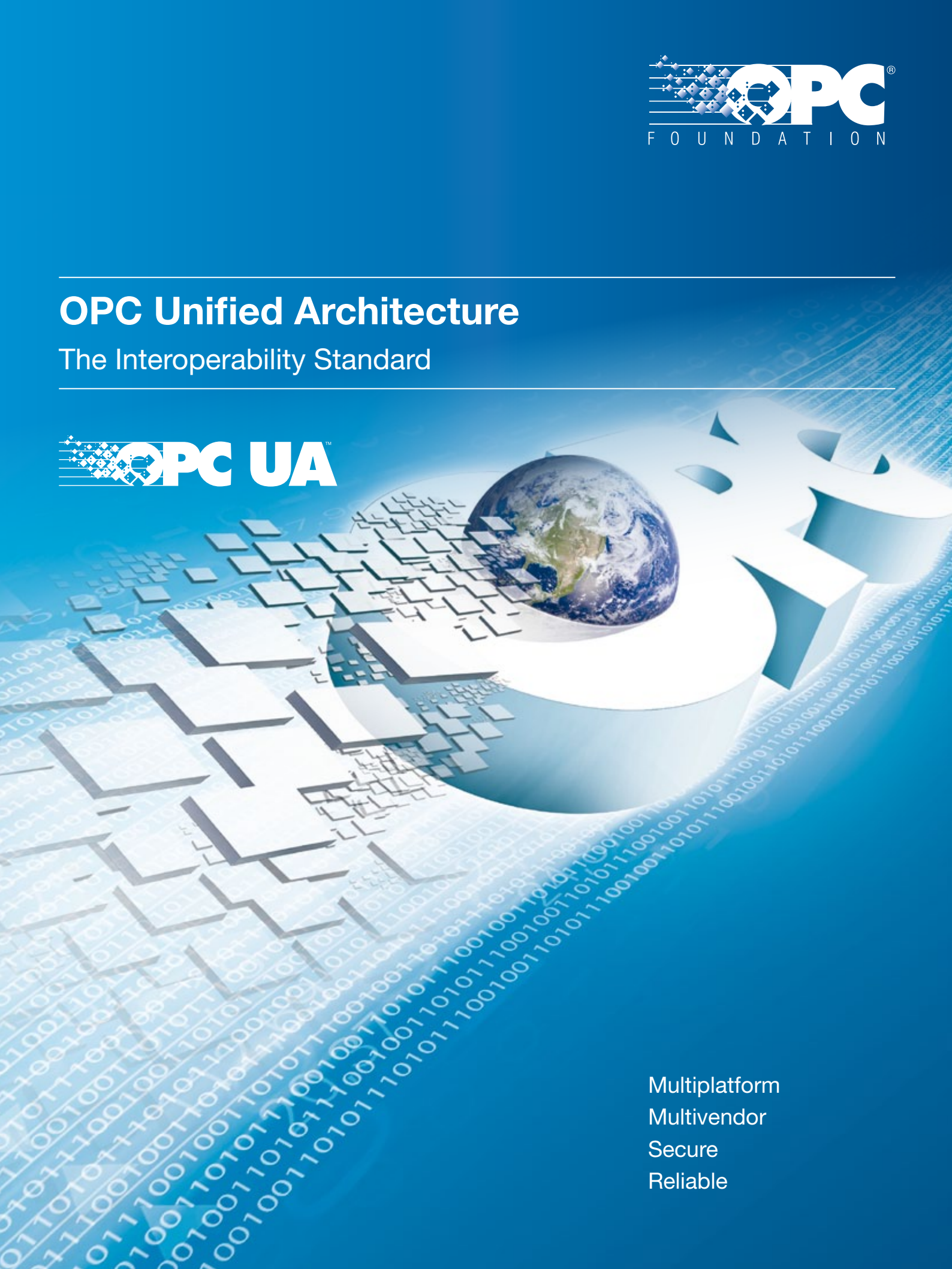
# OPC Unified Architecture

## The Interoperability Standard



Multiplatform
Multivendor
Secure
Reliable


**Thomas J. Burke**
President and Executive Director
OPC Foundation

# Welcome to the OPC Foundation, a global organization in which users, vendors and consortia collaborate to develop standards for multivendor, multiplatform, secure and reliable interoperability in industrial automation and other markets.

OPC is the interoperability standard for secure, reliable multivendor, multiplatform data exchange for Industrial Automation. It provides open connectivity across multiple products, regardless of hardware platform or software operating system.

The OPC standard is a series of specifications that are developed by industry vendors, end-users and software developers to facilitate data transmission and exchange. OPC specifications define an interface between clients and servers, as well as servers and servers, for different fields of applications, including access to real-time data, monitoring of alarms and events, access to historical data and other applications.

Since 1995 OPC has been gaining widespread adoption across multiple industries. OPC Classic was first released in August, 1996 with support for Microsoft Windows. With the introduction of service-oriented architectures in industrial automation systems, the OPC Foundation released the first OPC UA specification in 2009 which provides a migration path from OPC Classic to more secure and scalable solutions that take advantage of Web services and a unified data model.

Today there are over 20,000 OPC products from more than 3,500 vendors with millions OPC based applications installed worldwide. This reinforces OPC technology as the leading standard for interoperable data exchange between software applications from multiple vendors.

The OPC Foundation's vision is to manage a global organization in which users, vendors and consortia collaborate to create data transfer standards for multivendor, multiplatform, secure and reliable interoperability in industrial automation.

To support this vision, the OPC Foundation:
→ Creates and maintains specifications.
→ Ensures compliance with OPC specifications via certification testing.
→ Collaborates with industry leading standard organizations.

This brochure will help you better understand OPC UA technology and what the OPC Foundation can provide to your organization. For more information, please visit the OPC Foundation website at **www.opcfoundation.org.**

Sincerely,

**Thomas J. Burke**
President and Executive Director
OPC Foundation
thomas.burke@opcfoundation.org



## The OPC Foundation

The OPC Foundation is dedicated to ensuring interoperability in automation. By creating and maintaining open specifications that standardize the communication. This communication includes acquired process data, alarm and event records, historical data and batch data. The information is transferred vertical and horizontal from multivendor enterprise systems and between production devices. Production devices include sensors, instruments, PLCs, RTUs, DCSs, HMIs, historians, trending subsystems, alarm subsystems, and more. These systems are used in the process industry, manufacturing, and in acquiring and transporting energy, oil, gas and minerals.

| **O**peness | **P**roductivity | **C**ollaboration |
|---|---|---|
| – > 450 members | – Industry standard | – PLCopen |
| – Platform-neutral | – Manufacturer-independent | – BACnet Interest Group |
| – All areas of application | – Interoperability | – FDI Cooperation |
| – All connections | – Reliability | – EDDL and FDT |
| | | – MESA, MES-D.A.CH. |
| | | – OMAC |
| | | – Mimosa, ISA-95, ISA-88 |
| | | – MTConnect |
| | | – Smard Grid |
| | | – ODVA |
| | | – MDIS |

## The OPC Vision

The Vision of the OPC Foundation is to provide the best technology, specifications, certification and processes to enable companies to build products and services that demonstrate multiplatform multivendor secure reliable interoperability. OPC Foundation members benefit by being able to take advantage of the technology and marketing necessary to become leaders in the industry supporting industrial standards for industrial automation and other markets.

