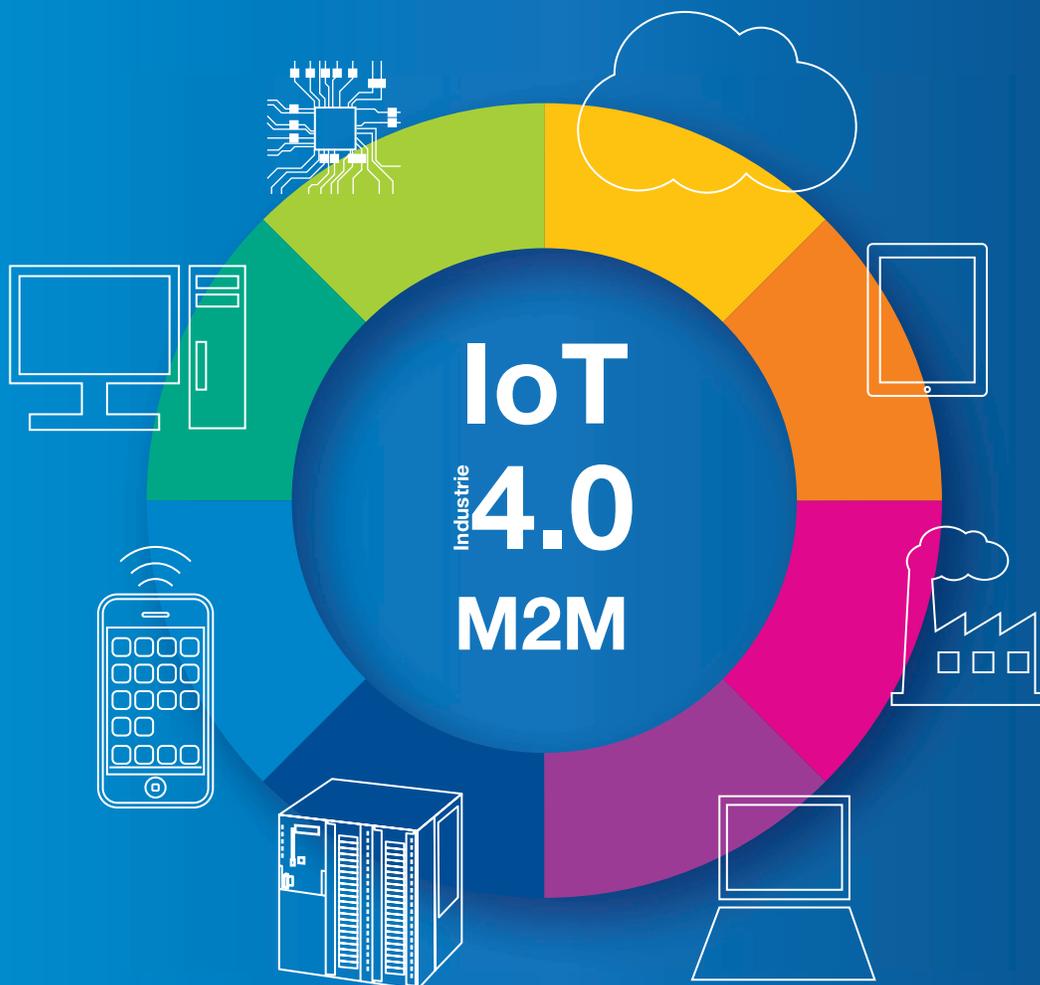

OPC Unified Architecture

Interoperability for Industrie 4.0 and the Internet of Things

Version 07 // November 2017





Thomas J. Burke
President and Executive Director
OPC Foundation

Welcome to the OPC Foundation! As the international standard for vertical and horizontal communication, OPC UA provides semantic interoper- ability for the smart world of connect- ed systems.

OPC Unified Architecture (OPC UA) is the data exchange standard for safe, reliable, manufacturer- and platform-independent industrial communication. It enables data exchange between products from different manufacturers and across operating systems. The OPC UA standard is based on specifications that were developed in close cooperation between manufacturers, users, research institutes and consortia, in order to enable safe information exchange in heterogeneous systems.

OPC has been very popular in the industry and also becoming more popular in other markets like the Internet of Things (IoT). With the introduction of Service-Oriented-Architecture (SOA) in industrial automation systems in 2007, OPC UA started to offer a scalable, platform-independent solution which combines the benefits of web services and integrated security with a consistent data model.

OPC UA is an IEC standard and therefore ideally suited for cooperation with other organizations. As a global non-profit organization, the OPC Foundation coordinates the further development of the OPC standard in collaboration with users, manufacturers and researchers. Activities include:

- Development and maintenance of specifications
- Certification and compliance tests of implementations
- Cooperation with other standards organizations

This brochure provides an overview of IoT, M2M (Machine to Machine) and Industrie 4.0 requirements and illustrates solutions, technical details and implementations based on OPC UA.

The broad approval among representatives from research, industry and associations indicates OPC UA to be a key ingredient of data and information exchange standards.

Regards,

Thomas J. Burke

President and Executive Director

OPC Foundation

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OPC UA: Industrial Interoperability for the IoT

Digitalization is an important and highly attractive growth market. The goal is to foster the integration of IT Technologies with products, systems, solutions and services across the complete value chain which stretches from design and production to maintenance. Once implemented, digitalization opens the doors to new business opportunities like the digitalization of products and systems, new and enhanced software solutions, and new digital services.

The Internet of Things (IoT) brings together a broad range of technologies that have traditionally not been connected via today's near ubiquitous IP-based networks. While Ethernet provides the ability for things to 'reach' each other, they still need a common way to communicate. Standardized data connectivity and interoperability addresses this need. In simple terms, with standardized data connectivity at its core, the Industrial IoT (IIoT) can be looked at from two perspectives: horizontal and vertical data connectivity. An example of horizontal communications is Machine to Machine (M2M) data connectivity between shop floor systems.

An example of vertical communications is device-to-cloud data transfer. In both cases, the OPC UA standard from the OPC Foundation provides a secure, reliable foundation robust enough to facilitate standards based data connectivity and interoperability. For years the OPC Foundation has worked with many companies and associations to make this a reality and will keep doing so as it continues to expand its collaboration activities.

MACHINE INTERACTION

M2M typically defines the communication between two machines or the data transfer between a more or less intelligent device and a central computer. The communication media is either a cable modem or wireless modem. In more modern devices – for example vending machines – data communications are increasingly established over cell networks via SIM cards embedded directly into the vending machine. This point-to-point connection allows the dedicated on-board computer to send key data like stock lev-

els, usage statistics, and alarm messages for the machine owners to best supply and maintain their assets. The business models resulting from this are mainly around logistics and maintenance as well as special condition monitoring and preventive maintenance. For example in the industrial environment, airplane turbines deployed at airports around the world can be constantly monitored to ensure replacement parts are sent just in time to reduce the maintenance times and unplanned down-times.

INTERNET

At its base, the IoT calls for remote device access as well. Hence, while M2M is a part of the IoT, the IoT is not limited to the exchange of data between intelligent devices. It also includes data from simple sensors and actuators (i.e. wearable fitness solutions in the consumer space, safety sensors like gas and proximity detectors in industrial settings) that will be first aggregated and processed locally then sent via gateways (a smart phone) to central systems in the cloud. Within IoT, complex networks of intelligent systems are emerging. A similar development can be observed for industrial solutions where shop floor machines and field devices are not just connected to networks sending raw data. Instead, they increasingly process and combine data from other devices due to the increasing computing power of these devices. They can consume and provide information from/to other field devices to create new value for the user. Ultimately, such machine collaboration enables individual machines to provide technicians with maintenance strategies and on-demand maintenance history. A far cry from raw sensor data only systems.

COMMUNICATION

Communication requirements between 'things' and services in the IoT era are far broader than what is seen in today's established infrastructures. For example, rather than query individual sensors and devices directly via point-to-point communications, broader systems will subscribe to the data these



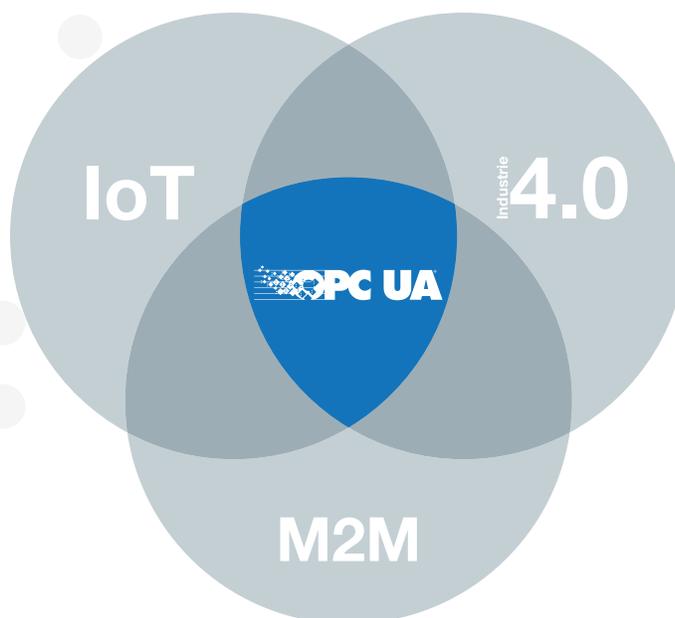
sub-components publish via publish-subscribe (PubSub) protocols. This will simultaneously facilitate high scalability and improve security. Typically these things and systems will communicate via IP-Networks between each other and with cloud based big-data applications. The customer benefits created by the combination of these intelligent devices and systems with services that operators and vendors provide to their customers will serve as the foundation for realizing the massive benefits the IoT promises to deliver.

OPC UA INTEROPERABILITY

The vision of IoT can only be realized, if the underlying communication between central components is based on a global communication standard that can fulfill a wide range of complex requirements. For example, while a publish/subscribe model for the low-resource, one-to-many communication is needed for scalability and speed; it still requires a secure con-

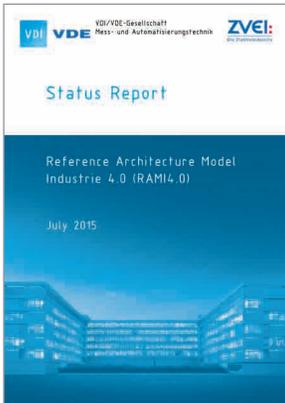
nection oriented client/server communication model to handle bi-directional communication that allows sending control commands to actors. Furthermore information must be accompanied by a semantic meta-data-model that describes the data and its purpose to help best use the data directly and especially when it is pooled together with data from a diverse eco system of other third party systems. As information is aggregated across multiple system layers, increasing amounts of meta-data are brought together. This makes using a common standard for preserving the context critical to ensure the value of the overall-data is preserved.

Scalability and the possibility of integration across all layers is required as well as platform and vendor independence. The OPC UA standard offers a complete solution for all of these requirements across vertical layers for remote device access.



OPC UA serves as the common data connectivity and collaboration standard for local and remote device access in IoT, M2M, and Industrie4.0 settings.

OPC UA – pioneer for Industrie 4.0



Source: www.zvei.org, July 2015

CHALLENGE

In order to maintain the competitiveness of modern industrial countries it is necessary to meet the challenges of increasing efficiency with ever shorter product cycles through more effective use of energy and resources, of reducing time to market by producing more complex products faster with high innovative cycles, and of increasing flexibility through individualized mass production.

VISION

The 4th industrial revolution (Industrie 4.0) is driven by advanced information and communication technologies (ICT), which are becoming increasingly prevalent in industrial automation. In distributed, intelligent systems physical, real systems and virtual, digital data merge into cyber physical systems (CPS). These CPS are networked and form “smart” objects that can be assembled into “smart factories”. With increasing processing power and communication capacity, production units are able to organize themselves and become self-contained. They have all the information they need or can obtain it independently. The systems are networked and autonomous, they

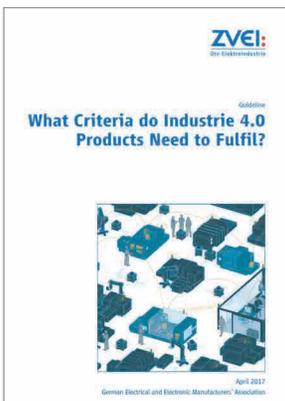
reconfigure and optimize themselves and are expandable (plug-and-produce) without engineering intervention or manual installation. Virtual images are carried throughout the production, product life time and value creation chain within the produced goods and always represent the current state of the actual product. Such “smart” products are networked with each other in the Internet of Things and respond to internal and external events with learned behavior patterns.

REQUESTS

Considerable effort is required for implementing the vision of Industrie 4.0 successfully, since demands vary considerably. In order to reduce the complexity, comprehensive modularization, wide-ranging standardization and consistent digitization is required. These demands are not new. They are not revolutionary either, but the result of continuous development.

This evolution is a long-standing process that started a long time ago. Solutions for many of the requirements outlined below already exist. They are the foundation of Industrie 4.0.

OPC UA COVERS THE COMMUNICATION AND INFORMATION LAYER IN RAMI4.0



Source: www.zvei.org, April 2017

Product properties 2017 for the criteria for Industrie 4.0 products

→ Criteria 2:

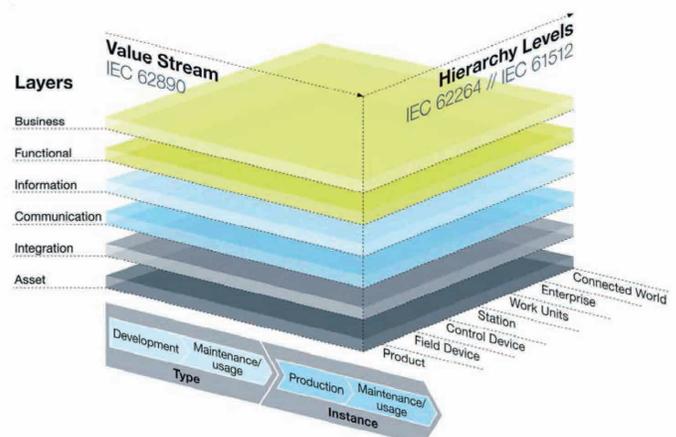
Industrie 4.0 communication

Mandatory: Product addressable online via TCP/UDP&IP with at least the information model from OPC UA

→ Criteria 5:

Industrie 4.0 services and conditions

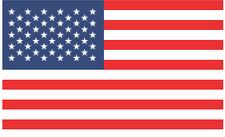
Optional: Information such as statuses, error messages, warnings, etc. available via OPC UA information model in accordance with an industry standard



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Industrie 4.0 requirements – OPC UA solution

