efficiency

More Connectivity, Less Cost

Fast to Deploy

Enhanced Security
OPC Specifications

**OPC Classic**
- Data Access (DA)
- Alarms & Events (A&E)
- Historical Data Access (HDA)

**OPC Unified Architecture (UA)**
- OS Independent
- Firewall Friendly
- Combine the “classic” specifications into a single interface.
OPC UA (Unified Architecture)
OPC UA (Unified Architecture)

OPC Unified Architecture (IEC 62541)

- **Functional equivalence:** all COM OPC Classic specifications are mapped to UA
- **Platform independence:** from an embedded micro-controller to cloud-based infrastructure
- **Secure:** encryption (RSA standards), authentication (x.509 standards), and auditing
- **Extensible:** ability to add new features without affecting existing applications
- **Comprehensive information modeling:** for defining complex information
### OPC DA compared to OPC UA

<table>
<thead>
<tr>
<th>Feature</th>
<th>OPC DA</th>
<th>OPC UA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solicited and Unsolicited Data Access</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Data Acquisition Controlled via Client</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Security</td>
<td>DCOM only.</td>
<td>Data encryption to RSA standards and authentication based on the x509 Certificate standard.</td>
</tr>
<tr>
<td>Runs on Multiple Operating Systems</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>Remote Access Across the Cloud</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>Separate Rates for Sampling and Publishing</td>
<td>✗</td>
<td>✔️</td>
</tr>
<tr>
<td>Native Support for Complex Data Structures</td>
<td>✗</td>
<td>✔️</td>
</tr>
</tbody>
</table>
OPC UA Environment

Uses Binary/TCP and SOAP/HTTP for a Service-Oriented Architecture (SOA).

Meant to work on multiple Operating Systems (OS). Platform independence!

Combines OPC “Classic” into a single service set and Complex Data takes a starring role.

Firewall friendly.
- Data Access (Classic DA)
- Historical Access (Classic HDA)
- Alarms & Conditions (Classic A&E)
OPC UA Connectivity

**OPC UA**

Endpoint communication

Data encryption to RSA standards and authentication based on the x509 Certificate standard.

This is the same encryption e-commerce uses.

opc.tcp://10.10.110.10:49320
OPC UA Server Architecture

[Diagram of OPC UA Server Architecture]

- OPC UA Server Application
  - Real Objects
  - OPC UA AddressSpace
    - Nodes
    - Views
    - Monitored Item
    - Subscription
  - OPC UA Server API
    - OPC UA Communication Stack
      - Req Msg
      - Rsp Msg
      - Publ Msg
      - Notif Msg
      - From OPC UA client
      - To OPC UA client

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OPC UA Client Architecture

[Diagram of OPC UA Client Architecture]

- Client-Application
  - Requests to send service requests
  - Delivery of received service responses
  - Requests to send publishing requests
  - Delivery of received notifications

- OPC UA Client API
  - OPC UA Communication Stack
    - Req Msg
    - Rsp Msg
    - Publ Msg
    - Notif Msg

- To OPC UA server
- From OPC UA server
OPC UA Publish/Subscribe

Local and Cloud Messaging Infrastructure
Microsoft Azure IoT Hub, Azure Event Hubs, IBM MQ, IBM Watson IoT, AWS IoT,
Red Hat A-MQ, Apache Active MQ, Apache Qpid, etc.

IT

OT

AMQP 1.0

MQTT (Future)

UDP

TSN

Device

Device

OPC UA Server

Capabilities

Address Space

Published Items

"Message Writer"

Encoding

Msg Security

Transport
OPC UA Server Endpoint & Certificate

UA Server Browser

Discovery Service
Discovery URL:
opc.tcp://CS-HP:49320

Discovery Port:
49320

Use Discovery URL

UA Servers

KepServerEX\UA\CS-HP

- opc.tcp://CS-HP:49320

- Basic128Rsa15 - Sign
- Basic128Rsa15 - Sign and Encrypt
- Basic256 - Sign
- Basic256 - Sign and Encrypt
- None - None

- FString:
- 1.
- 1.
- 1.
- 1.
- 1.