## Contents

»As a founding member of the OPC Foundation, Siemens strives to create added value for its customers through driving automation as well as the further development and interoperability of technologies between different system manufacturers.
In many of our innovations – such as the network management solution Sinema Server, the Human Machine Interface Simatic HMI, or the flexible, modular motor management system Simocode pro – OPC standards have been applied. OPC UA is an implementation we attach especially great relevance to. Thus, we have always been strongly involved in this field, and were among the first companies to have their products certified. «

**Thomas Hahn,** Siemens AG, OPC board member

## Commitment from Industry Leaders

»OPC DA is the most popular and successful standard interface on the automation systems. Yokogawa joins OPC Foundation from the beginning and has much contributed to the development of OPC interface. Now Yokogawa is fully committed itself to new promising OPC UA and will contribute to the development as ever.«

**Nobuaki Konishi,** Yokogawa, President OPC Council Japan, OPC board member

»OPC UA is now available on the market and is proving to solve the key issues it was intended to. Honeywell is investing in OPC UA and expects to provide leadership to ensure there is market acceptance and adoption. This is an exciting evolution for the OPC Foundation as it effectively solves many existing problems and expands the applicability of OPC far beyond its current accepted scope historically.«

**David Eisner,** Honeywell, OPC board member

»ICONICS is well positioned to take advantage of the new OPC UA interoperability standard with its newest SCADA, HMI and Analytics products which are designed to be “OPC UA to Core“.«

**Russ L. Agrusa,** CEO ICONICS, OPC board member

»Emerson, as a founding member of the OPC Foundation, has and will remain committed to the vision of the OPC Foundation to develop standards for open connectivity in industrial automation systems and adjacent domains.«

**Dr. Grant Wilson,** Emerson, OPC board member

»OPC UA is the future oriented communication standard for the industry. The emergence of the 4th industrial revolution will boost the need for OPC UA.«

**Dr. Reinhold Achatz,** Head of Corporate Center Technology, Information & Quality, ThyssenKrupp AG, Former OPC board member and Vice President from 1996 till 2012.

»OPC UA unlocks the potential for ERP to Factory Floor communications“.«

**Dr. Jürgen K. Weinhofer,** Vice President Control Architecture & Technology, Rockwell Automation, OPC board member

»Beckhoff joined OPC Foundation in 1998 and early provided OPC UA functionality integrated into smallest embedded controller in 2008. Actively pushing the collaboration with PLCopen our customers already benefit from easy, secured connection from our open PC based control philosophy up into MES and cloud scenarios.«

**Hans Beckhoff,** Managing Director, Beckhoff Automation GmbH

»OPC UA allows a platform independent, easy and secure connection between SAP business systems with distributed shop floor data even on smallest embedded devices.«

**Veronika Schmid-Lutz,** Product Owner Manufacturing, SAP AG

»Just as the OPC Foundation once transformed data access and interoperability for industrial applications on the PC platform, it stands on the threshold of another wave of transformation represented by the potential of the Internet of Things. Connected devices together with cloud services, unlimited storage, and open standards for security and communications are enabling Intelligent Systems, paving the way for a new wave of insights, applications and business models across the manufacturing landscape. The OPC UA standards play a key role in enabling this transformation and Microsoft is committed to working with the OPC Foundation to best help meet it’s needs.«

**Rohit Bhargava,** CTO WW Manufacturing & Resources Sector, Microsoft Corporation

# OPC UA at a Glance – Secure, reliable and platform-independent data communication

**Standardized communication via Internet and via firewalls**

→ OPC UA uses an optimized TCP-based UA binary protocol for data exchange with a standard IANA defined port “4840”; Web Services and HTTP are additionally supported. It is sufficient to open up just a single port in a firewall. Integrated security mechanisms ensure secure communication via the Internet.

**Security**

- → X509 certificates
- → OpenSSL encryption
- → User / password
- → Access rights for each attribute

### PLATFORM INDEPENDENT DATA COMMUNICATON

OPC Unified Architecture is the new technology generation of the OPC Foundation for the secure, reliable and vendor-neutral transport of raw data and pre-processed information from the sensor and field level up to the manufacturing level and into the production planning or ERP system. With OPC UA, all desired information is available to every authorized application and every authorized person at any time and in any place. OPC UA is independent of the manufacturer from which the applications originate. It is independent from the programming language in which the applications were developed. And it is independent from the operating system on which the software is used.

### STANDARDIZED COMMUNICATION VIA INTERNET & FIREWALLS

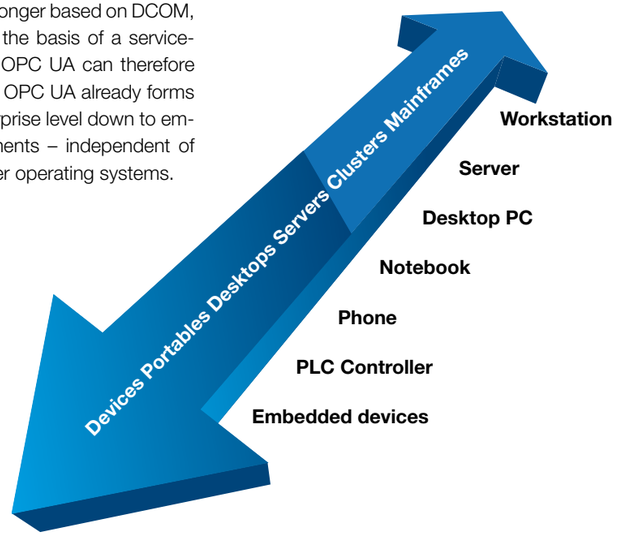
OPC UA supplements the existing OPC industry standard with important features such as platform independence, scalability, high availability and Internet capability. OPC UA is no longer based on DCOM, but has been conceived on the basis of a service-oriented architecture (SOA). OPC UA can therefore be ported very easily. Today, OPC UA already forms the bridge between the Enterprise level down to embedded automation components – independent of Microsoft-, UNIX- or any other operating systems.

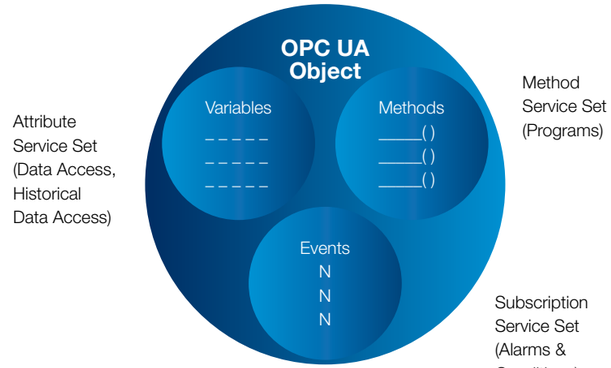
### PROTECTION AGAINST UNAUTHORIZED ACCESS

OPC UA technology uses a mature security concept, ensuring protection against unauthorized access or sabotage of process data and as well against errors due to careless operation. The OPC UA security concept encompasses options for user authentication, the signing of messages and the encryption of the transmitted user data. UA security is based on proven standards which are used also for secure Internet communications like SSL, TLS and AES.

### AVAILABILITY AND RELIABILITY

OPC UA defines a robust architecture with reliable communication mechanisms, configurable timeouts, and automatic error detection and recovery mechanisms. The communication connections between OPC UA clients and servers can be monitored. OPC UA offers redundancy features that can be applied to server and client applications to prevent loss of data and to implement highly available systems with maximum uptime.