Industrie 4.0 requirements	OPC UA solution
Independence of the communication technology from manufacturer, sector, operating system, programming language	The OPC Foundation is a vendor-independent non-profit organization. Membership is not required for using the OPC UA technology or for developing OPC UA products. OPC is widely used in automation but is technologically sector-neutral. OPC UA runs on all operating systems – there are even chip layer implementations without an operating system. OPC UA can be implemented in all languages – currently stacks in Ansi C/C++, .NET and Java are available.
Scalability for integrated networking including the smallest sensors, embedded devices and PLC controllers, PCs, smartphones, mainframes and cloud applications. Horizontal and vertical communication across all layers.	OPC UA scales from 15 kB footprint (Fraunhofer Lemgo) through to single- and multi-core hardware with a wide range of CPU architectures (Intel, ARM, PPC, etc.) OPC UA is used in embedded field devices such as RFID readers, protocol converters etc. and in virtually all controllers and SCADA/HMI products as well as MES/ERP systems. Projects have already been successfully realized in Amazon and Microsoft Azure Cloud.
Secure transfer and authentication at user and application level	OPC UA uses X.509 certificates, Kerberos or user/password for authentication of the application. Signed and encrypted transfer, as well as a rights concept at data point level with audit functionality is available in the stack.
SOA, transport via established standards such as TCP/IP for exchanging live and historic data, commands and events (event/callback)	OPC UA is independent of the transport method. Currently two protocol bindings are available: optimized TCP-based binary protocol for high-performance applications and HTTP/HTTPS web service with binary or XML coded messages. Additionally Publish/Subscribe communication model can be integrated. The stacks guarantee consistent transport of all data. Besides live and real time data also historical data and their mathematical aggregation are standardized in OPC UA. Furthermore method calls with complex arguments are possible, but also alarm and eventing via token based mechanism (late polling).
Mapping of information content with any degree of complexity for modeling of virtual objects to represent the actual products and their production steps.	OPC UA provides a fully networked concept for an object oriented address space (not only hierarchical but full-meshed network), including metadata and object description. Object structures can be generated via referencing of the instances among each other and their types and a type model that can be extended through inheritance. Since servers carry their instance and type system, clients can navigate through this network and obtain all the information they need, even for types that were unknown to them before. This is a base requirement for Plug-and-Produce functionality without prior configuration of the devices.
Unplanned, ad hoc communication for plug-and-produce function with description of the access data and the offered function (services) for self-organized (also autonomous) participation in "smart" networked orchestration/combination of components	OPC UA defines different "discovery" mechanisms for identification and notification of OPC UA-capable devices and their functions within a network. OPC UA participants can be located local (on the same host), in a subnet or global (within enterprise). Aggregation across subnets and intelligent, configuration-less procedure (e.g. Zeroconf) are used to identify and address network participants.
Integration into engineering and semantic extension	The OPC Foundation already collaborates successfully with other organizations (PLCopen, BACnet, FDI, AIM, etc.) and is currently expanding its cooperation activities, e.g. MES-DACH, ISA95, MDIS (oil and gas industry), etc. A new cooperation initiative is with AutomationML, with the aim of optimizing interoperability between engineering tools.
Verification of conformity with the defined standard	OPC UA is already an IEC standard (IEC 62541), and tools and test laboratories for testing and certifying conformity are available. Additional test events (e.g. Plugfest) enhance the quality and ensure compatibility. Expanded tests are required for extensions/amendments (companion standards, semantics). Additionally various validations regarding data security and functional safety are performed by external test and certification bodies.



One the major goals of the “Industrial Internet Consortium” (IIC) is the creation of industry use cases and testbeds for real-world applications. The testbeds create recommendations for the reference architecture and frameworks necessary for interoperability. OPC UA is the enabling technology for SoA interoperability and thus part of the IIC Connectivity Framework published in February 2017.

Testbeds with OPC UA involved



Source: www.iiconsortium.org

1. SMART MANUFACTURING CONNECTIVITY FOR BROWN-FIELD SENSORS

This testbed implements an alternative solution by substituting IO-modules that connect the sensors with the real-time automation system by a gateway that extracts the sensor data and transfers them to the IT system through an additional communication channel via OPC UA (IEC 62541).

2. TIME SENSITIVE NETWORKING (TSN) TESTBED

The TSN technology will be used to support real-time control and synchronization of high performance ma-

chines over a single, standard Ethernet network, supporting multi-vendor interoperability and integration. OPC UA over TSN uses standard IT infrastructure for controller to controller communication between devices from different vendors.

3. SMART FACTORY WEB TESTBED

Secure Plug & Work techniques based on the standards AutomationML and OPC UA are applied to adapt factories on-the-fly by inserting new manufacturing assets into the factory production with a minimum of engineering effort.



INDUSTRIAL VALUE CHAIN INITIATIVE (IVI)

»OPC UA is a key enabler for connected manufacturing, where huge variety of factory-floor operations are connected both through the cyber and physical ways. The Industrial Value Chain Initiative (IVI) is an organization providing win-win cooperation opportunities for enterprises moving toward the next era of connected industries. Since most of the members are manufacturers, IVI is especially focusing on ac-

tual and practical requirements of factories. In consideration of the Industrial Value Chain Reference Architecture (IVRA), those requirements are described in a form of smart manufacturing scenario, which shows a current situation as well as a desired goal of the factory. While the scenarios are evaluated in the test-bed factory, an IVI platform performs and OPC UA can give a reasonable way of implementation for secure and concrete connections. Furthermore, as an open standard specification, OPC UA is meaningful for the IVI platform ecosystem, where application suppliers, IoT device vendors, data infrastructure and software tool providers are involved to enhance the value of the platforms.«

Prof. Dr. Yasuyuki Nishioka, President, Industrial Value Chain Initiative



Chinese government puts forward Made In China 2025 plan in order to facilitate China's transformation from a manufacturing giant with a focus on quantity to one with qualitative edge. The main attack direction of Made In China 2025 is Intelligent Manufacturing, which is based on deep integration of new-generation information technology and advanced manufacturing technology, and is the effective means to achieve goals of shortening product development cycle, increasing production efficiency and product quality, and reducing operation cost and energy consumption.

Intelligent Manufacturing requires horizontal integration and vertical integration of all information systems, including IT system and OT system in factory/plant, which means communication is not only pure data transmission but also semantic-based information exchange. OPC UA, adopting semantic-based and services-oriented architecture (SOA), defining communication services and information models, is a natural fit for the integration of interconnected networks in digital factory/plant and implements semantic interoperability. Therefore, SAC/TC124 has organized to transfer OPC UA specifications to Chinese recommended national standard.

China: Made in China 2025 OPC UA parts 1 – 12 are Chinese National Standard



»Industrial IoT can be viewed as the convergence of ICT and OT in the various industrial verticals. The resulting technology innovation has created an inflection point that will change how we think of, participate in and benefit from the industrial sector. In response to this inflection point, there is an emerging ecosystem that includes standards, best practices and reference architectures. This ecosystem includes both industry stakeholders and government initiatives across geographies and verticals. OPC Foundation is an essential part of that emerging ecosystem. It defines OPC UA, a standard that is fundamental to linking the ICT an OT environments in a way that is both secure and forward looking, thus enabling new innovations such as real time manufacturing, digital manufacturing and low latency/time sensitive industrial systems.«

Wael William Diab, Senior Director, Huawei Technologies Co., Ltd.



»In 2015, ITEI undertook 7 Intelligent Manufacturing Projects issued from MIIT, in which basic and common standards regarding to intelligent manufacturing body will be set. One project is “Industrial control networks standard research and verification platform”, and one task of this project is to draft a national standard named “OPC UA-based unified architecture for interconnected networks in digital plant”, which will provide a unified solution for interconnecting the networks among device level, control and management level in digital plant. This standard will promote, that the device manufacturers should provide OPC UA servers for their produced devices directly, and the software vendors should better to embed OPC UA clients. Therefore, for the device manufacturers and the software vendors, it is only needed to invest and develop once, while for the manufacturing enterprises and the system integrators, it will avoid case-by-case solutions, which will decrease integrating costs and cycles greatly.«

Jinsong Ouyang, President, Instrumentation Technology & Economy Institute, P.R.China (ITEI) Vice chairman of the committee, National TC124 On Industrial Process Measurement, Control And Automation Of Sac



South Korea is pursuing smart factory based on “Manufacturing Industry Innovation 3.0 (MII3.0)” in response to the paradigm shift of the 4th Industrial Revolution. MII3.0 is aiming 3 achievements (High productivity, High flexibility, High resource awareness) through 3 technologies (Automation, Production, and ICT). By 2020, it is working as a practical goal to spread smart factory technology to 10,000 enterprises in cooperation with major domestic and foreign companies. Especially, OPC UA will be used as an industrial standard to connect between OT (Operational Technology) and IT (Information Technology).



KETI Korea Electronics
Technology Institute

»KETI is committed to technology development related to standards and interoperability in IoT. This is particularly important for industrial Internet of Things

(IIoT) deployments. In IoT environments, we see OPC UA as a critical standard for ensuring interoperability between a broad set of manufacturing processes and equipment. KETI is developing IIoS framework for information networking and applications and standard IIoT framework for field level interworking to support automatic recognition and connection between various factory-things in factory through OPC UA.«

Byunghun Song, The head of Smart Factory ICT Center, KETI

Korea: Manufacturing Industry Innovation 3.0



SAMSUNG

»The true potential of Industrial IoT will be realized with solutions that guarantee interoperability across business domains, where are independent from vendors and platforms on the market. As one of the largest manufacturing companies in the world, Samsung Electronics sees its great value proposition of the OPC Foundation in terms of protocol interoperability that enables seamless Industrial IoT services. Especially, the OPC Foundation delivers the promising solutions of the OPC UA framework in terms of not only specifications, but also the reliable open source implementations, which guarantees the OPC UA Certifications. This will help us to accelerate Samsung’s efforts in deploying the interoperable Industrial IoT edge platform for our manufacturing infrastructures.«

Kyeongwoon Lee, Senior Vice President, Samsung



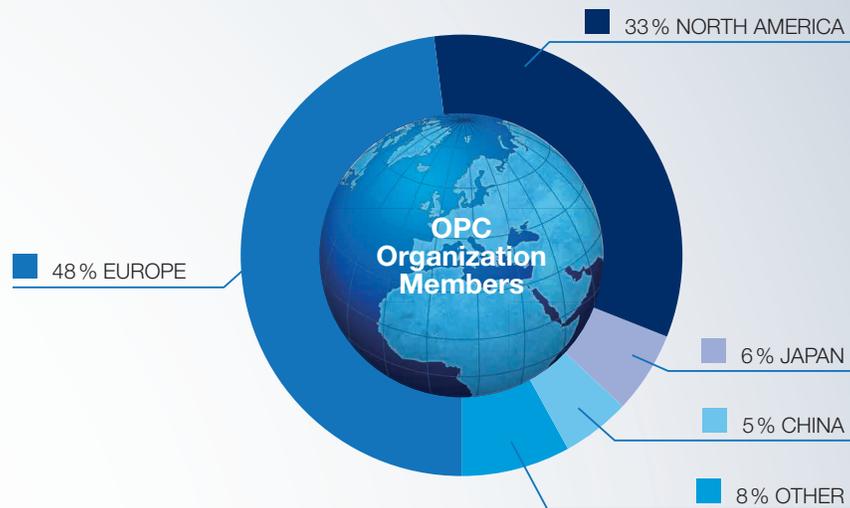
LG CNS

»OPC UA enables application integration, modeling, reunion and data exchange in a simple and consistent standardized way while maintaining high performance and stability.

With OPC UA, LG CNS can develop products that are ultimately going to be deployed to extend across facility control and the MES domain via a standardized and consistent approach for smart factory. It will be used in the integrated engineering business by providing device modeling and meta information exchange function on the server side, as well as basic data collection, monitoring, analysis and control functions on the client side.«

Charlie Cho, The leader of Smart Factory Solution Team, LG CNS

OPC Foundation – organization



With more than 540 members, the OPC Foundation is the world's leading organization for interoperability solutions based on the OPC specifications.

All members, including corporate members, end users and non-voting members, are committed to integrated, compatible communication between software-driven devices, including CPS, in industrial automation environments.

The OPC Foundation offers a marketing program including a newsletter, website and various training and information events aimed at manufacturers of automation solutions and providers of OPC technology. Member companies offer events and training programs for end users of the OPC technology. The cooperation of developers and users in working groups is crucial to ensure that practical requirements and user feedback are taken into account in the specifications.

INDEPENDENCE

The OPC Foundation is a non-profit organization that is independent of individual manufacturers or special technologies. The members of the working groups are provided by the member companies on a voluntary basis. The organization is financed entirely from membership fees and receives no government grants. The organization operates worldwide and has regional contacts on all continents. All members have identical voting rights, irrespective of their size.

MEMBER DISTRIBUTION

Although the head office is in Phoenix, Arizona, most members (almost 50%) are based in Europe. Around one third of the members are based in North America. All main German manufacturers of automation technology are members of the OPC Foundation and already offer OPC technologies in their products.

MEMBERSHIP BENEFITS

Members of the OPC Foundation have full access to the latest OPC specifications and preliminary versions. They can take part in all working groups and contribute requirements and solution proposals.

Members have free access to core implementations and sample code. In addition, script-based test and analysis tools are provided.

Manufacturers of OPC-capable products can have these certified in accredited test laboratories. The developer and user community meets at events for exchange of information and networking. Three times each year, a week-long interoperability workshop (IOP) is held, at which the latest products and their interaction are tested.



»OPC UA is an essential component of the connected products that manufacturing customers need today, and it is increasingly seen as an important part of enterprise IoT scenarios and business models. In keeping with our commitment to openness and collaboration, Microsoft is fully committed to supporting OPC UA and its evolution.«

Matt Vasey, Director of IoT Business Development, Microsoft,
OPC board member



»Manufacturing in the digital world requires a highly connected and intelligent approach to provide high responsiveness to individualized customer demands, to enable flexible manufacturing processes and to fully empower production workers. In order to achieve this SAP is using and supporting standards like OPC UA to ensure simple, scalable and safe information exchange with the shop floor.«

Veronika Schmid-Lutz, Chief Product Owner Manufacturing, SAP AG,
OPC board member

Global Players



»Our goal at Cisco is to drive data into actionable information. With OPC UA we are able to securely and easily access data and move it across the decision making value chain, with our customers and partners.«

Bryan Tantzen, General Manager, Cisco Industries Product Group (IPG)
Connected Industry and Manufacturing BU



»Rockwell Automation is embracing OPC UA to enhance the connectivity for the FactoryTalk® visualization and information software portfolio. FactoryTalk® Linx provides a scalable communications solution from a single computer to large high-volume distributed systems that, since its inception, has supported OPC communications. Extensions to FactoryTalk Linx communications software provide OPC UA client functionality to enable FactoryTalk software to access information from third-party systems. Furthermore, the addition of OPC UA server capabilities in FactoryTalk® Linx Gateway enables third-party software to access the robust data model of the Logix5000™ controller family. OPC UA is a natural fit for Rockwell Automation as it expands its reach of The Connected Enterprise to support a broader range of hardware and software.«

Ron Bliss, Communication Software Product Manager, Rockwell Automation



»The main challenges facing manufacturers and plant operators today continue to be safety, efficiency, reliability, productivity and security. By harnessing the power of digitization in the Industrie4.0 and IIoT era, Honeywell helps customers address these challenges in new ways by leveraging the incredible value hidden in the vast amounts of data being produced by our customers' facilities. OPC UA plays a key strategic role in Honeywell solutions by providing secure, reliable access to context rich 3rd party data which helps unlock the full potential analytics has to offer.«