- CER:
- C:
- C:
- C:
- C:
- C:

- CN = KepServerEX\UA Server
- O = Microsoft
- C = KR
- DC = CS-HP

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Slide 22
# OPC UA Certificates

<table>
<thead>
<tr>
<th>Certificate Authority</th>
<th>Certificate Type</th>
<th>Valid Until</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Go Daddy Class 2</td>
<td>Certification Authority</td>
<td>2024-06-30</td>
<td>G</td>
</tr>
<tr>
<td>Go Daddy Root Certificate Authority - G2</td>
<td></td>
<td>2038-01-01</td>
<td>G</td>
</tr>
<tr>
<td>GTE Cybertrust Global Root</td>
<td></td>
<td>2018-08-14</td>
<td>G</td>
</tr>
<tr>
<td>INCA Internet Co., Ltd. CA</td>
<td></td>
<td>2025-03-30</td>
<td>G</td>
</tr>
<tr>
<td>KEPServer EX/UA Client Driver</td>
<td></td>
<td>2022-06-18</td>
<td>G</td>
</tr>
<tr>
<td>KEPServer EX/UA Server</td>
<td></td>
<td>2025-06-18</td>
<td>G</td>
</tr>
<tr>
<td>KISA RootCA 1</td>
<td></td>
<td>2025-08-24</td>
<td>K</td>
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<tr>
<td>Microsoft Authenticode(tm) Root Authority</td>
<td></td>
<td>2000-01-01</td>
<td>N</td>
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<tr>
<td>Microsoft Root Authority</td>
<td></td>
<td>2020-12-31</td>
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<tr>
<td>Microsoft Root Certificate Authority</td>
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<td>2021-05-10</td>
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<tr>
<td>Microsoft Root Certificate Authority 2010</td>
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<td>2023-09-29</td>
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<tr>
<td>Microsoft Root Certificate Authority 2011</td>
<td></td>
<td>2036-03-23</td>
<td>N</td>
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<tr>
<td>NO LIABILITY ACCEPTED, (c)97 VeriSign, Inc</td>
<td></td>
<td>2004-01-08</td>
<td>N</td>
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<tr>
<td>SecureTrust CA</td>
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<td>2030-01-01</td>
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<tr>
<td>Starfield Class 2 Certification Authority</td>
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<td>2024-06-30</td>
<td>S</td>
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<tr>
<td>Starfield Root Certificate Authority - G2</td>
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<tr>
<td>Starfield Services Root Certificate Authority</td>
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<td>2030-01-01</td>
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<tr>
<td>StartCom Certification Authority</td>
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<td>2036-09-18</td>
<td>S</td>
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<tr>
<td>SwissSign Gold CA - G2</td>
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<td>2036-10-25</td>
<td>S</td>
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<tr>
<td>Thawte Premium Server CA</td>
<td></td>
<td>2021-01-01</td>
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<tr>
<td>Thawte Primary Root CA</td>
<td></td>
<td>2036-07-17</td>
<td>S</td>
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<tr>
<td>Thawte Primary Root CA - G3</td>
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<td>2037-12-02</td>
<td>S</td>
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<tr>
<td>Thawte Server CA</td>
<td></td>
<td>2021-01-01</td>
<td>S</td>
</tr>
<tr>
<td>Thawte Timestamping CA</td>
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<td>2021-01-01</td>
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<tr>
<td>UTN-USERFirst-Hardware</td>
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<td>2019-07-10</td>
<td>U</td>
</tr>
<tr>
<td>UTN-USERFirst-Object</td>
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<td>2019-07-10</td>
<td>U</td>
</tr>
<tr>
<td>VeriSign Class 2 Public Primary Certification Authority</td>
<td></td>
<td>2036-07-17</td>
<td>V</td>
</tr>
</tbody>
</table>

