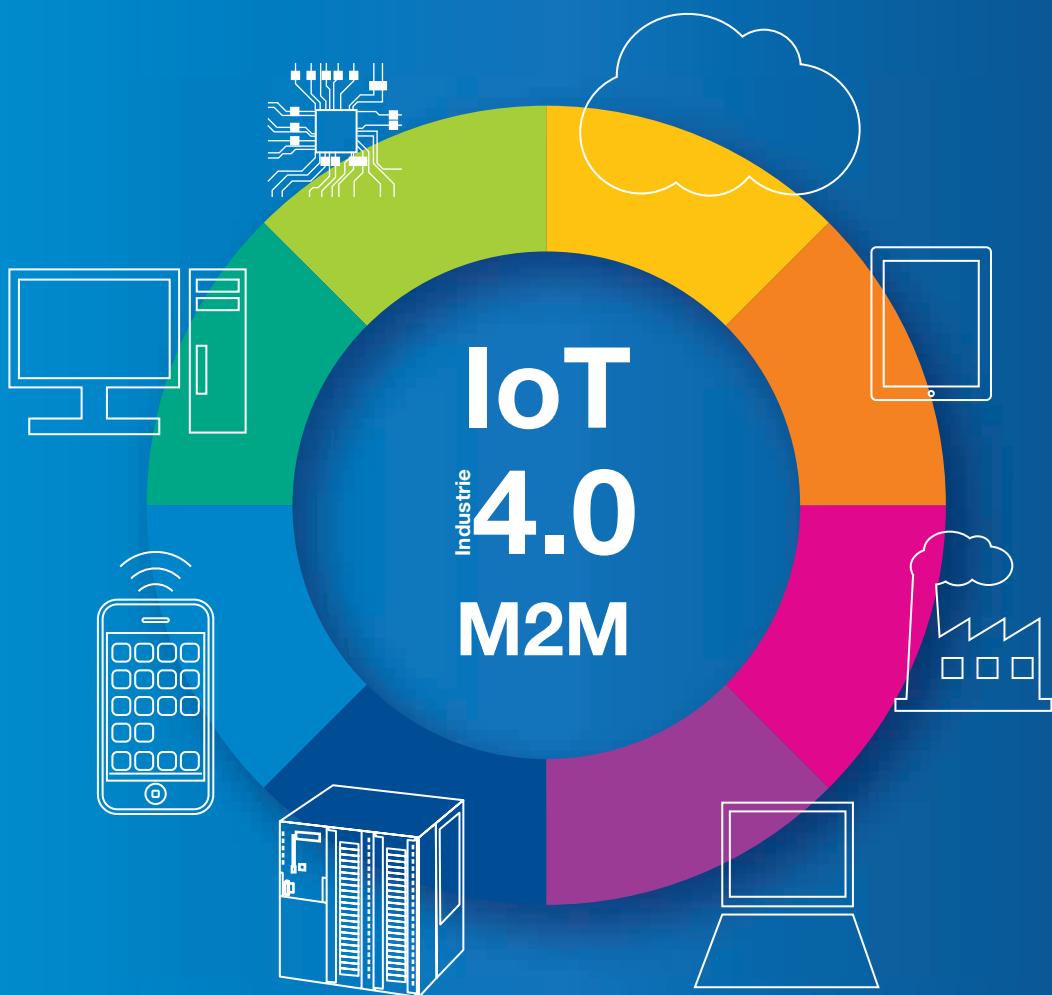


OPC Unified Architecture

Interoperability for Industrie 4.0 and the Internet of Things

Version 11 // June 2020





Stefan Hoppe

President and Executive Director OPC Foundation

Welcome to the OPC Foundation! As the international standard for vertical and horizontal communication, OPC UA provides semantic interoperability for the smart world of connected systems.

OPC Unified Architecture (OPC UA) is the data exchange standard for secure, reliable, manufacturer- and platform-independent industrial communications. 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 consistent information exchange in heterogeneous systems.