Vimal Kapur, President Honeywell Process Solution



»One of the principal ideas of the Industrial Internet of Things (IIoT) is to connect industrial systems that communicate data analytics and actions to improve performance and efficiency. The implementation of IIoT will require a paradigm change in the way organizations design and expand industrial systems. Therefore, the integration with existing or third-party automation devices through standard, secure communication protocols is paramount. OPC UA stands up to this challenge by providing a widely adopted and secure industry standard for interoperability between dissimilar processing elements and IT devices on the factory floor. NI has adopted OPC UA in its portfolio of embedded devices to help drive the interconnectivity of Cyber Physical Systems (CPS) in the evolutionary process of IIoT.«

James Smith, Director for Embedded Systems Product Marketing, National Instruments



»ABB is offering a classic OPC interface for most of its products or uses classic OPC to integrate data. As OPC UA does not only allow data exchange but provides information modeling capabilities and communication in a secure, platform-independent way we see a high potential and are fully committed to it. Our customers will benefit from reduced integration efforts and new application scenarios by utilizing the possibilities of OPC UA.«

Thoralf Schulz, Global Technology Manager for Control Technologies, ABB

OPC UA in the industry



»Yokogawa has been a member of OPC Foundation since its establishment and has made a major contribution to the development of the OPC specifications, from OPC Classic to OPC UA. Yokogawa has also released many OPC-compatible products and incorporates these in the many solutions that it provides to its customers. Yokogawa is fully committed to OPC UA and will continue to play a role in its development.«

Shinji Oda, Yokogawa, President OPC Council Japan, OPC board member



»OPC UA will provide a common layer of technical and semantic interoperability for M2M and M2H (Machine to Human) communications that is critical for enabling the Industrial Internet. By establishing interoperability standards together as an industry, we will provide a scalable, reliable platform for GE and others to build out the Industrial Internet and expand the value and capabilities we can provide for our customers.«

Danielle Merfeld, Global Research Technology Director, General Electric



Rexroth
Bosch Group

»With OPC UA a future proven and manufacturer-independent communication standard is offered to the industry. Its scalability allows horizontal and vertical networking of systems, machines and processes. Bosch Rexroth consistently uses this internationally accepted open standard as a key technology and offers extensive services and semantic information models for its products. We develop the functionality continuously, so that our customers are able to ideally integrate Rexroth products in their automation environment – for the optimal implementation of Industrie 4.0.«

Dr. Thomas Bürger, Vice President Engineering Automation Systems,
Bosch Rexroth AG



»OPC UA has the potential for an immediate cross-vendor implementation of Industrie 4.0 and the necessary internet based services.

The adoption of this open standard is an opportunity for vendors and users. Proprietary solutions will not generate an adequate value.«

Dr.-Ing. Reinhold Achatz, Head of Corporate Function Technology,
Innovation & Sustainability, ThyssenKrupp AG



SIEMENS

»Siemens is a global technology powerhouse and the world market leader in the area of automation systems. We're seeing digitalization of all sectors of industry and we're playing an active role in shaping it.

As a founder member of the OPC Foundation, Siemens is keen to drive the development of automation and optimize the interoperability of technologies from different system providers. And this commitment is already bearing fruit: OPC standards are used in many of our innovations, such as the Sinema Server network management solution, the Simatic HMI (Human Machine Interface) and the flexible, modular Simocode pro motor management system. OPC UA is an implementation that we regard as particularly relevant and key element for Industrie 4.0. This is why we have always been very active in this area right from the start and are among the first companies whose products are certified.«

Thomas Hahn, Siemens AG, OPC board member

Pioneers in automation



BECKHOFF

»Industrie 4.0 links the world of automation with the IT and Internet world and will enable the resulting synergies to be leveraged. Networking means communication, communication requires languages and associated functions and services. OPC UA offers a very powerful and adaptable standard basis that is accepted worldwide.«

Hans Beckhoff, Managing Director, Beckhoff Automation GmbH



»Schneider Electric sees the advent of the Industrial Internet of Things as an “evolution”, not a “revolution”. In a world where our smart connected products and systems operate as part of larger systems of systems, consistency when moving data is important. Even more important is putting data into context. With OPC UA we can efficiently and effectively deliver systems and applications that do just that – and thus help our customers fully realize the potential of Industrie 4.0.«

John Conway, VP Strategy & Partnerships, Schneider Electric



»In the production of the future, standardized interfaces like OPC UA will be essential for the communication and connection of intelligent components which are ready for Plug and Produce. Thereby we will be able to connect modular and scalable production facilities much easier to superordinate systems like MES or ERP. At the OPC Day Europe in 2014 we already showed an OPC UA test implementation in our production. Also the innovative transport system Multi-Carrier-System and the automation platform CPX both have an OPC UA interface for integration into Industrie 4.0 HOST environments.«

Prof. Dr. Peter Post, Leiter Corporate Research and Technology, FESTO

Global Players in the Industry



»OPC UA proves to be ideal for implementing the functionality required for Industrie 4.0, in terms of communication within automation systems, and interoperability between Industrie 4.0 components via defined objects and semantics. Due to the international support of different automation solution providers, the protocol already finds a use in numerous devices, from the sensor level to Manufacturing Execution Systems (MES) to Enterprise Resource Planning systems (ERP). Acceptance and a future-oriented technological basis will result in the development of an international and evolving standard – OPC UA provides this basis.«

Roland Bent, Managing Director, Phoenix Contact



»One main challenge of Digital Factory is the horizontal and vertical communication among with all systems and devices. For example, a MES system needs to fetch data from each PLC in a production line, which means huge costs. Fortunately, OPC UA connects but also reduces costs for this effort. It provides a secured standardized interface for device data and their meaning. Therefore, we developed Industry Real-time DB product suite, AicVision, completely based on OPC UA, and provide comprehensive data integration solutions for Digital Factory.«

Peizhe Wang, CEO AIC



OMAC
The Organization for Machine
Automation and Control

»OPC UA represents an essential step forward in truly open communications standards, without which there can be no Industrie 4.0 or industrial Internet of Things. OPC UA is consistent with OMAC's most important initiatives, combining standards with functionality to bridge the persistent gap between machines, control platforms, and management systems.«

John Kowal, Board member OMAC & PMMI
(B&R Industrial Automation Corp)



PLCopen
for efficiency in automation

»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

Cooperations with organizations



<AutomationML/>
The Glue for Seamless
Automation Engineering

»The complexity of industrial systems is continuously increasing. To manage this complexity within design and application methods and technologies are required enabling modularity and consequent structuring. The OPC technology and its newest representative OPC UA have been proven to be successfully applicable in this field. It is wide spread applied and can be regarded as entry point for the combination of engineering and application as intended in the Industrie 4.0 approach.«

Prof. Dr.- Ing. habil. Arndt Lüder, Otto-v.-Guericke University Magdeburg,
Fakulty Mechanical Engineering, AutomationML e.V. Board of Directors



aim
GERMANY

»The implementation of future concepts like the Internet of Things and Industrie 4.0 requires reliable data about the trace of moving objects in manufacturing and logistics. In order to achieve such data systems identifying objects automatically, sensors recording environmental data and real-time locating systems must be installed increasingly. OPC UA provides the right architecture to integrate such systems with the existing IT landscape in the enterprises. The OPC AIM Companion Specification will substantially facilitate these tasks.«

Peter Altes, Managing Director, AIM-D
Germany – Austria – Switzerland



»BACnet and OPC UA are already cooperating in the exploration of new opportunities for integration between industrial and building automation: Energy data are semantically defined through BACnet and can conveniently and interoperably be made available to enterprise systems via OPC UA: An ideal standardization from sensor right up to IT billing systems.«

Frank Schubert, member of the BACnet Interest Group Europe advisory board



„OPC UA offers a secure, reliable, interoperable and platform-independent basis for the MDIS information model. The simplified communication connections and increasing data quality offer the oil & gas operators a real value-add.“

Paul Hunkar, DS Interoperability, OPC Consultant of the MDIS Network



»As process automation field devices as system have increased in complexity, device integration with automation systems has become cumbersome. FieldComm Group and OPC Foundation worked together to create the FDI specification and information model for Field Devices based on the OPC UA specification, Future systems and field devices that conform to the FDI standard will be dramatically simpler to configure, integrate, and maintain.«

Ted Masters, President and CEO – FieldComm Group

Science & Research



»The paradigm of Industrie 4.0 requires standards on various levels, to enable an organization of modular plug&play capable production lines. OPC UA is an important standard, helping us to establish communications between plant components in a vendor independent and secure fashion. Because of the industry driven standardization process, we're seeing a high acceptance among industrial users of OPC UA as a platform across all levels of the automation pyramid. Furthermore, OPC UA's information models represents a basis for the realization of a semantic interoperability.«

Prof. Dr. Dr. Detlef Zühlke, Scientific Director Innovative Factory Systems (IFS), DFKI Kaiserslautern

OPC UA at a glance – secure, reliable and platform-independent exchange of information

SECURE, RELIABLE AND PLATFORM- INDEPENDENT EXCHANGE OF INFORMATION

OPC UA is the latest technology generation from the OPC Foundation for the secure, reliable and vendor-independent transport of raw data and pre-processed information from sensor and field level up to the control system and into production planning systems.

With OPC UA every type of information is available anytime and anywhere for every authorized use and to every authorized person.

PLATFORM AND VENDOR-INDEPENDENT

OPC UA is independent of the vendor or system supplier that produces or supplies the respective application. The communication is independent of the programming language in which the respective software was programmed and it is independent of the operating system on which the application runs. It is an open standard without any dependence on, or bind to proprietary technologies or individual vendors.

STANDARDIZED COMMUNICATION VIA INTERNET & FIREWALLS

OPC UA extends the preceding OPC industry standard by several important functions such as platform independence, scalability, high availability and Internet capability. OPC UA is no longer based on Microsoft's DCOM technology; it has been reconceived on the basis of service-oriented architecture (SOA). OPC UA is thus very simple to adapt. Today OPC UA already connects the enterprise level right down to the embedded systems of the automation components – independent of Microsoft, UNIX or any other operating system. OPC UA uses a TCP based, optimized, binary protocol for data exchange over a port 4840 registered with IANA. Web service and HTTP

are also optionally supported. Additional protocol bindings like Multicast or Message-Queuing can be integrated easily without breaking existing communication concepts. The integrated encryption mechanisms ensure secure communication over the Internet.

SERVICE-ORIENTED ARCHITECTURE

OPC UA defines generic services and in doing so follows the design paradigm of service-oriented architecture (SOA), with which a service provider receives requests, processes them and sends the results back with the response.

In contrast to classic Web services that describe their services over a WSDL and can thus be different with each service provider, generic services are already defined with OPC UA.

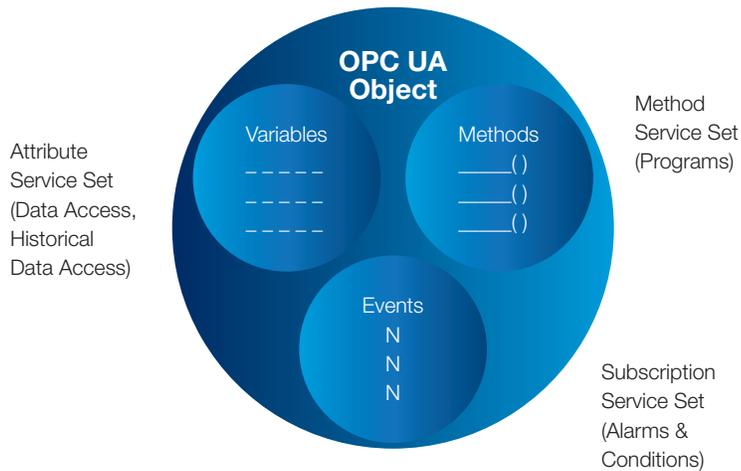
A WSDL is thus not required, because the services are standardized. As a result they are compatible and interoperable, without the caller needing to have any special knowledge about the structure or behavior of a special service. OPC UA defines various groups of services for different functions (reading/writing/signaling/execution, navigation/searching, connection/session/security). The flexibility results from the OPC UA information model. Building on a basic model, any desired complex, object-oriented extensions can be made without impairing the interoperability in the process.

PROTECTION AGAINST UNAUTHORIZED ACCESS

OPC UA technology uses proven security concepts that offer protection against unauthorized access, against sabotage, the modification of process data and against careless operation. The OPC UA security concepts contain user and application authentication, the signing of messages and the



Uniform OPC UA object



encryption of the transmitted data itself. OPC UA security is based on recognized standards that are also used for secure communication in the Internet, such as SSL, TLS and AES. The safety mechanisms are part of the standard and are obligatory for vendors. The user may combine the various security functions according to his case of use; thus scalable security results in relation to the specific application.

ACCESSIBILITY AND RELIABILITY

OPC UA defines a robust architecture with reliable communication mechanisms, configurable timeouts and automatic error detection.

The error elimination mechanisms automatically restore the communication connection between the OPC UA client and the OPC UA server without loss of data. OPC UA offers redundancy functions that are integrable in both client and server applications and thus enable the implementation of high-availability systems with maximum reliability.

SIMPLIFICATION BY UNIFICATION

OPC UA defines an integrated address space and an information model in which process data, alarms and historical data can be represented together with function calls. OPC UA combines all classic OPC functionalities and allows the description of complex

procedures and systems in uniform object-oriented components. Information consumers that only support the basic rules can process the data even without knowledge of the interrelationships of the complex structures of a server.

AREAS OF APPLICATION

The universal applicability of OPC UA technology enables the implementation of entirely new vertical integration concepts. The information is transported securely and reliably from the production level into the ERP system by cascading OPC UA components. Embedded OPC UA servers at field device level and integrated OPC UA clients in ERP systems at enterprise level are directly connected with one another. The respective OPC UA components can be geographically distributed and separated from one another by firewalls. OPC UA enables other standardization organizations to use the OPC UA services as a transport mechanism for their own information models. The OPC Foundation already cooperates today with many different groups from different industries, including PLCopen, AIM, BACnet, ISA and FDI. Additional specifications are compiled that contain common, semantic definitions of information models.

OPC UA technology in detail



Karl-Heinz Deiretsbacher,
Technology&Innovation,
Siemens AG
Director of the OPC UA Technical
Advisory Board



Industrie 4.0 communication is not only based on pure data, but on the exchange of semantic information. In addition, transmission integrity is a key factor. These tasks are essential aspects of the OPC Unified Architecture. OPC UA contains a comprehensive description language and the communication services required for information models and is therefore universally usable.

INTRODUCTION

The trend in automation is towards inclusion of communication data semantics in the standardization. Standards such as ISA 88 (also IEC 61512, batch processing), ISA 95 (also IEC 62264, MES layer) or the Common Information Model (CIM) with IEC 61970 for energy management and IEC 61968 for energy distribution define the semantics of the data in domains addressed by them. Initially this takes place independent of the data transfer specification.

OPC UA – also published as IEC 62541 – enables exchange of information models of any complexity – both instances and types (metadata). It thus complements the standards referred to above and enables interoperability at the semantic level.