This page contains a list of certificate authorities and their respective validity dates. The status column indicates whether the certificate is valid (G), revoked (R), or expired (X). The slide contains a screenshot of a certificate management interface.
Embedded UA Servers

AREVA’s SIPLUG® valve monitoring device
UA Server on ARM Cortex processor

Beckhoff TwinCAT PLC
UA Support from major Vendors

- Siemens S7-1500 PLC
- Siemens S7-400 controller with OPC UA Server (CP 443-1 OPC UA)
- Sinumerik CNC systems
  - SINUMERIK 828D
  - SINUMERIK 840D sl
- Simatic Net OPC Server
- Simatic WinCC Open Architecture
- Simatic HMI Comfort Panels
- SIOCODE pro Motor Management System
- Simatic RF600 RFID Reader

Rockwell CompactLogix 5480

Emerson Machinery Health Protection System (CSI 6500 ATG)

With native UA Support
# UA Support from major Vendors

<table>
<thead>
<tr>
<th>Item Name</th>
<th>RD81OPC96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported Model</td>
<td>iQ-R Series</td>
</tr>
<tr>
<td></td>
<td>RCPU, LCPU, QCPU (Q mode)</td>
</tr>
<tr>
<td>Connectable Ethernet port</td>
<td>CH1</td>
</tr>
<tr>
<td># Tags</td>
<td>10,000</td>
</tr>
</tbody>
</table>

![Diagram of Ethernet connection and OPC UA architecture](image-url)

- Embedded OPC UA server
- Simple data management
- Flexible and robust security
- Intuitive configuration software
- Vendor-neutral control system
OPC, Industrial IoT & Big Data
IT Data vs. OT Data

IT:
- Databases
- Web, email, and other servers
- Network monitoring systems
- Networked components
- Business tools
- Customer Relationship Management (CRM)
- Finance systems

OT:
- Sensors
- Industrial equipment, devices, and controllers
- Visualization applications
  - HMI, SCADA, MES, ERP
  - Historians
- OPC servers
The Emerging Smart Production Environment (IIoT, I4.0, etc.)

New or Changing …
- Software: Analytics, APS, MES/MOM, EAM/CMMS, LIMS, PAM, Security, etc.
- Mobility and enhanced worker connectivity
- Remote services; Product ‘as-a-Service’
- Smart sensors, assets, network connectivity, cloud
... All along with traditional automation and enterprise systems
PTC ThingWorx Industrial IoT Platform

The Thing Model is at the heart of ThingWorx.

- Complete digital representation of a physical “thing”
- Dynamic: services and events include the business logic of the “thing”.
- Creates a dynamic API for each “thing”
- Enables quick & consistent development across the platform
- More than just a database
Microsoft Azure UA Connectivity

1. Industrial Devices (OPC-UA Servers)
   - OPC UA Client Module
   - Azure IoT Gateway SDK

2. Firewall
   - OPC UA Proxy Module

3. Azure IoT Hub
   - Cold Path Analytics & Storage
     - Azure HD Insight, Azure Storage, SQL, DocDB, ...

4. Hot Path Analytics
   - Azure Stream Analytics, Azure Storm, ...

- OPC Clients, Servers, ERP Portals, OPC Graph Database and OPC UA .NET Standard Stack

Presentation & Business Connections
- Websites, Mobile Services
- Dynamics, BizTalk Services, Notification Hubs

On-Premise: Device Connectivity
Cloud: Data Ingest and Processing, Command & Control
Cloud: Presentation
SAP Plant Connectivity (PCo)

Supported Protocols: Citect, FileMonitor, IP21, ODBC, OLE DB, OPC A&E, OPC DA, OPC HDA, OPC UA, OSIsoftPI, Proficy Historian, Socket + SDK for additional agents

Devices and Controllers
GE Predix Edge Connectivity
Siemens MindSphere

**MindApps**
- Asset transparency and analytical insights, e.g., predictive maintenance
- Subscription based pricing model