### SIMPLIFICATION BY UNIFICATION

OPC UA defines an integrated address space and an information model in which process data, alarms, historical data and program calls can be represented. OPC UA unites classic OPC features and allows complex procedures and systems to be described in a component.

### RANGE OF USE

The versatile usability of the OPC UA technology enables the implementation of completely new vertical integration concepts. By cascading OPC UA components, information is transferred securely and reliably from the shop floor to the production planning or ERP system. Embedded UA servers at the field device level, UA components at automation level and integrated UA clients in ERP systems at enterprise level are directly connected with eachother. The respective UA components can be geographically distributed and easily separated from one another by firewalls.

OPC UA makes it possible for standardization organizations to use UA services as a transport mechanism for their own information protocols. Today the OPC Foundation cooperates with different standardization groups such as PLCopen, BACnet, ISA or FDI. They create companion specifications by using UA modeling capabilities.

### INVESTMENT PROTECTION

OPC UA will replace classic OPC in the long term. In the mid term however, DCOM-based OPC products and UA products can co-exist. The migration strategy of the OPC Foundation enables the combination of classic OPC and OPC UA products. The installed base of existing OPC products with millions of installations will work with the new OPC UA products, so migrating to OPC UA is painless and offers advantages to the user because any desired product from any manufacturer, whether OPC or OPC UA can be used.

# OPC Foundation – The Community of Visionaries and Communication Experts

**CONNECT WITH THE OPC COMMUNITY**
With more than 450 member companies, the OPC Foundation is the world's leading community for interoperability solutions based on the OPC specifications. All OPC Foundation members – including corporate, end-user and non-voting members – can proudly display the OPC Foundation logo and the OPC Foundation Member logo. For the OPC technology suppliers, the OPC Foundation offers a complete marketing program, including a newsletter, web site and educational events. For the OPC end-user community, membership offers the chance to collaborate with the OPC developer community to build best-in-class solutions.

**Why Join the OPC Foundation?**

- → Obtain full access to the OPC specifications
- → Get free use of the OPC Foundation sample code
- → Certify products at the OPC Foundation Certification Lab.
- → Connect with the OPC developer and user community.
- → Harden you product in interoperability (IOP) workshops.

**CREATE THE FUTURE**
The OPC specifications define the interface between clients and servers, as well as server to server (peer to peer), for different fields of applications, including access to real-time data, monitoring of alarms and events, access to historical data and other applications.

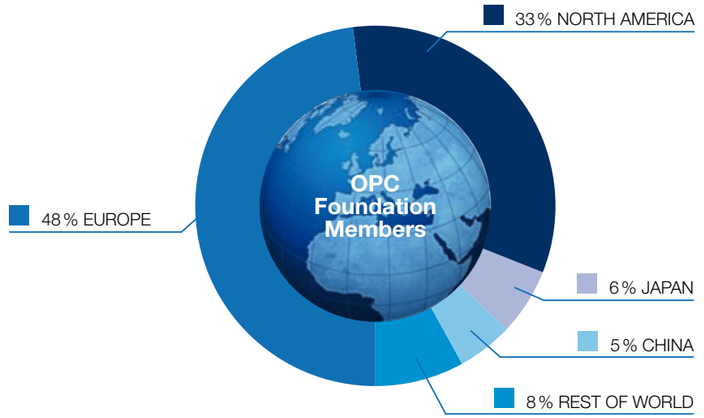
**BENEFITS OF MEMBERSHIP**
As an OPC Foundation corporate member, you get complete and early access to the OPC specifications before the general public. You can even join working groups and engage in the development of ongoing specifications.

**HOW TO JOIN**
Becoming an OPC Foundation member is easy! Membership provides the best way to stay up-to-date with technology and to reach the community most interested in the value and benefits of OPC technology. Download, review, and complete the membership application at **www.opcfoundation.org/howtojoin.**

If you have questions about the application process or membership, please contact the OPC Foundation at **membership@opcfoundation.org**.



**OPC FOUNDATION MEMBERS**
The OPC Foundation member companies are located in every major region of the world, Europe, North and South America, and Asia.




**CORPORATE MEMBERS**
are the OPC technology providers that offer OPC-compliant products. Membership dues are based on annual sales and include free product certification testing, based on membership class.

**END-USER MEMBERS**
are the consumers of OPC technology in the form of OPC-compliant products. End-user members can contribute to the advancement of OPC technology by commenting on Draft Specifications.

**NON-VOTING MEMBERS**
are organizations such as government and research institutions, universities and non-profit groups that need OPC information but who do not build OPC products for the open marketplace.

## THE OPC FOUNDATION IS …

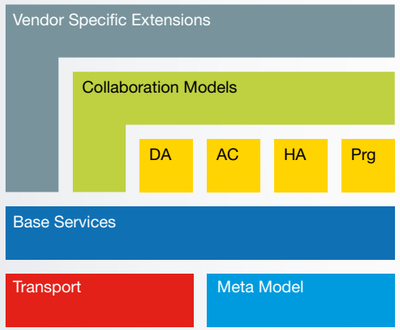
**COMMUNITY:**
→ The world's leading community for interoperability solutions based on OPC specifications that deliver universal connectivity.

**COMPLIANCE:**
→ The official source for the OPC Certification Program, ensuring OPC products plug and play in real-world applications.

**COLLABORATION:**
→ The collaboration with other organizations advances the adoption and use cases of OPC based products.

# OPC UA Technology in Detail

The technical working group for OPC Unified Architecture was formed in 2004. The objective was the design and creation of a communication technology, which functionally unifies all existing classic OPC specifications, but also addresses platform independence and object orientation. At the end of 2006 the new technology was presented to the public. The new service oriented architecture (SOA) incorporates modern security standards and object oriented meta model. It is scalable from embedded devices up to enterprise systems. Together with the release of the specification in 2008 the first reference implementations in ANSI C and .NET were available, Java followed one year later.



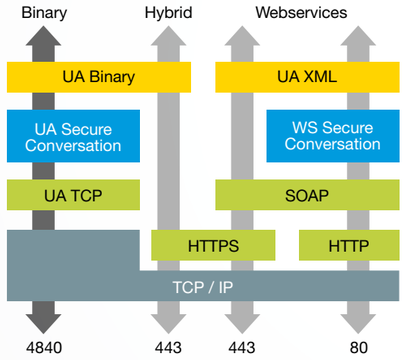

The key components of the Unified Architecture are:

- ➞ different protocol bindings
- ➞ object oriented modeling capabilities
- ➞ fixed set of base services
- ➞ OPC information model
- ➞ extendable by collaborating organizations
- ➞ extendable through vendor specific extensions

**PROTOCOL BINDING**

The OPC UA specification defines abstract services following service oriented architecture (SOA). The “Service Mapping” part of OPC UA specifies several protocol bindings to map these services to a network transport. Currently there are four (4) protocol bindings defined of which one, the UA Binary, is mandatory.