Dr. Wolfgang Mahnke,
Software Architect R&D Fieldbus
ABB Automation GmbH



DESIGN OBJECTIVES

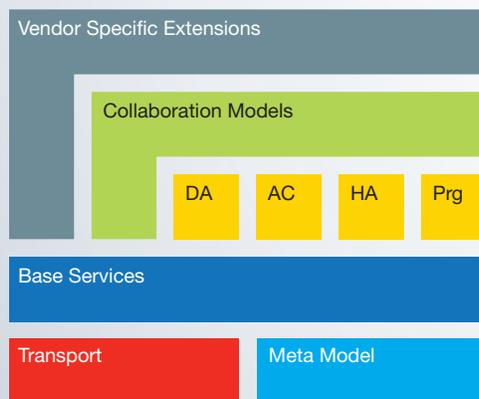
OPC UA was designed to support a wide range of systems, ranging from PLC's in production to enterprise servers. These systems are characterized by their diversity in terms of size, performance, platforms and functional capabilities.

In order to meet these objectives, the following basic functionalities were specified for OPC UA:

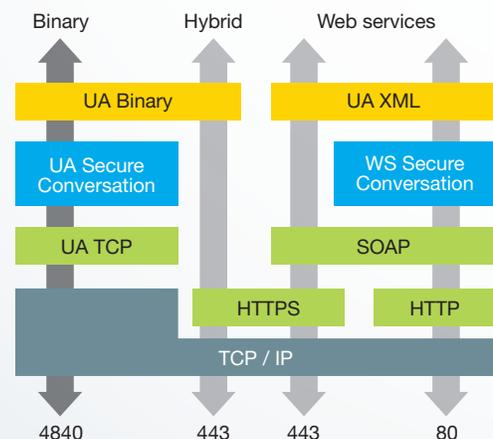
- Transport – for the data exchange mechanisms between OPC UA applications. Different transport protocols exist for different requirements (optimized for speed and throughput = UA TCP with UA Binary; firewall-friendly = HTTP + Soap).
- Meta model – specifies the rules and basic components for publishing an information model via OPC UA. It also includes various basic nodes and basic types.
- Services – they constitute the interface between a server as information provider and clients as users of this information.

Information models follow a layered approach. Each high-order type is based on certain basic rules. In this way clients that only know and implement the basic rules can nevertheless process complex information models.

Although they don't understand the deeper relationships, they can navigate through the address space and read or write data variables.



OPC UA layer model



OPC UA transport profiles



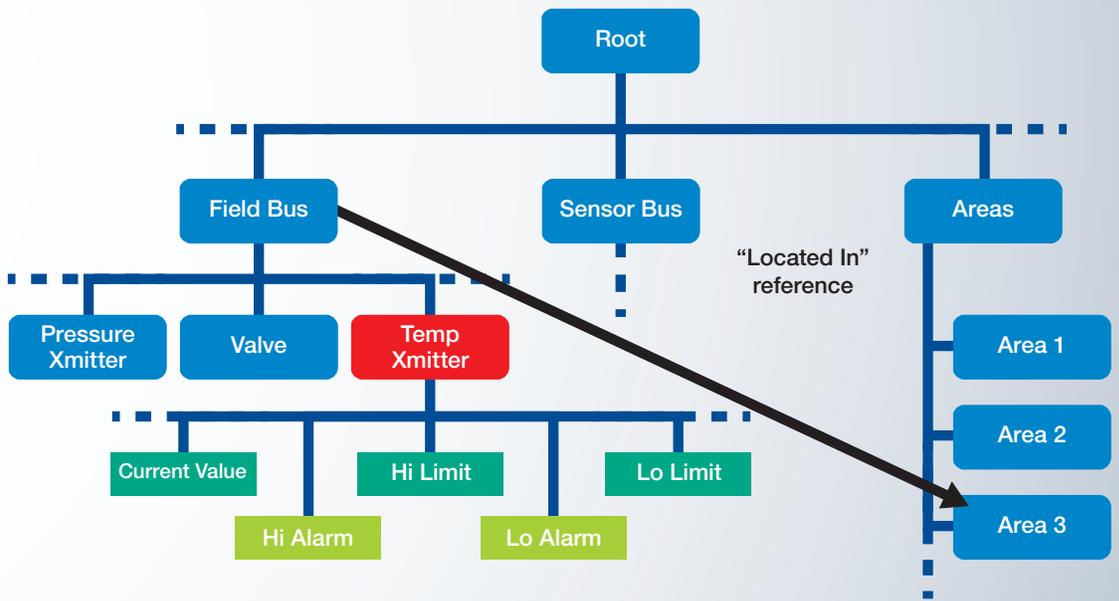
INTEGRATED ADDRESS SPACE MODEL

The object model enables production data, alarms, events and historic data to be integrated in a single OPC UA server. This allows, for example to represent a temperature measuring device as an object with its temperature value, alarm parameters and corresponding alarm limits.

OPC UA integrates and standardizes the different address spaces and the services, so that OPC UA applications only require a single interface for navigation.

The OPC UA address space is structured hierarchically, to foster the interoperability of clients and servers. The top levels are standardized for all servers. All nodes in the address space can be reached via the hierarchy. They can have additional references among each other, so that the address space forms a cohesive network of nodes.

The OPC UA address space not only contains instances (instance space), but also the instance types (type space).



Consistent address space

INTEGRATED SERVICES

OPC UA defines the services required to navigate through the namespace, read or write variables, or subscribing for data modifications and events.

The OPC UA services are organized in logical groupings, so-called service sets. Service request and response are transmitted through exchange of messages between clients and servers.

OPC UA messages are exchanged either via an OPC-specific binary protocol on TCP/IP or as a web service. Applications will usually provide both protocol types, so that the system operator can choose the best option.

OPC UA provides a total of 9 basic service sets. The individual sets are briefly described below. Profiles allow specifying a subset of all services which a server supports. Profiles are not discussed in detail here.

→ **SecureChannel service set**

This set includes services to determine the security configuration of a server and establish a communication channel in which the confidentiality and completeness (integrity) of the exchanged messages is guaranteed. These services are not implemented directly in the OPC UA application but are provided by the communication stack used.

→ **Session service set**

This service set defines services used to establish an application-layer connection (a session) on behalf of a specific user.

→ **NodeManagement service set**

These services provide an interface for the configuration of servers. It allows clients to add, modify, and delete nodes in the address space.

→ **View service set**

The view service set allows clients to discover nodes by browsing. Browsing allows clients to navigate up and down the hierarchy, or to follow references between nodes. This enables the client to explore the structure of the address space.

→ **Attribute service set**

The attribute service set is used to read and write attribute values. Attributes are primitive characteristics of nodes that are defined by OPC UA.

→ **Method service set**

Methods represent the function calls of objects. They are invoked and return after completion. The method service set defines the means to invoke methods.

→ **MonitoredItem service set**

This service can be used to determine which attributes from the address space should be monitored for changes by a client, or which events the client is interested in.

→ **Subscription service set**

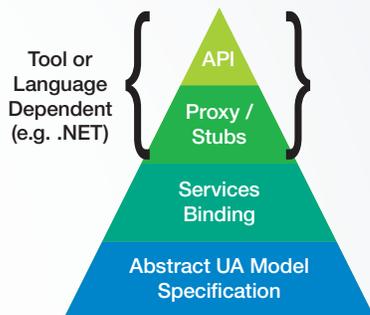
Can be used to generate, modify or delete messages for MonitoredItems.

→ **Query service set**

These services enable the client to select nodes from the address space based on certain filter criteria.

PLATFORM-INDEPENDENCE

Unlike “Classic OPC”, which is based on DCOM technology and is therefore inevitably linked to the Windows platform and the languages supported there, OPC UA was designed for application on arbitrary platforms using arbitrary program languages.



Services are independent of the model

→ **At the lowest level** are the abstract OPC UA model and the services, including the whole address space model, different object and variable structures, alarms and more.

→ **The next level** (Services Binding) is used to specify how the services are to be mapped to certain protocols. Currently mappings for TCP (UA-TCP) and for HTTP (OPC UA WebServices) are available. In the future – once new technologies become established – further mappings can be specified without having to change the OPC UA model and the services. The mappings are entirely based on standardized basic protocols, which already exist on all known platforms.

→ **The following levels** are realizations for dedicated platforms and languages. The OPC Foundation itself offers three such realizations, namely for Java, .NET and AnsiC/C++. The last option contains a platform adaptation layer.

PERFORMANCE

The OPC UA services can be mapped to different technologies. Currently there are essentially two mappings: UA-TCP and HTTPS. The use of UA-TCP on top of advanced Ethernet technologies ensures high performance.

The services themselves are also designed for high data throughput. An individual read call can access thousands of values, for example. Subscriptions services enable notification when values are changed and exceed configured thresholds

INFORMATION MODELS WITH OPC UA

THE OPC UA META MODEL

→ **Important:** The OPC UA model describes how clients access information on the server. It does not specify how this information should be organized on the server. It could be stored in a subordinate device or a database, for example.

The OPC UA object model defines a set of standardized node types, which can be used to represent objects in the address space. This model represents objects with their variables (data/properties), methods, events and their relationships with other objects.

The node properties are described through attributes defined by OPC UA. Attributes are the only elements of a server that have data values. The data types of the attributes can be simple or complex.

OPC UA enables modeling of any object and variable types and the relationships between them. The semantics is indicated by the server in the address space and can be picked up by clients (during navigation). Type definitions can be standardized or vendor-specific. Each type is identified by the organization that is responsible for its definition.

GENERIC OPC UA INFORMATION MODELS

Models for generally valid information (e.g. alarms or automation data) are already specified by OPC UA. Other information models with further specialization of the general definitions are derived from this. Clients that are programmed against the general models are therefore also able to process the specialized models to a certain extent.

1. DATA ACCESS (DA)

Data access, DA in short, describes the modeling of real-time data, i.e. data that represent current state and behaviour of the underlying industrial or business process data. It includes the definition of analog and discrete variables, engineering units and quality codes. Data sources are sensors, controllers, position encoders etc. They can be connected either via I/Os located directly at the device or via serial connections and fieldbuses on remote devices.

2. ALARMS AND CONDITIONS (AC)

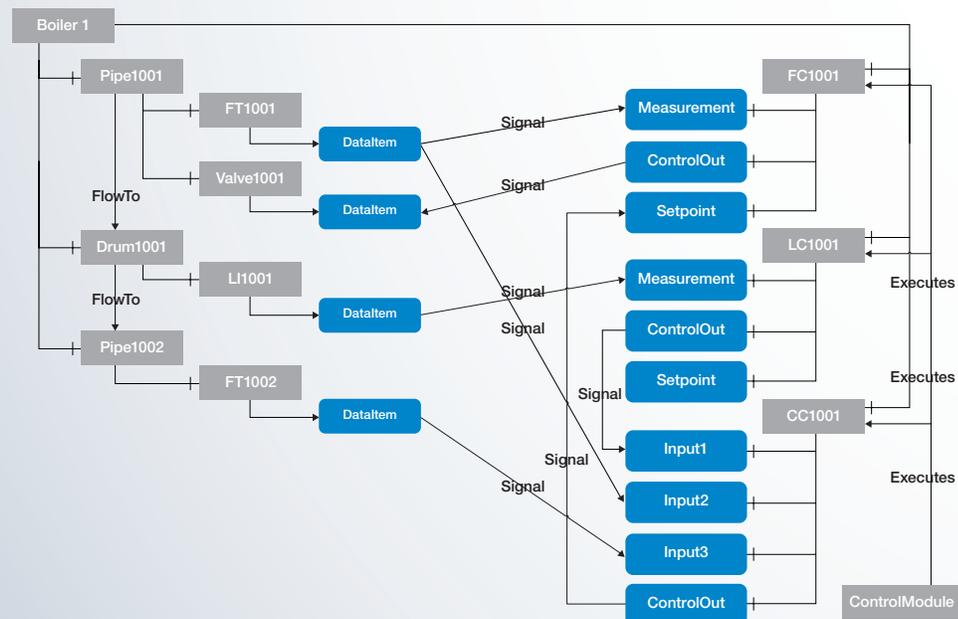
This information model defines how states (dialogs, alarms) are handled. A change of state triggers an event. Clients can register for such events and select which of the available associated values they want to receive as part of the event report (e.g. message text, acknowledgment behavior).

3. HISTORICAL ACCESS (HA)

HA enables the client to access historic variable values and events. It can read, write or modify these data. The data can be located in a database, an archive or another storage system. A wide range of aggregate functions enable preprocessing in the server.

4. PROGRAMS

A “program” represents a complex task, such as operation and handling of batch processes. Each program is represented by a state machine. State transitions trigger messages to the client.



UA modeling of a boiler as an example



TECHNOLOGY-SPECIFIC INFORMATION MODELS

Standardization committees dealing with the control/ automation technology prepare technology-specific information models. Examples are IEC61804 (EDDL), ISA SP 103 (field device tool), ISA-S88, ISA-S95 and IEC-TC57-CIM. These specifications are important, since they standardize the descriptions of units, relations and workflows in certain fields of knowledge. The OPC Foundation was keen to collaborate with other organizations in the development of the new standard right from the start. Rules for mapping the information models of these organizations to OPC UA (companion standards) are specified in joint working groups.

INDUSTRIE 4.0: OUTLOOK

OPC UA is a mature standard, which meets the requirements of Industrie 4.0 regarding secure semantic interoperability. OPC UA provides the protocol and services (the “How”) for publishing comprehensive information models (the “What”) and exchanging complex data between applications that were developed independently.

Although various important information models already exist, there is still a need for action:

- How for example, does a temperature sensor or a value control unit identify itself?
- Which objects, methods, variables and events define the interface for configuration, initialization, diagnostics and runtime?

The following companion standards currently exist or are in preparation:

- OPC UA for Devices (IEC 62541-100)
- OPC UA for Analyser Devices
- OPC UA for Field Device Integration
- OPC UA for Programmable Controllers based on IEC61131-3
- OPC UA for Enterprise and Control Systems based on ISA 95
- OPC UA for Machine Tool Connectivity (MTConnect)
- OPC UA for AutoID (AIM)
- OPC UA for BACnet (Building Automation)

Security model built in by design

GENERAL

Security was a fundamental OPC UA design requirement so it was built into the architecture from ground up. Security mechanisms similar to the W3C Secure Channel concept, were chosen based on the detailed analysis of real world data security threats and the most effective counter measures against them. OPC UA security addresses key issues like the authentication and auditing of OPC UA clients and servers, message confidentiality, integrity, and availability, and the verifiability of functional profiles. As illustrated below, OPC UA security can be divided into three security levels: User, Application, and Transport. This architecture aligns with the security infrastructure provided by most web-enabled platforms.

- **1. OPC UA User level security** mechanisms are engaged when a session is set up. An OPC UA client transmits an encrypted security token, which identifies the user to the OPC UA server. The server authenticates the user based on the token and then authorizes access to appropriate objects. The OPC UA specification does not define authorization mechanisms such as access control lists because they are application and/or system specific.
- **2. Application level security** is also part of the session setup and includes the exchange of digitally signed certificates. Instance certificates identify the concrete installation. Software certificates identify the client and server software and the

implemented OPC UA profiles which describe capabilities of the server, such as support for a specific information model.