For nearly two decades, OPC has been, and continues to be, the go to connectivity standard in industry. With the advent of the Internet of Things (IoT) era, OPC adoption has also shown growth in new, non-industrial markets. By introducing a Service-Oriented-Architecture (SOA) in industrial automation systems in 2007, OPC UA started to offer a scalable, platform-independent solution for interoperability which combines the benefits of web services and integrated security with a consistent data model.

OPC UA is an IEC standard and is therefore ideally suited for collaboration with other organizations. As a global, independent, non-profit organization, the OPC Foundation coordinates the further development of the OPC standard in collaboration with us-

ers, manufacturers and researchers. Activities include:

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

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

With broad acceptance among representatives from research, industry, and associations, the OPC UA standard is well positioned to serve a key role in facilitating today's complex data and information exchange needs and in helping shape the future of data interoperability.

Regards,

Stefan Hoppe

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OPC UA: Interoperability for the IIoT

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 spans entire product and service life cycles. Once implemented, digitalization opens the doors to unprecedented new business opportunities and customer value; however, this is only possible if meaningful information can be shared openly and securely at every level. OPC UA is a standard that makes this possible.

INTERNET OF THINGS (IOT)

The IoT brings together a broad range of technologies that have traditionally not been connected via today's near-ubiquitous IP-based networks and puts them to work in novel new ways. While Ethernet enables things to 'reach' each other, they still need a common way to communicate meaningfully to be useful.

At the heart of the Industrial IoT (IIoT), OPC UA addresses the need for standardized data connectivity and interoperability for both horizontal and vertical data communications. An example of horizontal communications is Machine-to-Machine (M2M) data connectivity among shop floor systems. An example of vertical communications is device-to-cloud data transfer. In both cases, OPC UA provides a secure, reliable foundation, robust enough to facilitate standards-based data connectivity and interoperability. This did not happen overnight. The OPC Foundation has worked for years with companies and associations around the world and continues to expand its collaborations to ensure OPC UA meets the ever-growing diversity of communication needs the IoT era brings.

GROWING MACHINE INTERACTIONS

M2M typically refers to communications between two machines or between a more or less intelligent device and a central computer. The communication medium can either be a cable modem or wireless modem. In more modern devices, which range from vending machines to robots, data communications

are increasingly established over ever faster and resilient cell networks (5G for example) via SIM cards embedded directly into the machines. Such point-to-point connections allow the dedicated, on-board computers to send key data like stock levels, usage statistics, and alarm messages for the machine owners to best supply and maintain their assets. Such machine visibility opens the doors to new business models typically around logistics, maintenance, and special condition monitoring. For example, in the commercial environment, reword – turbines are not deployed at airports but rather on aircraft – but parts are stocked at airports. This optimizes maintenance scheduling, reduces unplanned down-time, and flight delays – all of which reduce operating or operational and maximize customer satisfaction.

INTERNET

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 are first aggregated and processed locally then sent via gateways (e.g. a smart phone) to centralized cloud-based systems. Within the IoT complex networks of intelligent systems are emerging. A similar development can be observed in industrial solutions where networked, shop floor machines and field devices are increasingly expected to process and combine data from other devices instead of just sending their own raw data. As such, 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 historical data. A far cry from the raw sensor-data-only systems of yesteryear.

EXPANDED COMMUNICATION DIVERSITY

Communication requirements between 'things' and services in the IoT era are far broader than what is seen in today's established infrastructures which, pri-



marily rely on point-to-point communications. For example, rather than query individual sensors and devices directly via point-to-point communications, broader IoT systems will subscribe to the data these sub-components publish via publish-subscribe (PubSub) protocols over IP-based networks. This will simultaneously facilitate high scalability and improved security. The customer benefits, created by the combination of intelligent devices and systems, along with the expanded services operators and vendors provide, will serve as the foundation for realizing the potential benefits the IoT has to offer.