- ➞ Native UA Binary (mandatory)
- ➞ HTTPS with UA Binary
- ➞ HTTPS with SOAP and XML Encoding
- ➞ HTTP with SOAP and WS SecureConversation and XML Encoding



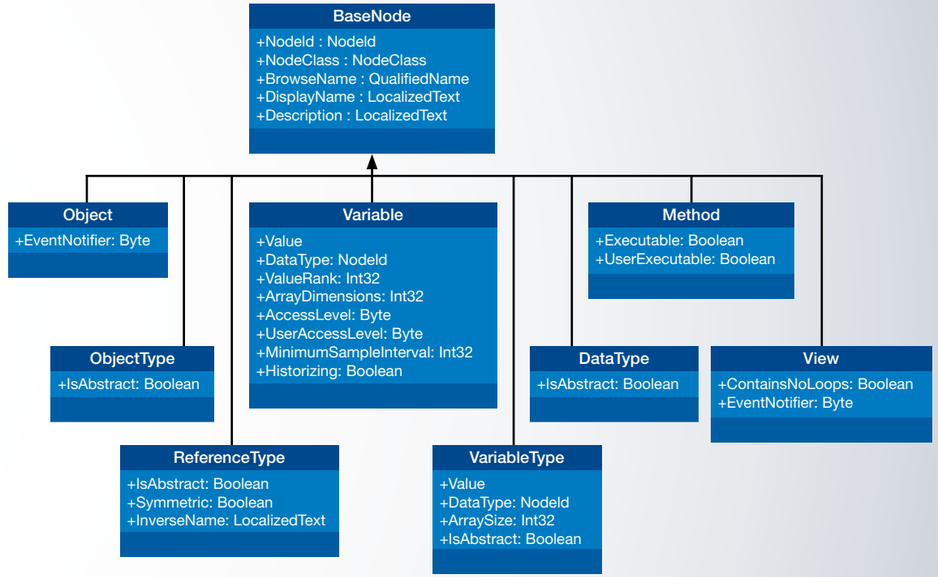

The OPC Foundation provides protocol implementations in the form of communication stacks written in three (3) different programming languages to its members, ANSI C, C# and Java. The stacks are maintained by the OPC Foundation to insure interoperability. Each stack provides a language specific API, the service encoding layer (binary or XML), the secure channel layer and the transport layer.

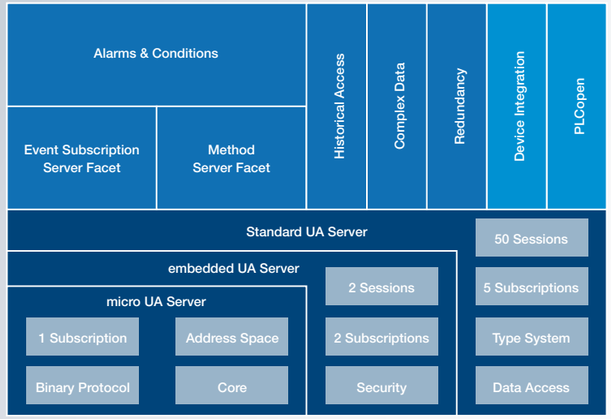


The mandatory UA Binary protocol is intended to be used by all UA enabled software and devices. It is highly optimized and extremely fast, hence it is the preferred protocol between embedded devices, SCADA/HMI level devices and DCS systems. TCP port 4840 is reserved for OPC UA Binary transport.
The Hybrid protocol runs UA binary encoded content inside an https message frame. Instead of message based security this binding uses TLS encrypted transport security. Hence it is still fast and efficient, and it can be implemented down to low end and midrange level devices. In a wide area network (WAN) the TCP port 443 will be open on all firewalls allowing the Hybrid protocol pass through. The Hybrid is intended to be used in web client applications or in cases where only port 443 can be used.
The web service binding runs on http, typically on port 80, using WS secure conversation for message based security or transport layer security with https. The XML encoded message including SOAP header requires more powerful processing. The intended use case is the communication between enterprise applications and high level systems that are already used to handling web services and that are only permitted to communicate on port 80. Those systems typically will not require direct access to field level devices.

**DATA MODEL**

OPC UA defines a generic object model including the corresponding type system. In addition to the generic data model, modeling rules are defined that describe how any physical system can be transformed in an UA conformant model representation of that particular system. With this data model any kind of equipment, function and system information can be described. The base type system supports relation between objects, so called references, and it supports multi inheritance, hence it is comparable to any modern object oriented programming language. This base model provides object and variable types as well as reference and data types. Given that, as the basis, OPC UA can describe any kind of data including it’s meta data and semantics.
The UA data model is the foundation of the UA Information Models, which are specialized models that enhance the basic set of models to provide certain functionality like Data Access, Alarms and Conditions, Historical Access or Programs.






## SERVICES

Independent from the transport binding, OPC UA defines a fixed set of services that must be supported by all UA servers. In contrast to classic web service protocols this abstract service definition guarantees a defined and interoperable set of functionality which the communication partner can rely on. These services are fixed in terms of the signature of parameters and their behavior. They are grouped into functional blocks depending on their task, the so called service set. Even though a server must propagate functionality, a basic set of services is mandatory for all servers to insure minimum of basic functionality like connection establishment.

## PROFILES

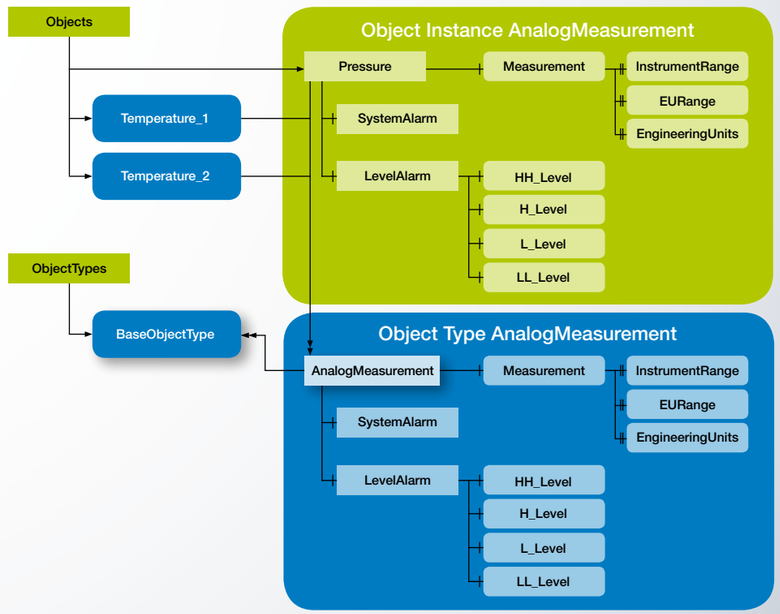
The functionality of an OPC UA Server can be precisely described in terms of profiles. Profiles are compositions of conformance units defining the smallest possible set of services required for certain functionality. The UA client as communication partner can rely on the supported profiles and expected behavior. The compliance certification program insures that UA servers and clients behave within the limits of their supported profile. A conformance unit is also a testable and certifiable functionality. The concept of profiles is the key to scalability of the OPC UA technology. E.g. servers following the “embedded UA Server Profile” need to support fewer connected clients and parallel subscribed nodes compared to a “standard UA Server Profile”. Memory and resource consumption becomes predictable and thus can be handled by the embedded devices. A UA server running on a powerful PC platform is expected to support more parallel connections. However, and that is the important part, they both use the exact same services for the same functionality e.g. read and write of their data points. When a server supports the full profile of a “Standard UA Server” it can be easily enhanced. By adding event subscriptions and method facets to the full featured profile, it becomes an Alarms&Condition UA Server. A detailed list of profiles and their contained conformance units can be found on the OPC Foundation website:
**www.opcfoundation.org/profilereporting**

| Service Set | Description |
|---|---|
| **Discovery** | Obtain endpoint and security information needed for connect attempt |
| **SecureChannel** | Establish a secure end-to-end communication channel |
| **Session** | Create and manage sessions and authenticate user credentials |
| **NodeManagement** | Modify the address space of a server |
| **View, Query** | Browse and request filtered information and view on the servers address space |
| **Attribute** | Read and write values of variables and other node attributes including the history of data and events |
| **Method** | Invoke methods that a server may offer |
| **Suscription, MonitoredItem** | Monitor variable values for data changes and objects for event notifications |