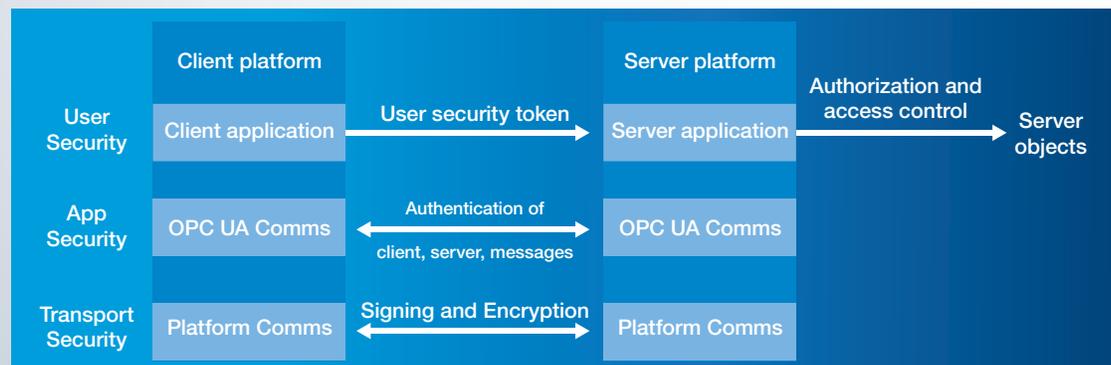
- **3. OPC UA Transport level security** can be used to provide integrity via message signing and confidentiality via message encryption. This prevents message tampering and eavesdropping respectively. The OPC UA security mechanisms are realized as part of the OPC UA stacks, i.e. they are included in a software package provided by the OPC Foundation – ready for use in OPC UA clients and servers.

SCALABLE SECURITY

Security mechanisms come at a computing resource cost which can adversely impact device performance. The OPC UA standard defines different levels of security (via end points) to enable vendors to implement OPC UA in products with various computing resources. This makes OPC UA scalable. In addition, system administrators can enable or disable such OPC UA server endpoints as required. For example, an end point without security (“NoSecurity” profile) could be disabled.

During operation, an OPC UA client application user selects the appropriate exposed OPC UA server end point prior to establishing a connection with the OPC UA server.

In addition, OPC UA clients can be configured to only use sufficiently secure end points if they work with sensitive data.



Scalable security concept

Extending the communication methods

An OPC UA working group is currently integrating additional communication methods into the OPC UA standard. This will extend the original OPC UA Client-Server architecture with the well-known Publisher-Subscriber (PubSub) model where the OPC UA Server (Publisher) can publish its data for use by an arbitrary number of OPC UA Clients (Subscribers). This will improve the usability of OPC UA in application fields like M2M (Machine to Machine) and IoT (Internet of Things).

TWO METHODS WILL BE AVAILABLE TO SUPPORT DIFFERENT SCENARIOS:

→ 1. OPC UA PubSub for Messaging over local networks (LAN)

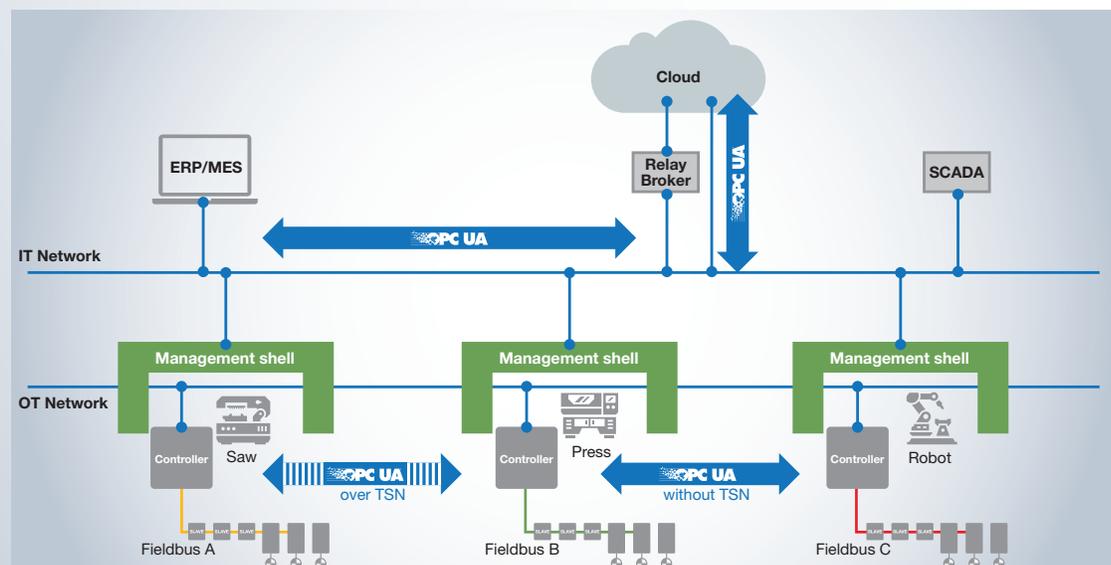
Targeted for use on local networks, data will be multicast over UDP by an OPC UA Server (published) for consumption by any number of authorized OPC UA Clients (Subscribers). This will allow for extremely efficient data distribution without brokerage.

→ 2. OPC UA PubSub for Messaging over global networks (WAN/Cloud)

This model supports connectivity between OPC UA applications that reside on different networks

and where data will be published for use by consumers that residing “in the Cloud”. If required, relays, brokers, and event hubs may also be used to best facilitate data transmission across complex network topologies. This method provides a secure and highly scalable method for sharing data from any number of OPC UA publishers with any number of OPC UA enabled sub-scribers.

Both additions integrate seamlessly into the multi-layer OPC UA architecture where extensibility is part of the design. As with the existing Client-Server communication methods, the new OPC UA PubSub methods utilize well-established protocols like the User Datagram Protocol (UDP) for Secure Multicasting and Time Sensitive Networking (TSN) for deterministic networking. For data sharing across global networks, OPC UA PubSub specification defines mappings on the most relevant messaging protocols, like MQTT and AMQP. The addition of PubSub to OPC UA extends the OPC UA transport layer without impacting the information model of an application. I.e., OPC UA enabled applications and the information they expose do not need to be changed to take advantage of the OPC UA PubSub capability.



Deterministic message delivery

In fast, local networks having the appropriate hardware support, the Publisher/Subscriber communication mechanism can fulfill requirements of deterministic communications. Therefore messages must have fixed content and constant length and transmission on the network (layer 2) must be run with exactly identical duration through all network nodes. Such „planned“ layer 2 transfer is enabled by Time Sensitive Network (TSN).

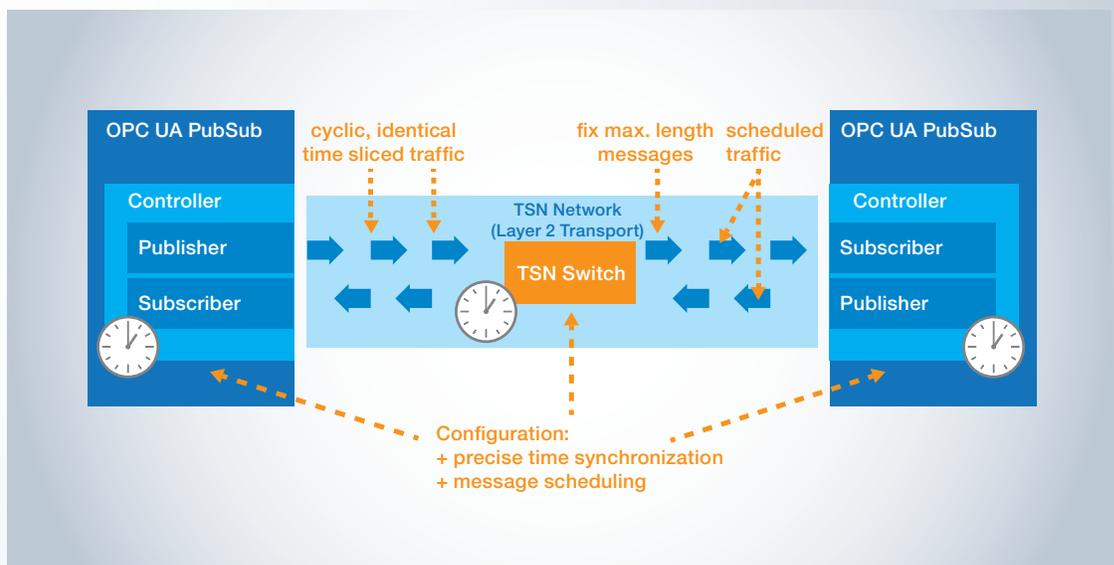
TIME SENSITIVE NETWORK

All participants and all switches within the deterministic TSN-network must be time synchronized and must be configured to be able to transmit the data to the final receiver (scheduling). TSN is a set of extensions to the Ethernet standard defined in IEEE 802. OPC UA needs at least two of these Ethernet enhancements i) 802.1 AS-Rev for time synchronization and ii) 802.1Qbv for scheduling. The OPC Foundati-

on is pushing forward specification and implementation work with a dedicated OPC UA over TSN working group consisting of 85+ members.

CONTROLLER-TO-CONTROLLER

As soon as TSN enabled Ethernet switches and devices are commonly available and can consistently be configured, OPC UA (Pub/Sub) over TSN will enable deterministic data transfer among controllers. For example, this will enable real time communications between things like robot-controllers and machine-controllers. The OPC Foundation plans to enhance their certification efforts for vendor-independent, deterministic Controller-to-Controller communication. With this technology enhancement OPC UA delivers another important building block for special, deterministic application scenarios in Industrie 4.0 and the IIoT.



OPC Foundation provides specifications and information

RESOURCES

The distribution of a technology is based on the persuasion of the users and their understanding of the functionality and the technical details, plus simple implementation and verification and certification. The OPC Foundation offers users and particularly its members a number of information sources, documents, tools and sample implementations.

OPC UA SPECIFICATIONS AND IEC 62541

The main source of information are the specifications. They are publicly accessible and also available as an IEC standard series (IEC 62541). Currently 13 OPC UA specifications are available, subdivided into three groups.

→ **1. Basic specifications.** These contain the basic concepts of the OPC UA technology and the security model, plus an abstract description of the OPC UA metamodel and the OPC UA services. In addition they describe the concrete OPC UA information model and its modeling rules, plus the concrete mapping at the protocol level and the concept of the profiles for scaling the functionality.

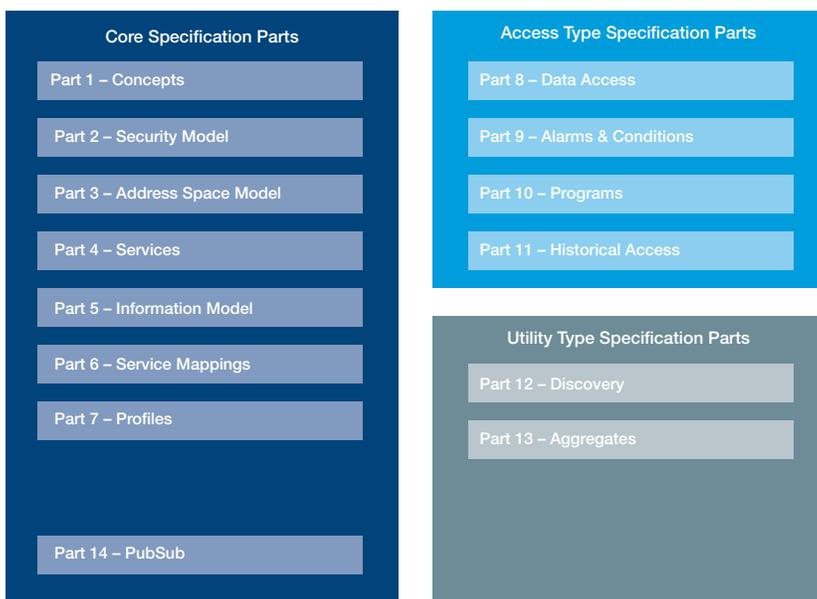
→ **2. Access models.** These contain extensions of the information model for typical access to data, alarms, messages, historic data and programs.

→ **3. Extensions.** These contain additional solutions for finding of OPC UA-capable components and their access points in a network, plus the description of aggregate functions and calculations for processing historic information.

WEBSITE AND EVENTS

A further source of information is the global website of the OPC Foundation plus regional sites for Japan and China. This is where the products made available by the members and their certification results are published. Information on technology and collaborations is provided in different languages.

In addition, information on events organized by the OPC Foundation itself and its members is provided.



Source code and certification

SOURCE CODE AND TEST TOOLS

To ensure compatibility, the OPC Foundation offers the implementation of the communication protocols, plus a certification program, including the tools required for verifying and testing the conformity of applications with the specification.

→ 1. OPC UA stack.

The communication stacks are available in three programming languages: ANSI C for scalable implementation on virtually all devices, in managed C# for application with the .Net Framework from Microsoft, plus an implementation in Java for applications in corresponding interpreter environment. These three implementations ensure the basic communication in the network. They are compatible with each other and are maintained by the OPC Foundation.

→ 2. **Example Code.** Besides the communication stacks, which basically contain the protocol implementation only, the OPC Foundation provides sample applications. The samples are provided in source code (mainly C#) and can be used for evaluation of the OPC UA technology and for proof-of-concept coding, for rapid implementation of prototypes and demonstrators. For integration of OPC UA technology in professional and industrial hardened products, the OPC Foundation suggests the use of commercial Toolkits and Software Development Kits (SDK), as they are offered by various OPC member companies.



→ 3. **Certification program.** For testing and certification of logically correct behavior, the OPC Foundation offers a test software (compliance test tool). It can be used to verify the logically correct and specification-compliant behavior of an OPC UA application. In independent certification laboratories manufacturers can have their OPC UA products certified based on a defined procedure. In addition to conformity the behavior in fault scenarios and interoperability with other products is also tested.

→ 4. Interoperability workshops

The OPC Foundation holds three week-long interoperability workshop (IOP) per year, at which companies can test the interaction of their products.

The IOP Europe takes place in the autumn at Siemens AG in Nuremberg. Other IOPs are held in North America and Japan. These meetings offer a comprehensive test environment with around 60 – 100 products and bring developers and testers together.

Laboratory – Certification

End users and integrators are encouraged to only use certified OPC products in productive environment. OPC server and client products which were tested in one of the independent certification laboratories, are recognizable by the „Certified“ logo. These test labs are accredited by the OPC Foundation and follow the defined test scenarios to guarantee that your product complies with the following:



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

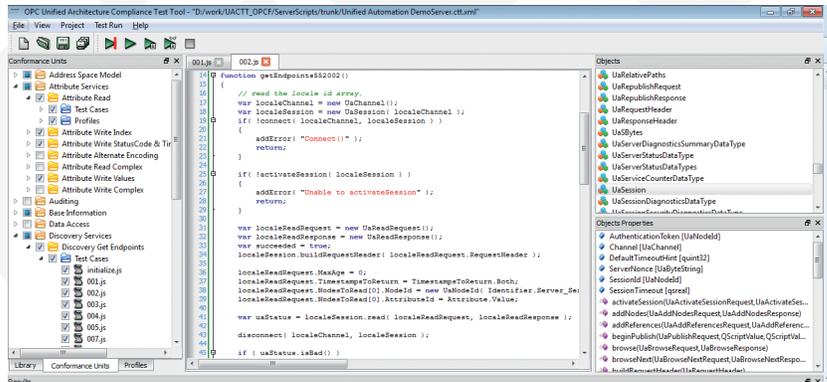
TEST TOOLS AND QA

There are different test tools available to validate the correct function of an OPC UA server or client product. OPC Members have access to all the tools and thus can easily build up a comprehensive test environment. Especially the OPC Compliance Test Tool (CTT) implements several hundred test cases and provides a functional test with enormous test coverage. The script based tool is permanently enhanced with new test cases and hence also covers enhancements specification in a timely fashion. Additionally it can be extended with your own product specific test cases. The CTT is a test platform which perfectly can be integrated into your company's automated system and regression test.