OPC UA FOR VERSATILE INTEROPERABILITY

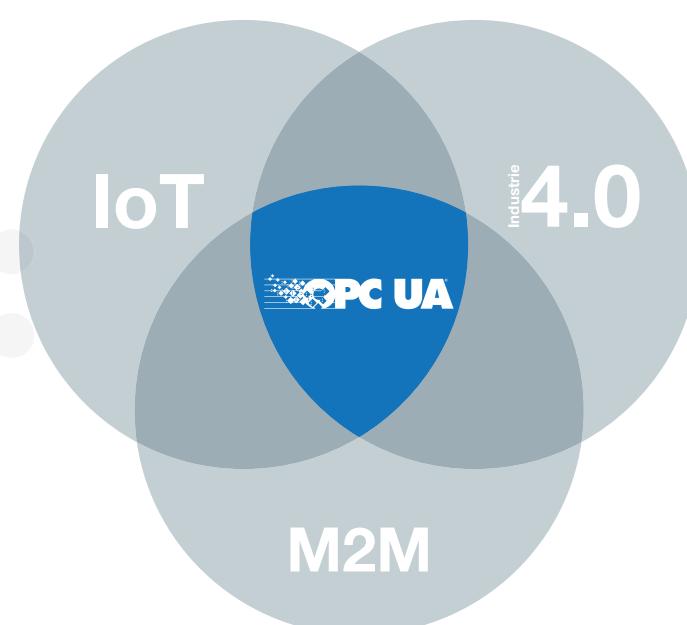
The vision of the IoT can only be realized if the underlying communication between components is based on a global communication standard that can fulfill a wide range of complex requirements.

For example, while a PubSub model is essential in low-resource, one-to-many communications, where

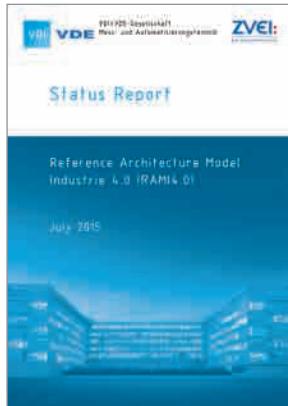
high scalability and speed are needed, the standard must also support a secure, connection-oriented, client/server model for bi-directional communication that allows sending control commands to actors. OPC UA supports both models.

Beyond simple ‘data’ sharing, a core IoT era standard must facilitate rich information exchange, which requires it to support a semantic metadata model that describes the data, and its purpose, to help best use the data directly. This is especially important when large amounts of data are pooled (aggregated) from a diverse eco system of third party systems. The OPC UA standard, object-oriented, information modeling mechanisms, directly fulfill this requirement.

Scalability and the possibility of integration across all network layers is required as well as platform and vendor independence. Here too, the OPC UA standard meets these requirements in a single, integrated package.



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



Source: www.zvei.org, July 2015

OPC UA – pioneer for Industrie 4.0

CHALLENGE

To remain competitive in the modern global economy, industrialized nations and their businesses must answer the challenges of increasing efficiency with ever shorter production cycles: through more effective use of energy and resources; by reducing time-to-market; by producing more complex products, faster, with rapid innovation cycles; and by increasing flexibility through individualized mass production.

VISION

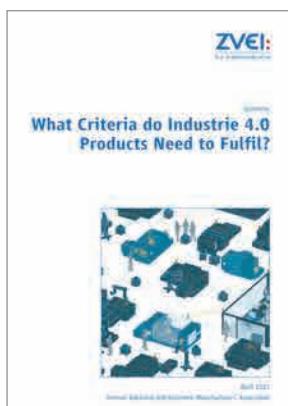
The 4th industrial revolution (Industrie 4.0) is driven by advanced Information and Communication Technologies (ICT), which are becoming increasingly prevalent in industrial automation. In these distributed, intelligent systems, physical components, and their data-based virtual counterparts, merge into cyber physical systems (CPS). When networked, CPS components form “smart” objects that can be further assembled into “smart factories” where production units can organize themselves and become self-contained, since they have all the information they need or can obtain it independently. Such systems can

reconfigure and optimize themselves and are expandable (plug-and-produce) without engineering intervention or manual installation. Beyond the manufacturing process itself, digital product information is also maintained within the product itself throughout its lifecycle and the value chain it moves through. When networked, such “smart” products then join the broader IoT conversation, responding to internal and external events with learned behavior patterns – benefiting both consumers and producers.