## INFORMATION MODEL

From a functional point of view, UA information models unify the classic OPC specifications data access (DA), alarms and events (A&E), historical data access (HDA) plus the two previous specifications Commands and Complex Data. The new UA node represents anything, starting from a simple variable up to a node object that encapsulates and fully represents a machinery subcomponent or a complete machine. An object may contain data variables, it can initiate events and can provide callable methods, and it may have historic information on values and events.
A server exposes instances – accessible nodes of a certain type – in its address space. The address space can be organized in a hierarchical or non-hierarchical manner as nodes are interlinked by references in a full meshed network. UA defines so called “well known types” that cover all use cases known from previous OPC functionalities, but the UA type system is extendable. Custom types can be inherited and enhanced, but also complex types can be composed as needed. A client can generically discover or browse through the server’s instance and type system following certain references. Hence the client will gather all required information to interpret the data provided by that particular server. The beauty of this concept is that the data describes itself including all metadata and semantic information.
OPC UA distinguishes between the types and the instances when describing data models. For that reason the OPC Foundation has defined a graphical syntax according to UML, but enhanced for special OPC UA needs. The DA Information Model of UA for example enhances the base variable type with an AnalogItemType, which defines standard properties like range and unit to describe analog measurement values. When composing an analog measurement object type, which is derived from the BaseObject type, it will use an AnalogItem type for the measurement value itself, but it also can include system and level alarm objects including their conditions. The UA server on the measurement device or PLC, will now have multiple instances of analog measurements, for measuring pressure, temperature or any other analog value but all instances have the same node tree below the instance nodes and the type node.



## SECURITY

OPC UA addresses all the security threads modern interlinked industrial devices are facing today. Security is not optional and was built into the core of OPC UA. The core security features of OPC UA are:

- → Authentication
- → Authorization
- → Confidentiality
- → Integrity
- → Auditability
- → Availability

features. Similar to the WS SecureConversation used in the web service binding, the OPC UA SecureConversation in the UA Binary protocol uses message-layer-encryption based on shared security context, the so called secure channel.

For double sided authentication of the applications the well accepted asymmetric cryptographic PKI mechanism using X.509 certificates is used. It fully supports certificate authorities (CA) for easy administration and support of trusted chains in large networks. In addition OPC UA defines authorization mechanism for application layer security in terms of user identification using user/password or personal certificates. The individual data points within an OPC UA server itself have access rights comparable to a Linux file system (rwx). With a granularity down to a single node with their attributes, a certain group or individual user may be granted read access. Only an operator or administrator may write a value to this node, whereas a guest may not even see or browse this tag. OPC UA defines audit mechanisms to keep track of who modified which value and when and these audit events are logged in the server. Therefore OPC UA is usable in food and pharmaceutical domains fulfilling FDA rules.

| Feature | UA Native Binary | UA XML Web Service |
|---|---|---|
| **Confidentiality** | Options: encrypt all messages or encrypt only channel management<br>Encryption: AES (symetrix), RSA (asymetric) | WS SecureConversation:<br>XML Encryption (WS Security) |
| **Integrity** | No message alteration: HMAC or RSA encryption, SHA1 hash, periodical key change<br>No message sequence alterations: Nonce, Timestamp | WS SecureConversation:<br>XML Signature (WS Security) |
| **Application Authentication** | X.509 certificates are exchanged when the secure Channel is established | security context establishment and sharing, session key derivation (WS SecureConversation)<br><br>validate credentials, request and issue security tokens (WS Trust) using any of:<br>User/Password, Kerberos, X.509 |
| **User Authentication** | Optional user security token types: User/Password, X.509, Issued Token like Kerberos and Anonymous<br>Server application can validate the user's token | |
| **User Authorization** | Product developer specifies user authorization scheme, implements scheme in server application | |
| **Auditing** | All security events are recorded, traceable through intermediate nodes, minimum required set of logged parameters (for interoperability) | |
| **Availability** | Depends primarily on infrastructure and the Site for protection, minimum processing before authentication | |

Besides the transport connection a UA client and server build up a secure channel, a virtual end to end connection on the communication layer and they establish a session, the virtual communication relation ship, on the application level.

Integrity and confidentiality of the messages between the communication partners is insured by signing and encrypting of messages. Keys are updated after certain time and changed while communicating. This is an integral part of the communication stack. The UA Stack interfaces provide both a Public-Key-Infrastructure (PKI) and crypto library to provide security



## PLATFORM INDEPENDENCE

The available communication stacks cover almost every platform known today. The Java implementation requires Java runtime environment JRE1.6. and can be run on Android based devices up to Windows or Unix based enterprise servers. The .NET implementation requires Microsoft .NET Framework 3.5 which is available on XP up to Windows 7 and 8 Desktop including the 64bit variants.

The ANSI C implementation has the highest flexibility. It is completely platform independent and all operation system specific code is capsulated in a platform layer. There are platform layers available for Windows, Linux but also for real time OS like Windows CE, VxWorks, QNX, RTOS, and many others. The ANSI C stack can be compiled for Intel, ARM and PowerPC architectures and many others. It can be optimized for a certain use case and it can run in single or multi-threaded mode. It is currently the fastest of the three stacks and the smallest in size. In addition there are implementations available that do not even need an operating system. These bare metal C stacks can be used on microcontrollers and they come with their own TCP implementation.

## SPEED AND THROUGHPUT

Even though today's TCP based bindings of OPC UA are not suitable for deterministic hard real time communication, because they use standard TCP, the response time and the general speed and throughput are impressive. Future protocol bindings may support deterministic communication, the abstract service definition of OPC UA supports priority handling of publish messages.

All service calls in OPC UA are designed for accessing large amounts of data and at the same time reducing the used bandwidth as much as possible. For fast access OPC UA defines all services as multi node function e.g. a single read request can read several thousand nodes at once. To avoid the transmission of thousands of node names in each request, OPC UA defines node registration service. Once registered at the server, the following read services can use a handle for fast access and fast transmission of the data.

The subscription services monitor tags for changes and only notify the changed values, such that the bandwidth is minimized without loosing information. For each subscribed node an individual sampling rate and individual queuing allows extreme fast scanning of data at the data source. The server can send the queued data at once, so that it gets published to the client by highly effective transmission over the wire.

## ROBUST COMMUNICATION

OPC UA communication follows the client-server paradigm, even though it is expected that most products will be both, client and server. The client sends an asynchronous service request and receives a response from the server. Every single service call contains a configurable timeout until the client will wait for response to arrive. This insures a highly responsive system. Sequence numbers are used to identify the corresponding request/response message pairs.