»The Certification Program is a key benefit of the 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, MatrikonOPC



Integration – Toolkits and Books

CODE AND ADVICE

The OPC Foundation manages three OPC UA communication stacks (C, .NET and Java) in order to ensure interoperability at protocol level. Although members have access to the source code of the stacks, it is recommended to use a commercial toolkit in view of the fact that, in addition to the actual communication layer for OPC UA applications, – especially for an OPC UA server – further specific administrative functions have to be implemented.

In particular, commercial toolkits help by abstracting and consolidating generic functions such as connection management, certificate management and security features. Using toolkits e.g. developer frameworks offers vendors advantages for implementation and time to market.

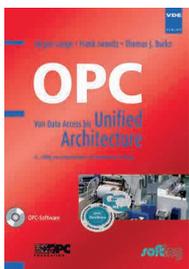
EXPERT KNOWLEDGE

A number of companies around the world offer commercial support for the integration of OPC UA communication technology in existing products and the implementation of new products, ranging from advice and developer training to selling software libraries and development support right up to long-term support and maintenance contracts.

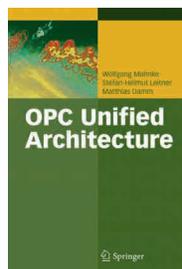
The developer frameworks e.g. toolkits are available at attractive prices as binary “black box” components or including complete source code. In addition to the source code for the OPC UA stacks of the OPC Foundation, commercial toolkits offer simplifications and convenience functions. The general OPC UA functionality is encapsulated behind an API. For this reason application developers do not need detailed OPC UA expertise. A stable, tested library enables them to focus on their own core competence.

QUALITY AND FUNCTION

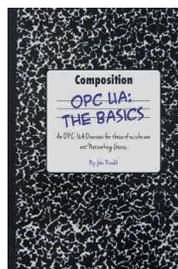
OPC UA toolkits are used for a wide range of application scenarios in industrial environments. For that reason they are robust, certified, are being maintained and continuously enhanced. Toolkit providers offer specialized and optimized developer frameworks for various programming languages. Toolkits differ in their OPC UA-specific functionality and in terms of their application, use-case and operational environment. All toolkits are offered with professional support and development service. Further information is available from toolkit manufacturers.



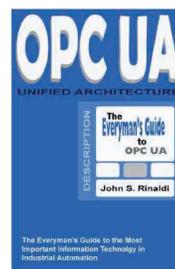
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FURTHER INFORMATION ABOUT TOOLKITS IS AVAILABLE FROM ...

→ MatrikonOPC, OPC-Labs, ProSys OPC, Softing Industrial Automation GmbH, Software Toolbox, Unified Automation GmbH

Collaborations

The OPC Foundation closely cooperates with organizations and associations from various branches. Specific information models of other standardization organizations are mapped onto OPC UA and thus become portable. The organizations define „what“ shall be communicated. OPC UA delivers „how“

through its secure and effective transport and offers access privileges and generic interoperability. Thus communication across branches and domains is made possible without sacrificing particular, semantic, branch-specific objects and types.



COLLABORATIONS

Page 35: VDMA

Page 36: MDIS – Offshore Oil & Gas

Page 37: OPEN-SCS – Pharmaceutical Industry

Page 38: PLCopen

Page 39: AIM-D – Auto-ID

Page 40: AutomationML

Page 41: FieldComm Group – FDI



»A step towards Industrie 4.0«

Dr. Christian Mosch, Project Manager Standardization Industrie 4.0, VDMA – Europe's largest Mechanical Engineering Industry Association

The VDMA is Europe's largest industry association with over 3200 member company from the mechanical engineering industry. These companies integrate the latest technologies in its products and processes. The standard OPC UA is increasingly establishing itself in this industry sector. OPC UA enables the industry to integrate its products and its production by information and communications technologies (ICT).

THE BENEFIT FOR THE MECHANICAL ENGINEERING INDUSTRY:

Machines and plants can be redesigned as required by plug & work – irrespective of which manufacturers the machines and components originate. Condition

monitoring, predictive maintenance and the optimization of production can be implemented independent of the manufacturer. Thus, VDMA prioritizes its activities on the interface standard OPC UA and provides an important network for the OPC UA development.

VDMA'S ACTIVITIES DEFINING OPC UA COMPANION SPECIFICATIONS

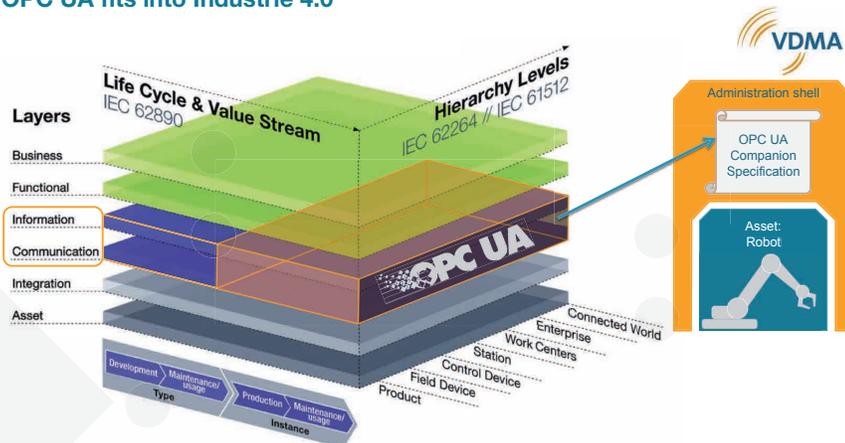
OPC UA CS under development

- Food Processing Machinery and Packaging Machinery
- Integrated Assembly Solutions
- Machine Tools and Manufacturing Systems
- Machine Vision
- Measuring and Testing Technology
- Plastics and Rubber Machinery
- Power Transmission Engineering
- Pumps and Systems
- Robotics

Awareness existent

- Electrical Automation
- Fluid Power
- Foundry Machinery

OPC UA fits into Industrie 4.0



CONTENT

- Why should manufacturers implement OPC UA
- Migration path: How should manufacturers implement OPC UA
- Guideline shows the steps that companies must take into account to ensure an interoperability within the factory

BENEFITS

- VDMA positions to OPC UA
- Favors the development of OPC UA Companion Specifications
- Designed for small and medium-sized enterprises of the VDMA
- Investment sustainability for SMEs in the expansion of I4.0 communication networks



Offshore Oil & Gas: OPC UA Information Model for MDIS

»Standardization between Master Control System (MCS) and Distributed Control Systems (DCS) simplifies connection«

Paul Hunkar, DS Interoperability, OPC Consultant for the MDIS Network



The MDIS Network:

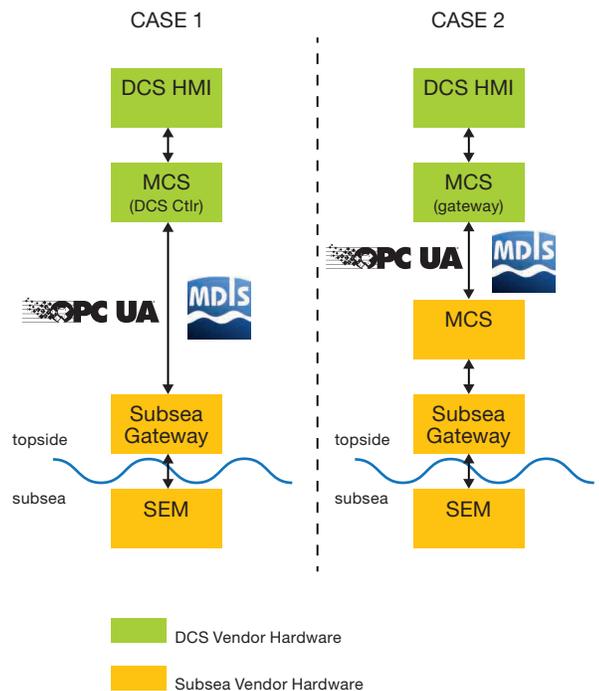
- ABB
- Aker Solutions
- BP
- Chevron
- ConocoPhillips
- Dril-Quip
- Emerson
- ENGlobal
- ExxonMobil
- FMC Technologies
- GE Oil and Gas
- Honeywell
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- Rockwell Automation
- Shell
- Siemens
- Statoil
- Total
- W-Industries
- Woodside
- Yokogawa



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In the oil and gas industry the major operating companies, oil & gas service companies, DCS vendors, subsea equipment vendors and systems integrators all have their unique requirements and rules when it comes to their own software and hardware systems. But on the offshore oil and gas platform all of these systems have to come together and work seamlessly. Further these offshore platforms are many times located in harsh environments such as the North Sea or at least inaccessible such as platforms that are near the limit of helicopter travel. Typically the starting point for these platforms is engineering efforts in excess of a year and costs in the millions of dollars. And changes to systems after it has shipped are very expensive if possible at all. In 2010 the oil and gas companies banded together to form an organization, the MDIS Network, to decide on the standard communication interface and develop a standard set of objects to link the Subsea gateway, the MCS and the DCS.

MDIS did not wish to build something new, the organization had to select a protocol upon which to build their standard. Their initial list of many protocols, was narrowed down by performance evaluations and detailed technical evaluations, finally selecting OPC UA. Formed by a unique set of requirements by each MDIS member, the key shared features included the support for multi-platforms and information modeling capabilities, which helped the group decide on OPC UA.





Track & Trace: OPC UA in Pharmaceutical Industry

OPEN-SCS Open Serialization Communication Standard

Marcel de Grutter, Executive Director: Open Serialization Communication Standard Group (OPEN-SCS)

Members:

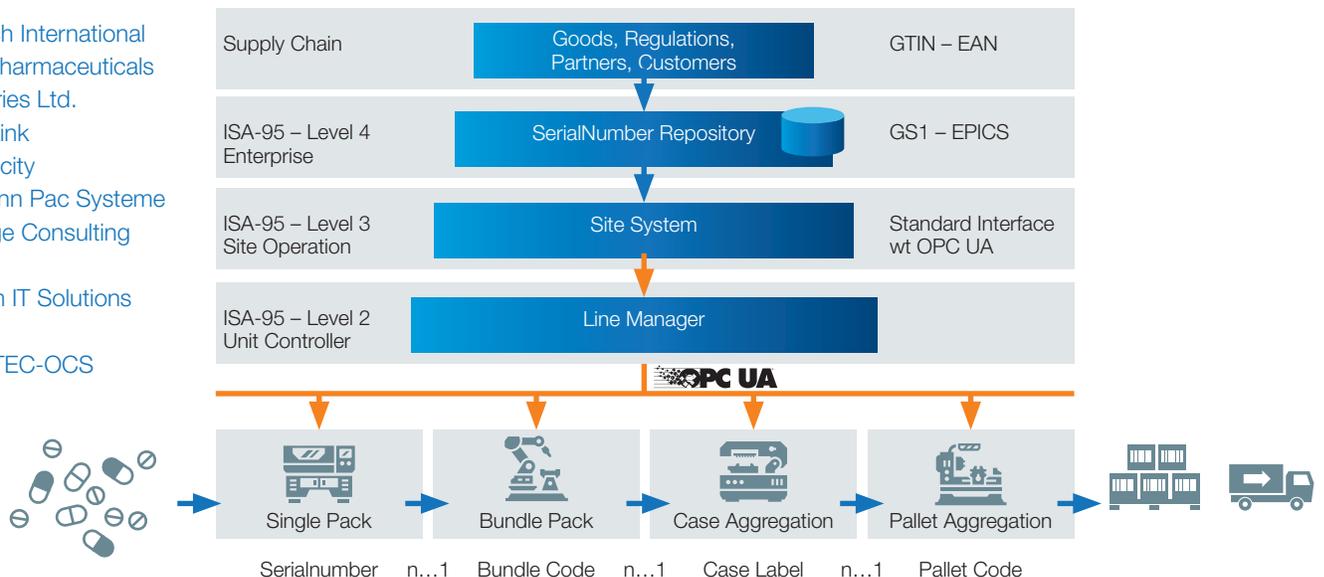
- Abbott
- ACG Inspection Systems
- Adents
- Avanco
- Antares Vision
- Arvato Systems GmbH
- ATS-Global facilityboss
- Giesecke & Devrient
- Laetus
- Mettler Toledo PCE
- Omron Europe
- Optel Group
- Pfizer
- Roche
- Rockwell Automation
- SAP
- Systech International
- Teva Pharmaceuticals Industries Ltd.
- TraceLink
- Tradetivity
- Uhlmann Pac Systeme
- Vantage Consulting Group
- Werum IT Solutions GmbH
- WIPOTEC-OCS

The OPEN-SCS initiative is driven by leading health-care providers, packaging and automation companies, with the goal to define and standardize the provision of global unique serial number on prescription medicine. Different national regulations enforce the implementation of secure serialization and transparent identification to prevent illegal trading of potentially lethal, counterfeit medicine. OPEN-SCS standardizes the serialization data objects and required data exchanges for the primary product Track & Trace use cases for inter-plant, packaging line, and equipment unit levels.

OPC UA communication technology allows vendor independent, secure transmission of structured serialization information into production and packaging systems. By adding product- and production-specific information (EAN, GTIN, expiry date, batch number) to a data matrix code printed on the package,

the medicine becomes uniquely marked. In combination with a tamper-proof seal on the package the integrity of the original content is insured.

On the packaging line the single pack are first grouped to bundles, and these bundles are boxed into cases, which finally are stapled on pallets. The informational data is aggregated over multiple, hierarchical layers and becomes the input of a global database (digital twin). The medicine can be verified in all packaging formats and at every point in the supply chain, especially at its end, in the drug store, for its originality and origin. According to the information models of ISA-95 (Enterprise Control) and ISA-88 (Batch Control) the Object Types and Methods are standardized using OPC UA technology and are published in the companion standard for OPEN-SCS.