**MindSphere**
- Open interface for development of customer specific apps
- Various cloud infrastructures: public, private or on-premise (planned)

**MindConnect**
- Open standards (e.g. OPC UA) for connectivity
- Plug and play connection of Siemens products
- Secure and encrypted data communication
Edge or Cloud

Devices

IoT Gateway

On-Premises Server

Network Switches

Cloud/Industrial Infrastructure

Edge Analytics

Big Data
KepServerEX

The Ultimate Industrial Connectivity Platform
KepServerEX Industrial Connectivity Platform

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**Application Interface Layer**

- Included by default - OPC DA & OPC UA Server
- Included by default - Native Interface (Thingworx, InTouch HMI, iFIX HMI)
- Optional: Database Interface (SQL Server, Oracle, MySQL, Access, PostgreSQL, etc.)
- Optional: OPC Historical DA (HDA)
- Optional: IoT Gateway Interface (MQTT & RESTful)
- Optional: Data Forwarder for Splunk

---

**Device Communication Layer**

- AB, Mitsubishi, Modbus, Siemens, GE, Fanuc CNC, Honeywell, Omron, Toshiba, Yokogawa
- BACnet, Beckhoff TwinCAT, DNP3, IEC-60870, IEC-61850, SNMP
- OPC DA client, OPC UA client, ODBC client, InTouch client
- User-Configurable Driver, Simulator, Advanced Simulator

**KepServerEX**

(150+ Communication drivers supported)
IoT Gateway Plug-in

Protocols Supported
- RESTful Client
- RESTful Server
- MQTT Client
- ThingWorx

Seamlessly streams real-time control data into IT or IoT applications

Big Data

MQTT

REST

Client

Server

ThingWorx

APIs

(Microsoft)

IoT API

Scheduling

Analytics

Modeling

Connectivity

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Slide 39
Local Historian Plug-in

Local Data Store
- Store up to 10K+ tags
- 10ms resolution of data
- Archive and transport
- Deadband to compress stored

Collect at source to reduce data loss
Easily configure both static and dynamic tags
Viewer for raw tag data
Access historical data using OPC HDA enabled clients
- Trending, analysis and reporting solutions

Scalable tags: 500, 10000, Unlimited

Easy, Flexible, High Speed, Cost Effective
DataLogger Plug-in

OPC Data to RDBs:
  - SQL Server, Access
  - Oracle, MySQL
  - PostgreSQL, Tibero
  - Any ODBC Databases
Drag & Drop Configuration
Automatic table creation
  - Narrow & Wide formats
Trigger Conditions:
  - Data Change
  - Time
  - User Expression

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Kepserver OPC Connectivity Suite provides DA Client driver + UA Client driver
OPC UA Tunnelling

1. Any OPC UA Server
2. Any OPC DA Server with Kepware UA Client driver

1. Any UA Client
2. Any DA Client with Kepware UA Client driver

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Cogent DataHub
Real-Time Middleware for Industrial Automation
Data connectivity, integration, and visualization features

**OPC DA** or **OPC UA** Support – connect to OPC DA or UA servers and clients.

**WebView** – build and display private cloud-based web pages.

**Tunnel/mirror** – secure networking of OPC data without DCOM problems.

**Database write** – write data to any ODBC database.

**Database read** – read data from any ODBC database.

**Data bridging** – connect two or more data sources to share data in real time.

**MQTT** – Connect to MQTT clients and brokers

**Modbus** – connect to Modbus TCP slave devices.

**OPC A&E** – connect to OPC A&E servers and clients.

**Data aggregation** – merge data from multiple sources into a common data set.

**Secure Remote Configuration Tool** – Configure a network of DataHub installations from a single location.

**QuickTrend** – view live, real-time trends for selected data.

**Scripting** – program custom solutions to meet your specific needs.

**Security** – control access and set permissions for users and groups.
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