When subscribed to notifications of events or value changes, each published response of data is acknowledged by the client with the next publish request. In case of connection interruption or transmission failure the server keeps the unacknowledged messages and resends them when connection is up again. Data collected in the meantime will be buffered or queued by the server such that no data gets lost during short network interruptions. OPC UA insures robust data transmission without the loss of data, even on an unreliable transport medium.

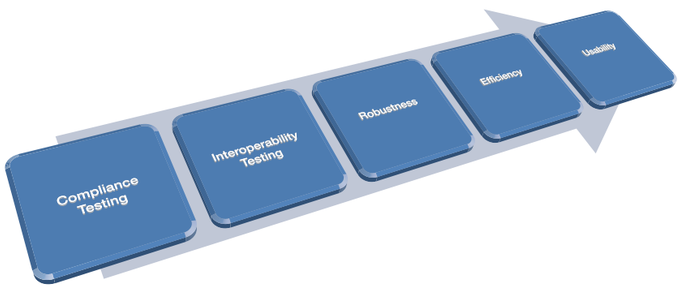
# Certification Program – The Key to Successful Interoperability

Especially for OPC UA the OPC Foundation has enhanced the certification program. The end-users' demand for high quality products and reliable communication led to the foundation of a dedicated working group inside the OPC Foundation. The group has defined test procedures and test cases including the development of test tools. The goal is to provide useful tools for testing and development having highest possible coverage in automated testing. Not only compliance to the specification is tested, but also typical error scenarios and environmental conditions are evaluated. Ease of use is also a focus of the certification program. Certified products are listed as OPC-compliant products in the interactive OPC Product Guide on the OPC Foundation web site.

**CERTIFICATION**

OPC Foundation corporate members can test their OPC server and client products at the OPC Foundation Certification Test Lab. Objective certification testing by the independent test lab guarantees that your products comply with the following:

→ **Compliance** to the OPC Specifications
→ **Interoperability** with other vendors' products
→ **Robustness** and recovery from disaster
→ **Efficiency** of CPU, RAM, and bandwidth etc.
→ **Usability** insures a good user-experience.




**INTEROPERABILITY TESTING**

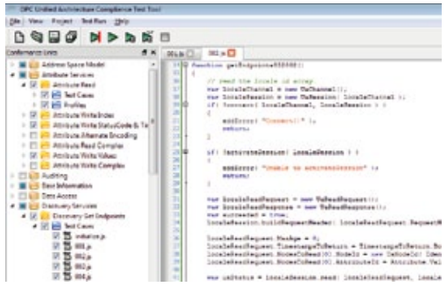
In addition to test lab certification, the OPC Foundation hosts workshops for interoperability testing (IOP), which are held around the globe. There are three IOPs each year: North America, Europe and Asia. Members can participate and test their new products against the software and devices of other members. During the five day session typically 40 to 60 products are tested. The high number of clients and servers create an extraordinary test environment, you would never be able to set up on your own. The IOP is an valuable endorsement of products. Each client participating must connect and interact with each server and execute a set of operations defined in a test matrix. The results of the session are published in a database.

For many years the European IOP workshop has been hosted by Siemens in Nuremberg, Germany. Since 2010 there have been more UA products registered than classic OPC products showing the strong commitment to OPC UA technology and interoperability of high quality products. During the event you can meet and network with other developers, testers, and the core team of OPC UA technology enthusiasts.



**TEST TOOLS**

There are different test tools available to validate the correct function of an OPC UA server or client product. As an OPC member you have access to all the tools and test code. Members also have access to the OPC Compliance Test Tools (CTT) to ensure OPC products meet the appropriate specifications. The script based tool can be enhanced with self created product specific test cases. Also the CTT can be integrated into your company's automated system and regression test.



# Certification that Matters

»The Certification Programme is a key benefit of OPC Foundation membership. Extensive functional testing with the CTT and interoperability testing in the lab has helped us deliver a product of the highest quality.«

**Liam Power,** Embedded Labs

»We achieved Independent confirmation of the highest product quality, which is well applicable as sales argument and appreciated informative discussions with OPC Senior Experts about further opportunities with OPC UA.«

**Rene Bernhard,** Siemens

»Becoming lab certified by the OPC Foundation instills confidence to our customers and potential customers that our software products are held at the highest level of interoperability and reliability.«

**Ron DeSerranno,** Mobiform Software, Inc.

»With a global customer base, we hold our Matrikon OPC products and solutions to the highest quality standards. Based on this commitment to quality – we were pleased to work the OPC Certification lab to be the first OPC vendor in the Americas to achieve independent, 3rd party OPC UA Certification. The lab personnel were experienced professionals which, helped make the process straightforward.«

**Rod Stein,** MatrikonOPC

»No matter how much history exists on a product's OPC interface, there is nothing better than the endorsement from an independent party – especially when it comes from the OPC Foundation, the organization responsible for the definition of these standards.«

**Tony Paine,** Kepware Technologies

MACHINE MANUFACTURING

## Arburg – OPC UA enables machine manufacturer delivery reliability

**»We were looking for a globally accepted data exchange standard and found it in the form of OPC Unified Architecture.«**

**Michael Vieth,** Group Leader TA Control Technology, ARBURG GmbH + Co KG

**HIGH DELIVERY RELIABILITY THROUGH CONTINUOUSLY AVAILABLE KEY DATA**

Customers of Arburg moulding machines can centrally manage product, tool and material master data, as well as capture data online regarding order progress, machine status, process parameters and alarms.

They can also determine key data on orders in same progress, production shifts and production quality at any time. All this runs silently in the background via an OPC UA connection between the host computer system and the machine. This allows the user to receive reliable data and enables them to use the existing capacities to their fullest extent, and thus achieve high delivery reliability.

**PLATFORM INDEPENDENCE THROUGH OPC UA**

While the embedded OPC UA server runs under VxWorks on the visualization CPU of the control system, the OPC UA client runs in a Java environment, showing platform independence of the OPC UA standard. Just as customers can connect their own host computer systems to the Arburg injection moulding machines via OPC UA, the Arburg host computer system can access third-party injection moulding machines via OPC UA.



RENEWABLE ENERGY

## AREVA uses OPC UA for monitoring offshore wind farm

OPC UA was the favored technology in ‘Alpha Ventus’, an offshore wind park test site in the North Sea, 45 kilometers from the German coast. The fully automated wind turbine controlled by a Windows Embedded CE with IEC6-1131-3 logic and OPC UA server is connected to operators to constantly monitor plant and equipment conditions remotely from onshore control room on a .NET platform.

Compared to other open standards the inherent security and authentication mechanism of OPC UA was the determining factor for this decision.

With a complex network infrastructure including different subnets and domains, connected via routers and protected by firewalls, configuration and administration becomes a difficult and time-consuming task. In the past VPN tunnels for secure transmission and remote desktop connections were used, but OPC UA includes encrypted transmission and adds user authentication and audit functionality down to individual data points.

The fast and secured communication, between industrial automation and the enterprise systems that support OPC UA industry standards, delivered important business and technical benefits, reduced administration combined with high reliability machines via OPC UA.