OPC UA communication between assets in ISA-95 model



Integration: OPC UA Client and -Server in controller

»**OPC UA: Via semantic information modelling from controller into cloud**«

BECKHOFF

Stefan Hoppe, Beckhoff Automation,
Chairman of the joined working group PLCopen & OPC Foundation, President OPC Foundation Europe



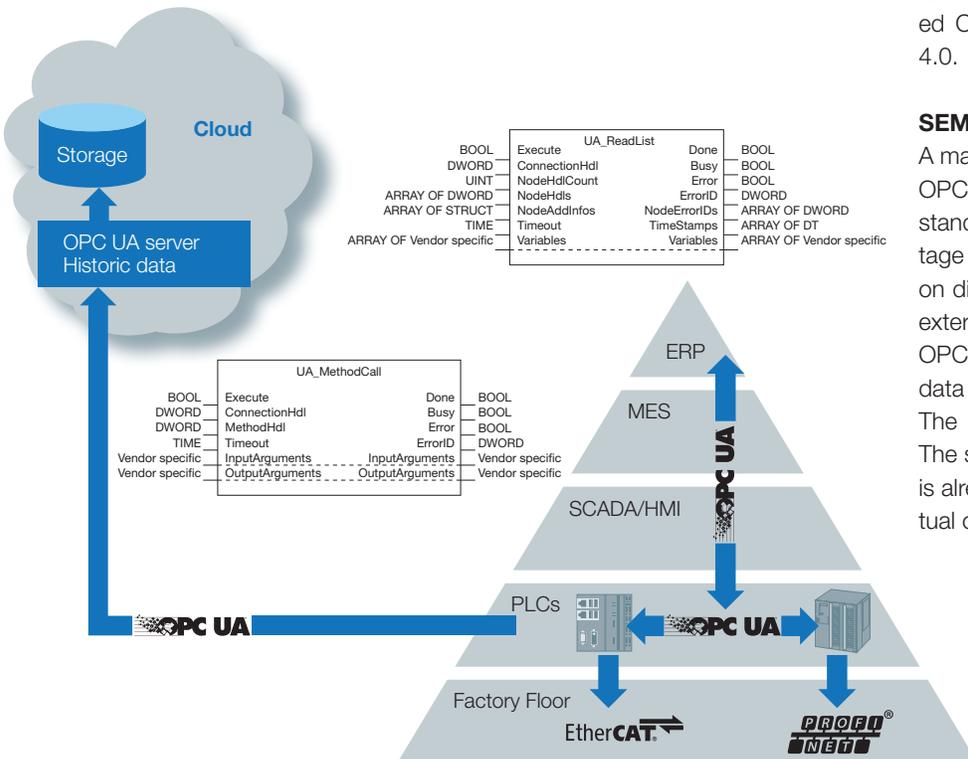
The interaction between IT and the world of automation is certainly not revolutionary, but is based on the long-established model of the automation pyramid: The upper level initiates a data communication (as a client) with the level below, which responds (as server) cyclically or event-driven: A visualization, for example, can request status data from the PLC or transfer new production recipes to the PLC. With Industrie 4.0 this strict separation of the levels and the top-down approach of the information flow will start to soften and mix: In an intelligent network each device or service can autonomously initiate a communication with other services.

PLC CONTROLLER INITIATES HORIZONTAL AND VERTICAL COMMUNICATION

In collaboration with the OPC Foundation, the PLCopen (association of IEC6-1131-3-based controller manufacturers) has defined corresponding OPC UA client function blocks. In this way the controller can play the active, leading role, in addition or as an alternative to the usual distribution of roles. The PLC can thus horizontally exchange complex data structures with other controllers or vertically call up methods in an OPC UA server in an MES/ERP system, e.g. to retrieve new production orders or write data to the cloud. This enables the production line to become active autonomously – in combination with integrated OPC UA security a key step towards Industrie 4.0.

SEMANTIC INTEROPERABILITY

A mapping of the IEC61131-3 software model to the OPC UA server address space is defined through the standardization of the two organizations: The advantage for users is that a PLC program that is executed on different controllers from different manufacturers, externally results in semantically identical access for OPC UA clients, irrespective of their function: The data structures are always identical and consistent. The system engineering is simplified significantly. The sector-specific standardization of the semantics is already used by other organizations and is the actual challenge of Industrie 4.0.





Identification: OPC UA in RFID

»A unified communication standard is revolutionizing the AutoID industry«

Olaf Wilmsmeier, HARTING IT Software Development GmbH & Co. KG

The trend towards increased automation is demanding systems that are more heterogeneous. New challenges and tasks can only be dealt with properly when communication nodes are able to exchange all relevant information directly in a flexible manner.

UHF RFID and other AutoID technologies are clearly the key technologies for implementing the concept of „Integrated Industry“. That is why it is so critical that these technologies are integrated into complete solutions as simply as possible.

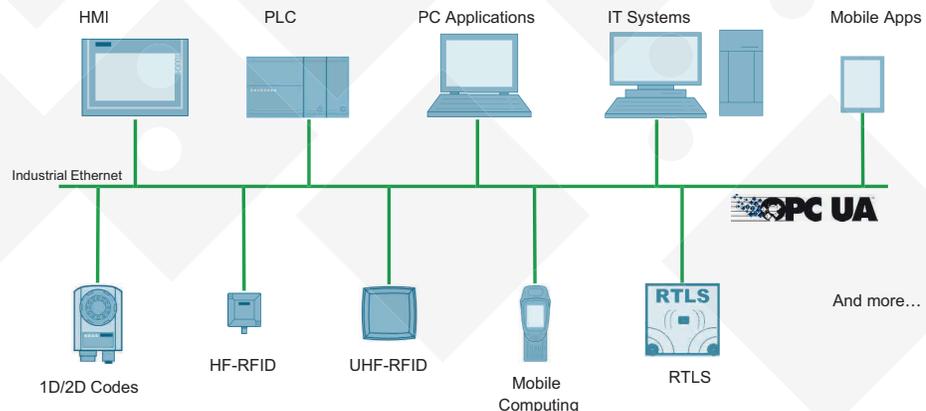
Thanks to its advantages and broad, cross-vendor acceptance, OPC UA has emerged as a viable communication standard in the automation industry. One of the many benefits that OPC UA offers is the ability to pre-define data models of device groups in so-called companion specifications. These specifications contain the essential functionality, including the data type description of the individual variables, transfer parameters and return parameters.

HARTING already initiated such cross-vendor standardization for the AutoID industry back in 2013. Motivated by the knowledge that an accepted, standardized communication interface for AutoID devices

would make the work of system integrators significantly more efficient, HARTING and Siemens raised the OPC UA issue in an AIM Germany (Association for Automatic Identification and Mobility) working group. Together with other industry leaders, this association defined and released a companion specification for AutoID devices in cooperation with the OPC Foundation.

The advantage of such a companion specification is quite evident. As more manufacturers follow this recommendation and implement their communication interfaces accordingly, it will be possible to integrate various devices, even from different manufacturers, more quickly into new applications. This saves time and provides improved protection for our customers' investments.

This specification can also be extended with device-specific or vendor-specific customizations, because of OPC UA's object-oriented design. Manufacturers can thus retain their unique features while still relying on a common, widely accepted communication platform.



AutoID topology with OPC UA



Engineering: Interoperability by combining AutomationML with OPC UA

»Requirements for the factory of the future«



Dr. Olaf Sauer, Fraunhofer Institute for Optronics, System Technology and Image Exploitation (IOSB), Initiator of common working group "AutomationML and OPC UA"



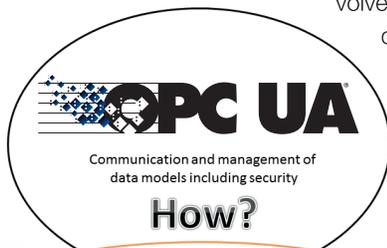
The factory of the future shall be capable of producing customer-specific products in ever new variants. Those involved in engineering and production shall react on short notice to changed customer wishes, even after order intake. Uncertainties in markets lead to versatile factories and manufacturing equipment. Industrie 4.0 is the strategic framework program for the German industry entrenching growing digitalization in its construction bureaus and production halls. A wide range of individual industrial-suited standards is available, which now have to be purposefully consolidated.

Also the Industrie 4.0 ICT architecture needs the ability to adapt to changes – either by adding new equipment or production processes into the system or by changing existing production systems e.g. because a new, additional product variant has to be manufactured. In the future work pieces, machines or material flow systems communicate with each other, they need a common language and a universal transmission channel. Only both components collectively lead to inter-operable solutions.

A central idea of Industrie 4.0 is that objects involved in production comprehensibly describe their unique identity and their capabilities. If then new components, machines or equipment are brought into the production system or changes appear in production, the appropriate software modules can quickly and efficiently adjust the configuration of ICT systems.

AUTOMATION ML™ AND OPC UA FOR INDUSTRIE 4.0

Self-configuration can be achieved by using Automation ML to describe the capabilities of components and machines and OPC UA to enable them to communicate with each other. The companion standard that was mutually developed between OPC Foundation and AutomationML e. V. aims at combining the two technologies such that in case of modifications in the factory data is communicated currently, consistently and reliably. To this end, features and capabilities are stored as AutomationML objects within the very components. Consequently, they are readily available to the control system as OPC UA information model at the time of physical integration. Component suppliers identify the information required for this purpose in advance and include it in the components themselves. Machine builders or system integrators thereby save approximately 20 % time in the case of initial start-ups or changes in machines and production systems for the physical and informal integration of components on the basis of the "plug & play" principle. Configuration mistakes will be reduced because the data flow is automated. Even greater potential can be opened up if data required for the configuration of an HMI or superimposed MES are taken from the engineering systems on which they are based and stored directly in OPC UA information models as AutomationML objects.



What?





PROCESS AUTOMATION

Integration: Easing Field Device Integration with OPC UA and FDI

»Standardized information models lead to lower costs and enable best-in-class integration«

Ted Masters, President and CEO, FieldComm Group

OPC UA promotes collaboration among the industry's best domain experts to define information models. For example, OPC Foundation and FieldComm Group collaborated to define an information model that forms the core of FDI technology (IEC 62769-5). FDI technology includes i) virtualized field device information models encapsulated in a standardized open packaging convention, the "FDI Device Package"; ii) an FDI Server with information about Device instances and Device types; and FDI Clients that access information from the server. This information is provided via OPC UA Services and is called the FDI Information Model.

The FDI standard has been endorsed by Industrie 4.0 and NAMUR for inclusion in future process automation systems and field devices.

MAJOR ELEMENTS OF THE FDI INFORMATION MODEL

TOPOLOGY INFORMATION

The Information Model represents the devices of the automation system as well as the connecting communication networks.

PROTOCOL TYPE AND DEVICE TYPE DEFINITIONS

Topology is organized in the OPC address space using Type definitions. For example, ProtocolType = HART. Type definitions contain the Parameters, and

default values for Parameters, Methods, Actions and Functional Groups including user interface elements.

ONLINE/OFFLINE CONFIGURATION MODELING

Management of the Device Topology is a configuration task, i.e., the elements in the topology (Devices, Networks, and Connection Points) are usually configured "offline" and – at a later time – will be validated against their physical representative in a real network.

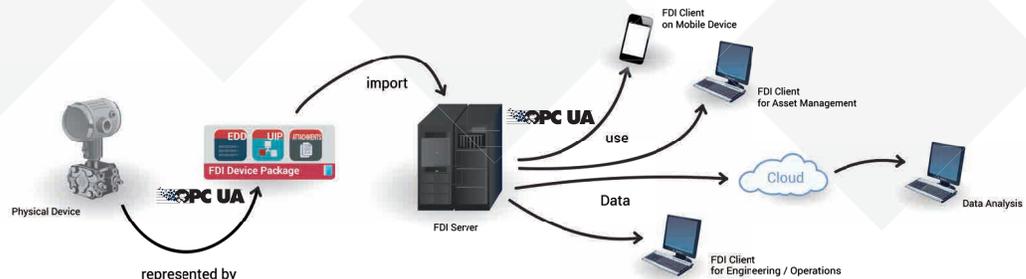
EDDL MAPPING

The OPC UA Object Model provides a standard way for Servers to represent Objects to Clients. EDDL defines a set of language constructs that are used to describe industrial field devices. EDD information adds semantic contents to the raw data values read from and written to the field devices.

The FDI OPC UA information model describes the correspondence between the OPC UA Object Model elements and the EDDL elements when an EDD is used to populate the FDI Server with Objects.

USER INTERFACE ELEMENTS

Both descriptive user interface elements (UIDs), analogous to EDD interfaces, and programmed (executable) user interface elements (UIPs), as specified in the FDI standard, are supported in the information model





Horizontal: OPC UA enables M2M and IIoT

»Intelligent water management – M2M interaction based on OPC UA«

Silvio Merz, Divisional Manager, Electrical/Process Technology
 Joint Water and Wastewater Authority, Vogtland



If we regard some of the basic concepts of Industrie 4.0, such as platform and vendor-independent communication, data security, standardization, decentralized intelligence and engineering, then a technology for M2M (Machine-to-Machine) or IoT (Internet of Things) applications is already available in OPC UA. OPC UA is used for direct M2M communication between plants for the intelligent networking of decentralized, independently acting, very small embedded controllers, i.e. around 300 potable water plants and 300 wastewater plants (pumping plants, water works, elevated reservoirs, etc.) distributed over about 1,400 km²:

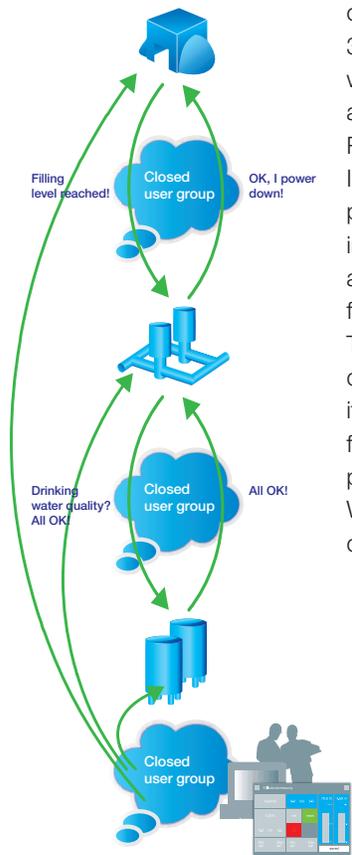
Real objects (e.g. a pump) were modeled in the IEC61131-3 PLC as complex objects with interactive possibilities; thanks to the OPC UA server integrated in the controller these objects are automatically available to the outside world as complex data structures for semantic interoperability.

The result is decentralized intelligence that makes decisions independently and transmits information to its neighbors or queries statuses and process values for its own process in order to ensure a trouble-free process cycle.

With the standardized PLCopen function blocks the devices independently initiate communication from

the PLC to other process devices as OPC UA clients, whilst at the same time being able to respond to their requests or to requests from higher-level systems (SCADA, MES, ERP) as OPC UA servers. The devices are connected by wireless router: a physical interruption of the connection does not lead to a loss of information, since information is automatically buffered in the OPC UA server for a time and can be retrieved as soon as the connection has been restored – a very important property in which a great deal of proprietary engineering effort was invested beforehand. The authentication, signing and encryption safety mechanisms integrated in OPC UA were used in addition to a closed mobile radio group to ensure the integrity of these partly sensitive data. The vendor-independent interoperability standard OPC UA opens up the possibility for us as end users to subordinate the selection of a target platform for the demanded technology in order to avoid the use of proprietary products or products that don't meet the requirements.

The replacement of a proprietary solution by a combined OPC UA client/server solution, for example, provided us with a saving on the initial licensing costs of more than 90 % per device.



	UA_Read		
BOOL	Execute	Done	BOOL
DWORD	ConnectionHdl	Busy	BOOL
DWORD	NodeHdl	Error	BOOL
TIME	Timeout	ErrorID	DWORD
ST_UANodeAdditionalInfo	NodeAddInfo		
ANY	Variable	Variable	ANY



Scalability: OPC UA integrated in sensors

»The integration of OPC UA into our measuring instruments provides our customers with comprehensive, secured communication«

Alexandre Felt, Project Manager at AREVA GmbH

SCALABILITY: AREVA BENEFITS FROM SENSORS WITH INTEGRATED OPC UA PROTOCOL

Comprehensive, end-to-end networking across all levels represents a challenge to Industrie 4.0. As an evolutionary step towards realization of the 4th industrial revolution and IoT, companies can already take a decisive step in the right direction with Embedded OPC UA. AREVA recognized early on the potential of OPC UA, in sensors and started integrating them into monitoring instruments (SIPLUG®) for mountings and their associated electric drives. The solution is used in the nuclear industry for monitoring critical systems in remote environments, without negatively affecting the availability of the system.

Before this, SIPLUG® utilized a proprietary data exchange protocol, just like most of the applications in the nuclear energy sector – this meant however that integration into existing facility infrastructures was difficult, and the outlay for various aspects, such as data buffering or data analyses, was always linked with extra costs.

BENEFITS OF EMBEDDED OPC UA

From an end-user perspective, the native OPC UA connectivity enables direct embedding of AREVA products into the infrastructure, without the need for any additional components: The solution allows the reporting and trend monitoring system of AREVA to access the SIPLUG® data directly. This means that the need for additional drivers and infrastructures can be dispensed with completely. What's more, additional values, such as pressure and temperature



With AREVA, OPC UA can be used to provide access to SIPLUG® data within the upper levels of a company via an open, international standard (IEC62541) – the challenge of “end-to-end data availability” has therefore been solved with OPC UA.

values available at the factory level, can be utilized easily in order to improve the precision of the data evaluation.

With AREVA, OPC UA can be used to provide access to SIPLUG® data within the upper levels of a company via an open, international standard (IEC62541) – the challenge of “end-to-end data availability” has therefore been solved with OPC UA.

SMALLEST DIMENSIONS – INTEGRATED SECURITY

In addition to the reliability of the data, integrated security was also an important aspect for the utilization of OPC UA. The minimal memory requirements, which start at 240kB flash and 35kB RAM, can be integrated into the smallest devices of AREVA.



OPC UA ensuring the availability in a tunnel project

»Ensuring the availability in a project of this enormous scale is an exciting challenge. ...«

SIEMENS

ETM professional control GmbH –
A Siemens Company

Dipl.-Ing. Dr. techn. Bernhard Reichl, Geschäftsführer ETM

“...due to the use of OPC UA as a standard interface to the infrastructure subsystems we can guarantee this.”

The Gotthard Base Tunnel in Switzerland is by its opening in June, 2016 with 57 km the longest railway tunnel of the world.

OPC UA was defined as the standardized interface between the tunnel management system and the electromechanical systems. Given the need to integrate sixteen different facilities from different suppliers, it was vital to use a platform-neutral, standardized and uniform protocol.

The tunnel management system is responsible for ensuring the remote control and monitoring of relevant data points across the electromechanical systems. Using the information being constantly supplied from the infrastructure subsystems, encompassing power supply, catenary system, ventilation and air conditioning, lighting as well as operation and surveillance of wide-ranging different doors and gates, a graphic system overview is prepared.

Beside the indication of the statuses of the various electromechanical systems, also the locations of trains within the Gotthard Base Tunnel alongside additional information are displayed. All of these systems are managed by the overriding tunnel management system on the basis of the SCADA system SIMATIC WinCC Open Architecture. The entire infrastructure is displayed, monitored and operated at two Tunnel Control Centers, one at the North and the other at the South Portal.

REASONS FOR OPC UA IN THE GOTTHARD BASE TUNNEL

→ High availability of the communication

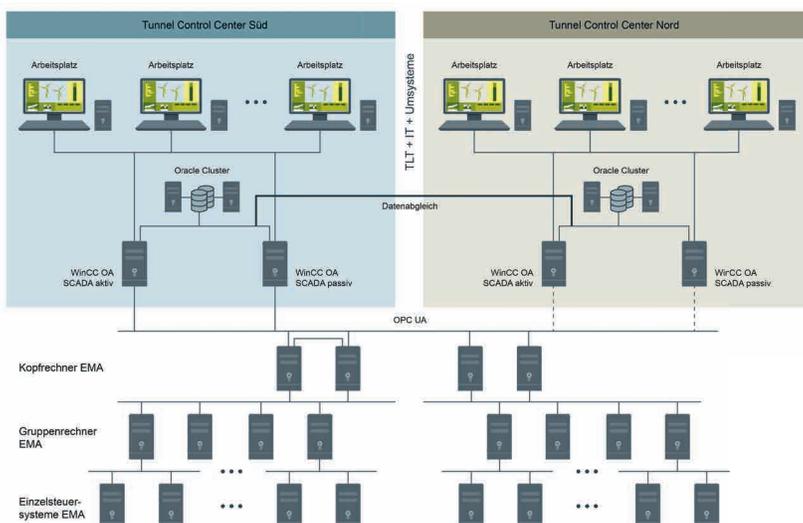
- Redundant configuration set up both for the OPC UA client and server
- OPC UA Heartbeat used for monitoring the connection in both directions

→ Reliable data exchange

- Authentication and authorization both on the server and the client side
- Security based on current standards (SSL/TLS specification)
- Use of standardized X.509 certificates
- Same certificates also used in IT for safeguarding the https connections
- Use of a standardized infrastructure (CA)
- Secured OPC UA due to encryption and a digital signature
- Simple configuration of the firewall (only one port needed)

→ High performance

- Several hundred thousand data points
- Use of the binary protocol (OPC UA Binary, UA TCP)
- Binary protocol requires few overheads
- Consumes minimal resources
- Offers outstanding interoperability





Honeywell

Smart Metering: Consumption information from the meter right up to IT accounting systems

»**Safe and flexible:**
Meter data collection with OPC UA«

Carsten Lorenz, Head of Product Management, Low Pressure Gas Metering & AMR/AMI, Honeywell

“A safe and reliable communication protocol plays an important role in smart metering”, says Carsten Lorenz, AMR (Automatic Meter Reading) Manager at Honeywell, a leading supplier of smart meter products for gas, water and electricity. Our UMI (Universal Metering Interface) protocol ensures optimum energy efficiency and long battery life in networks.

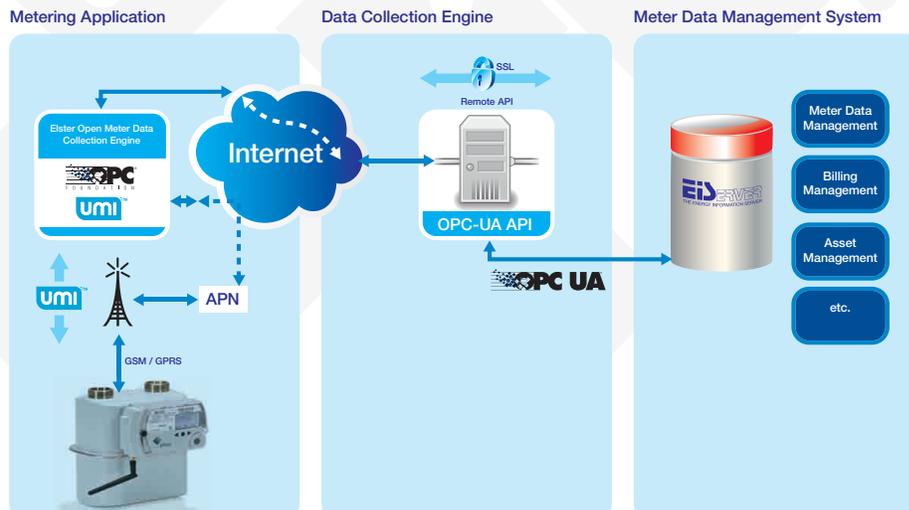
At Honeywell, we offer a software with OPC UA interface for our own systems as well as other head-end systems, since many systems used by supply companies already support this established standard. Integrated encryption of sensitive meter data is an important argument for OPC UA“.

Security and encryption of personal data is a MUST when Smart Metering is introduced. This means: Corresponding security concepts have to be introduced together with Smart Metering in existing and new systems. They have to take account of new processes such as exchange of encryption mechanisms between manufacturers and energy suppliers.

Communication protocols are transferred in encrypted form with respect to gas meters. This means: Personal data and critical commands, such as closing and opening of a valve integrated in the meter, are not visible for third parties and cannot be intercepted or simulated.

The communication protocols support both asymmetric and symmetric state-of-the-art encryption methods, such as the Advanced Encryption Standard (AES). AES encryption is approved in the United States for government documents with maximum security classification.

Smart Metering is the precursor for the energy infrastructure of the future. Transparent online display of consumption data offers customers the option to optimize their energy consumption and utilize flexible tariffs based on their device and energy mix.





Vertical: OPC UA from production right into SAP

»Seamless MES integration of systems with OPC UA simplifies shop floor programming«

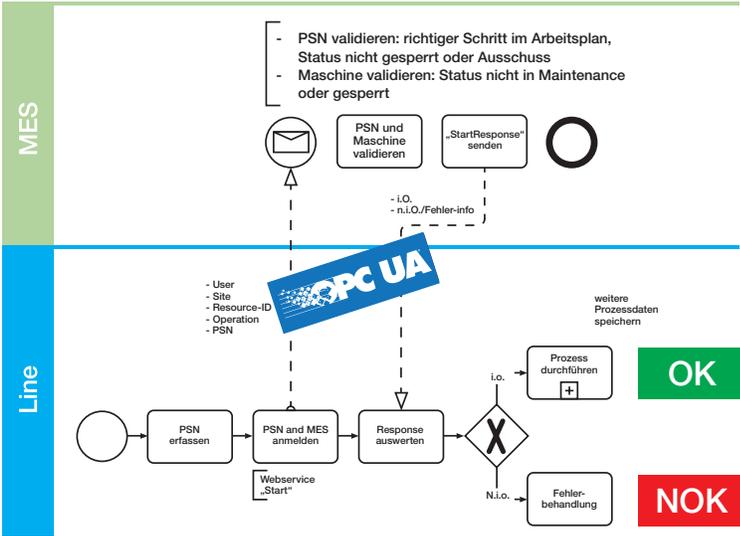
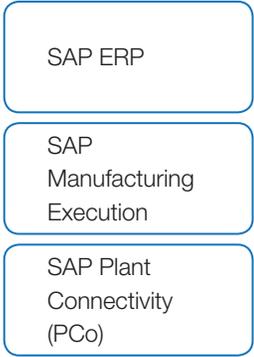
Rüdiger Fritz, Director Product Management, SAP Plant Connectivity (PCo), SAP

The product itself determines the way it should be produced. Ideally this enables flexible production without the need for manual setting up. Elster have already implemented the vision of Industrie 4.0 in first pilot lines.

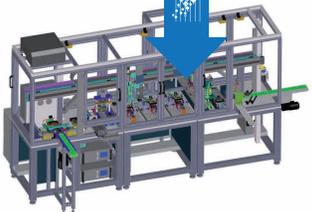
A key factor is the seamless integration between shop floor, MES and ERP based on OPC UA. At each step the product is identified through its unique shopfloor control number (SFC). OPC UA enables the plant control system to be coupled directly with the MES system, so that flexible procedures and individual quality checks can be realized in one-piece flow mode. Without any additional effort, PLC variables are published as OPC tags, and simply mapped to the MES interface. This enables fast and consistent data transfer, even for complex struc-

tures. The MES system receives the QM specifications via orders from the ERP and reports the finished products back to the ERP. Vertical integration is therefore not a one-way street, but a closed loop. In future, intelligent products with their own data storage will offer the prospect of exchanging much more than just a shopfloor control number with the plant. It is conceivable to load work schedules, parameters and quality limits onto the product, in order to enable autonomous production.

Before this can be implemented across the board, a number of challenges relating to the semantics (terminology) have to be addressed. However, one important aspect in the Industrie 4.0 has already been settled in practice: The communication between product and plant will take place via OPC UA.



Roland Essmann, Elster GmbH





Cloud: OPC UA for IoT up into the cloud

»The road to industrial cloud analytics leads through OPC UA.«

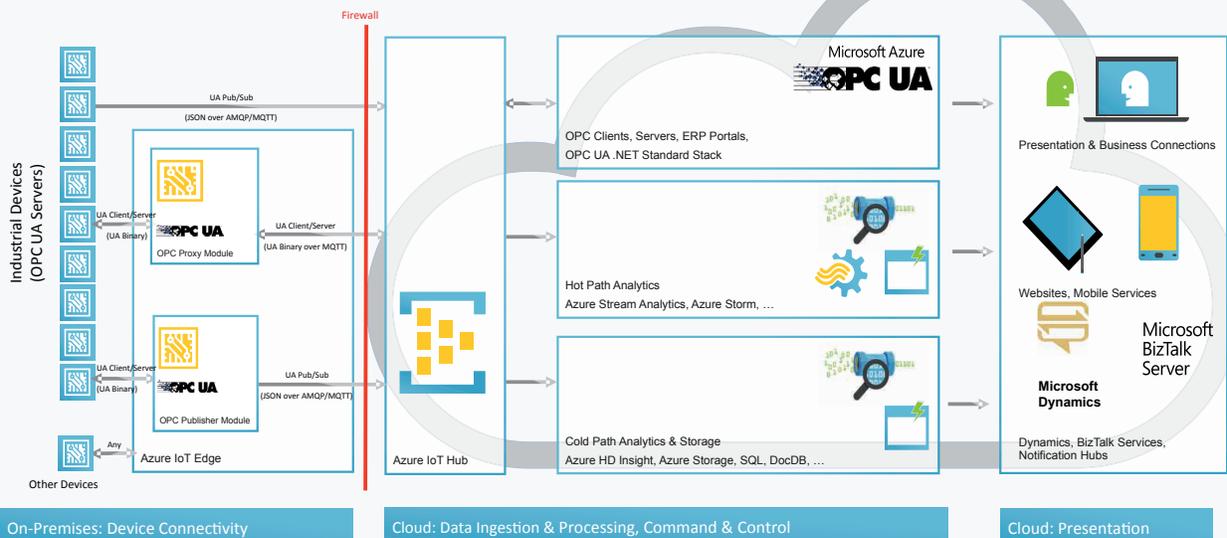


Erich Barnstedt, Principal Software Engineering Lead, Azure Industrial IoT, Microsoft Corporation, Platform Industrie 4.0 Member and OPC Foundation Technical- and Marketing Control Board Member

Microsoft Azure

OPC UA is an essential foundation for the convergence of OT and IT, providing a standardized communication, security and metadata/semantics abstraction for almost all industrial equipment. From an IT perspective, OPC UA is the programming interface of the “connected factory” and any other industrial facility and a critical enabler for Industrial Internet of Things (IIoT) as well as the Reference Architecture Model for Industry 4.0 (RAMI4.0) adoption. OPC UA also serves as a critical gateway technology to cloud-enable industrial equipment, enabling data

and device management, insights, and machine learning capabilities for equipment that was not designed to have these capabilities built-in. The cloud enables globally-available, industry-specific Software as a Service (SaaS) solutions that are cost-prohibitive to stand up for each industrial facility on its own. As customers and partners collaborate to modernize their plants and facilities, OPC UA is delivering digital transformation simply and easily. Microsoft’s support of OPC UA offerings will reduce barriers to IIoT adoption and help deliver immediate value.





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