**»The integration of OPC UA Client functionality into our SCADA software was an important step towards OPC UA technology.«**

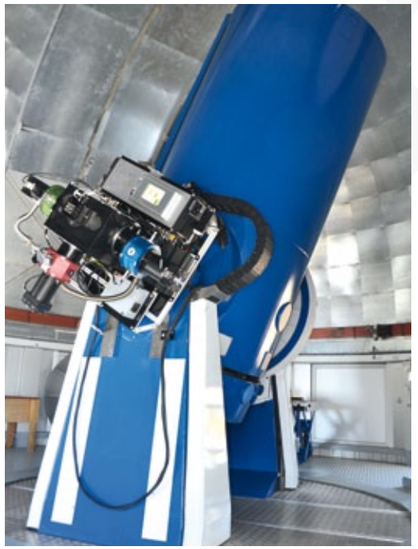
**Bernd Zickert,** Head of Development, Multibrid

## SCIENTIFIC

### KU Leuven uses OPC UA for ground based observatory control

Astronomical observatories are complex distributed real-time systems encompassing a wide range of technology domains. The integration of industrial automation components such as Programmable Logic Controllers (PLCs) and supervisory software has long been hampered by the lack of an adequate industrial communication technology. With OPC UA, these limitations are now eliminated and in addition a powerful new range of functionality has become available.

The extensive OPC UA support for standard communication paradigms and information modeling offers the engineers of the Catholic University of Leuven, Belgium the opportunity to shift from their traditional custom communication solutions towards an industry standard, as they apply their research results to the Mercator Telescope based at the international observatory of La Palma on Canary Islands, Spain. Researchers of the KU Leuven considered OPC UA suitable to serve as the "backbone" technology of ground-based observatory control systems. With respect to a "general purpose" middleware, OPC UA is naturally more tailored to facilitate interaction between the components of a heterogeneous and distributed control system. The engineers proceeded by implementing the control of a new scientific instrument and a new support for the tertiary mirror of the Mercator telescope, on commercial PLCs with on-board OPC UA server. These PLCs were integrated within the Scientific Linux infrastructure of the observatory via OPC UA.



## DISCRETE MANUFACTURING

### Elster GmbH connect shop floor to SAP ME top floor

**ELSTER USES SAP ME AS THEIR STANDARD FOR TRACEABILITY AND PROCESS CONTROLLING**

"More customers demand comprehensive and fast access to production data." Dr. Schlichtegroll, Key Account Manager for OEM customers in the heating energy sector, sees a clear trend: "In the near future a high-performance MES will become a key factor for winning new orders."

An MES roll-out places special demands on Manufacturing IT, such as safe and high-performance interfacing with production (shop floor control) and the higher-level MES and ERP layers.

For direct communication based on high-level languages Elster uses the comprehensive SAP ME web services interface. In most cases PLCs and machines have no option for calling web services. This means that ideally a technology is needed that deals with the communication to the MES system without additional effort in the PLC source code. OPC UA offers ideal prerequisites for this purpose.

Elster is using high-performance Windows Embedded CE controllers with an integrated OPC UA server directly in the PLC, thereby simplifying the system environment and keeping the PLC and OPC UA server always in sync automatically. This results in a fast connection but also easy to handle commissioning and service without special programming knowledge. Using OPC UA opens up new possibilities for lean PLC coding by using SAP ME routing information to control the assemble and test steps.

We see OPC UA as an important standard for ERP communication via MES right down to the smallest embedded system. Trends such as "Industry 4.0" and "Internet of Things" show the way to comprehensive networking that goes far beyond the factory boundary. Safe communication that is independent of the operating system is a prerequisite for achieving the smart factory aim.

1. Print Serial Number
2. Assembly
3. Leakage Test
4. Functional Test
5. Packing


**»OPC UA is a reliable, high performance and easy to use interface which allows our PLC software engineers to connect MES without additional effort.«**

**Roland Essmann,** Head of Laboratory Controls and Project Leader MES, Elster GmbH

# Collaboration with other organizations

Cooperation with other standardization organisations was important for OPC UA from the beginning. The simple extensibility by information models makes OPC UA very interesting for other standardization organizations. They only have to define which information has to be exchanged, but no longer how the information must be exchanged. Before the start of the OPC UA specification, it was one of the most important requirements that OPC UA, as a universal communication platform and IEC standard can form a basis for other standards.

**OPC UNIFIED ARCHITECTURE COMPANION SPECIFICATIONS**

OPC UA consists of a list of specifications for the basic functions and the information models based on them, such as Data Access and Alarms & Conditions. Specifications that define further information models beyond that are called Companion Specifications.

**HOW ARE COMPANION SPECIFICATIONS CREATED?**

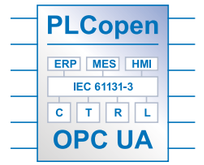
OPC UA Companion Specifications are developed in various ways. One possibility is a working group of OPC members within the OPC Foundation which defines an information model for special branches of industry or areas of application. E.g. the specification OPC UA for Analyzer Devices (ADI) was created in this way on the basis of customer requirements. Another possibility is a common working group with one or more other organisations with the objective of defining an OPC UA information model for a standard outside the OPC Foundation. The information model OPC UA for IEC 61131-3 was created in this way with PLCopen.

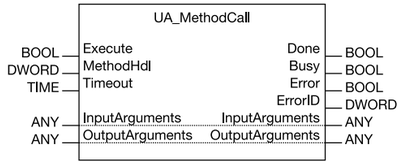
# Collaboration

– PLCopen
– BACnet Interest Group
– FDI Cooperation
– EDDL and FDT
– MESA, MES-D.A.CH.
– OMAC
– Mimosa, ISA-95, ISA-88
– MTConnect
– Smard Grid
– ODVA
– MDIS



**PLCopen**
*for efficiency in automation*




→ Information model in a standardized format
  – provide semantic identical access to various vendor PLC's
→ PLCopen-OPC UA function blocks enable
  – Controller act as UA client
  – Controller invoke methods in UA server
→ Vertical: Moving information from shop floor to enterprise
→ Horizontal: controller-to-controller connectivity
→ Secure, remote "out-of-the-PLCopen-box" communication
→ Rapid engineering for HMI / MES / ERP

**INTEROPERABILITY ON THE NEXT LEVEL**

The IEC 61131-3 standard defines various programming languages and a software model for the programming of control systems. The implementation of this software model on an OPC UA server address space is defined in the combined PLCopen and OPC Foundation specification. Thus, corresponding OPC UA object types are created from declarations of function blocks in the PLC and corresponding OPC UA objects from instances of the function blocks. The advantage is that a control program, regardless of the controller being used and the OPC UA server, is always implemented in the same structure of objects in the address space.

**»Communication is not about data. Communication is about information and access to that in an easy and secure way. This is what the cooperation PLCopen and OPC Foundation is all about. OPC UA Technology creates the possibility for a transparent communication independent of the network, which is the foundation for a new communication age in industrial control.«**

**Eelco van der Wal,** Managing Director PLCopen

**www.plcopen.org**

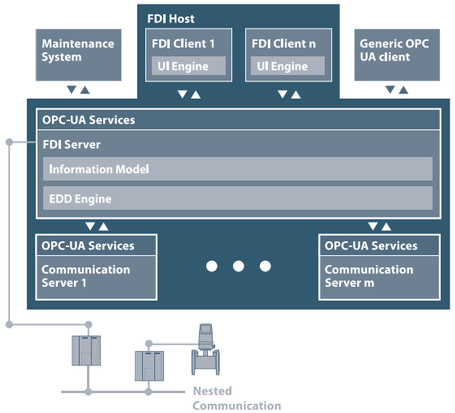

**UNIVERSAL MACHINE CONNECTIVITY FOR MES – UMCM IS: THE NEW STANDARD TO CONNECT MACHINES TO MES.**

→ Based on the PLCOpen ICE 61131-3 standard, it defines a set of complex data profile required by MES systems.
→ OPC UA provides the fast, secured transport from controller to MES in a semantic identical way

**»The fusion of automation technologies and information technologies requires 2 key elements. First – an intelligent network based system which is able to create rule based decisions and which could store data – that is a Manufacturing Execution System (MES) – and perhaps more important, secondly – a communication layer that is fast, platform independent, scalable, secure and could be integrated horizontally and vertically from the device level to ERP level – OPC UA. So we have – regardless of the location of the data storage – an industry 4.0 or a so-called cyber-physical system (CPS).«**

**Angelo Bindi,** Senior Manager Central Control and Information Systems, Continental Teves, MES DACH Board member

**www.mes-dach.de**




### DEVICE CONFIGURATION

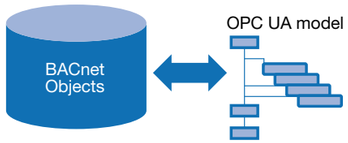
The OPC UA services supported by the FDI server allows safe and secure access to the device or to stored offline data. Generic OPC UA clients can be maintenance tools or a MES or ERP system.

### FDI USES SCALABILITY OF OPC UA

The FDI standard allows the implementation of different software architectures for a host. A host can be implemented starting from a tool for a single user up to a distributed multi-user application with a client/server-architecture which typically consists of three main components: FDI clients, an FDI server and one or more FDI communication servers.

**www.fdi-cooperation.com**






**OPC UA INFORMATION MODEL FOR BACNET**

→ Cooperation between OPC Foundation and BACnet Interest Group Europe
→ Enables BACnet enterprise integration through OPC UA
→ Enables cross domain connectivity Building Automation with BACnet Industrial Automation with OPC UA

**TYPICAL USE-CASES OF THE OPC UA / BACNET MAPPING:**

→ **Observation:** Building automation may be observed/controlled by enterprise systems and multi-domain integration allows connecting industry automation to building automation.
→ **Operations:** Beyond simple data-exchange access to historical data, alarms and schedule programs offers a very detailed depth of integration.
→ **Engineering:** The configuration of building automation systems may be modified using the mapping profile.
→ **Maintenance:** Access to runtime information like alarm-detection or schedule programs offers configuration of BACnet devices from OPC UA systems.

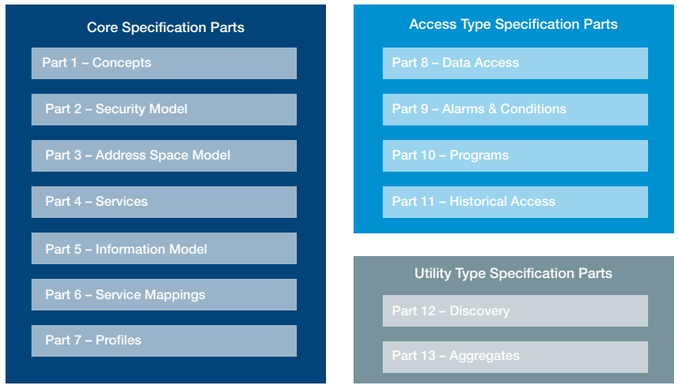
**»The benefits of connecting BACnet and OPC UA are various. Building automation components may provide data, alarms, schedule programs, trend-log information and remote device management to enterprise systems. Connecting OPC UA components to building automation management systems or devices opens the connectivity to industry systems.«**

**Frank Schubert,** Member of the Advisory Board of the BACnet Interest Group Europe

**www.big-eu.org**

# OPC UA is IEC 62541

OPC UA technology was presented to the International Electrotechnical Commission (IEC). The national representatives worked closely together and OPC UA quickly became an IEC standard. This shows the importance and relevance of OPC UA as an internationally accepted and open standard that is usable far beyond the industrial automation domain. Being an open IEC standard made OPC UA the sustainable and credible communication technology for multivendor interoperability.




| IEC Number | Release Date | OPC UA Specification Titel |
|---|---|---|
| IEC/TR 62541-1 | February 2010 | OPC Unified Architecture – Part 1: Overview and Concepts |
| IEC/TR 62541-2 | February 2010 | OPC Unified Architecture – Part 2: Security Model |
| IEC 62541-3 | July 2010 | OPC Unified Architecture – Part 3: Address Space Model |
| IEC 62541-4 | October 2011 | OPC Unified Architecture – Part 4: Services |
| IEC 62541-5 | October 2011 | OPC Unified Architecture – Part 5: Information Model |
| IEC 62541-6 | October 2011 | OPC Unified Architecture – Part 6: Mappings |
| IEC 62541-7 | July 2012 | OPC Unified Architecture – Part 7: Profiles |
| IEC 62541-8 | October 2011 | OPC Unified Architecture – Part 8: Data Access |
| IEC 62541-9 | July 2012 | OPC Unified Architecture – Part 9: Alarms and conditions |
| IEC 62541-10 | July 2012 | OPC Unified Architecture – Part 10: Programs |

**OPC UA SPECIFICATION**

The OPC UA specification is a multipart specification. In contrast to the COM based specifications, the UA specification is not only a user specification. Most parts of the multipart spec describe OPC UA internals, that are implemented and handled by the UA communication stacks. This information is only interesting for developers that want to port the UA stack to other platforms or those who want to implement a new UA stack from scratch. However, UA application developers will typically use only the API documentation. For implementers of UA server and clients mainly the part 3, 4, and 5 are of interest.

**THERE ARE 3 GROUPS CATEGORIZING THE MULTIPLE PARTS OF THE OPC UA SPECIFICATIONS:**

→ **1. Core Specifications:**
Contains the basic concepts of UA technology and the security model, and contains abstract description of UA meta model and UA services, also contains the concrete UA information model and protocol mappings, plus the concept of profiles for scalability

→ **2. Access Type Specifications:**
Contains the information model extension for the typical UA access types DA, A&C, HA and Programs

→ **3. Utility Type Specifications:**
Contains additional concepts for finding UA enabled components and endpoints in and across networks, and contains the description for aggregates and calculation methods to be applied on historical values

IEC 62541 Standard – Every OPC UA core specification is also available as open IEC 62541 standard.



# OPC Foundation Website www.opcfoundation.org

Regional OPC Foundation Websites with all details regarding regional activities can be found here:
→ Europe: www.opcfoundation-events.com
→ Japan: www.opcjapan.org/eng/index.asp
→ China: www.chinaopc.org

→ OPC UA Technology
→ OPC Foundation
→ Case Studies
→ Certified Product List
→ Vendor List
→ Product Search
→ Member List
→ Member Press Releases
→ Member Login Area
→ Newsletters and Articles
→ Blogs
→ Upcoming Events

→ Downloads
(White papers, specifications, sample code, test tools, …)
→ Regional Area
(Europe, Japan, China)
→ Videos
→ Webinar Recordings
→ IP Policy
→ Support Area
→ Careers

# Further Information


**OPC FOUNDATION MEMBERSHIP BENEFITS**

**OPC UA OVERVIEW**

**SECURITY**

**COLLABORATION OVERVIEW**

**COLLABORATION PLCOPEN**

All flyers are available in English, German, French, Spanish, Italian.

# Recomended Literature


OPC
From Data Access to
Unified Architecture

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OPC
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