REQUIREMENTS

Considerable effort is required to implement the vision of Industrie 4.0 successfully, since a broad range of requirements must be met to make it all work. To manage the inherent complexity of this undertaking, comprehensive modularization, wide-ranging standardization, and consistent digitization are needed. As these requirements are more evolutionary than revolutionary, the technology to address them already exists but needs to be carefully brought together to build the foundation for 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:

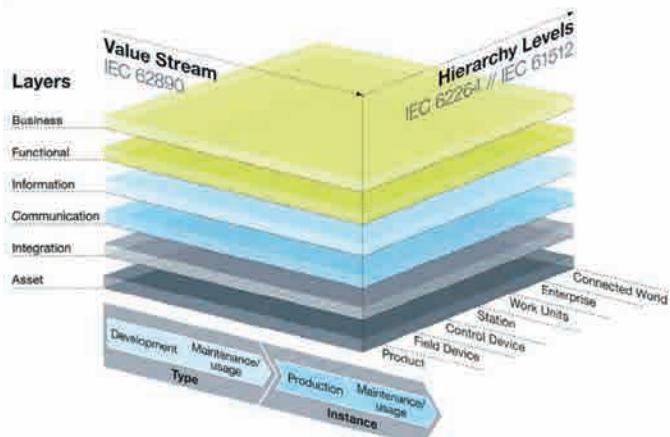
Industrie 4.0 communication

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



Copyright © ZVEI, SG2



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, there are communication stacks available in Ansi C/C++, .NET, and Java.
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, SCADA/HMI products, and MES/ERP systems. Projects have already been successfully realized in various cloud environments, including: Amazon, Foxconn, Google, and Microsoft Azure Cloud.
Secure transfer and authentication at user and application levels	OPC UA provides mechanisms for application and user authentication. It further includes signed and encrypted transfer mechanisms for data integrity and confidentiality, as well as a rights concept at the data-point level for authorization, including audit audit functionality.
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. Different protocol bindings are available for different use-cases (e.g. high-performance applications, Web Browser access). Additionally, a Publish/Subscribe (PubSub) communication model can be used. The communication stacks guarantee consistent transport of all OPC UA data. Besides live and real-time data, historical data and its mathematical aggregates are also standardized in OPC UA. Furthermore, method calls with complex arguments are supported along with alarming and eventing via a 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, object-oriented address space (hierarchical and full-meshed networks), that includes metadata and object descriptions. Object structures can be generated via referencing between object instances and their underlying type definitions, which are also object oriented and can be extended through inheritance. Since OPC UA servers carry both their object instances and associated type objects, OPC UA clients can navigate in any given OPC UA server's address space to obtain all the instance and type information they need, even for types previously unknown to them. 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 collocated (on the same host), in a subnet, or distributed globally (within the enterprise). Aggregation across subnets and intelligent, configuration-less procedures (e.g. Zeroconf) are used to identify and address network participants.
Integration into engineering and semantic extension	The OPC Foundation successfully collaborated with other organizations (PLCopen, MDIS, FDI, AIM, VDMA, MTConnect, AutomationML, etc.) and continues to expand its collaboration activities with groups from an ever-broader range of industries. See page 20 for a list of current collaboration partners.
Verification of conformity with the defined standard	OPC UA is an IEC standard (IEC 62541) for which tools and test laboratories are available for testing and certifying conformity. Additional test events (e.g. Plugfest) enhance quality and ensure compatibility. Expanded tests are required for extensions/amendments (e.g. companion standards, semantics). In addition, various validations of data security and functional safety are performed by external test and certification bodies.



One of 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.

IIC Testbeds Using OPC UA



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 via a gateway that extracts underlying sensor data and transfers it 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 AutomationML and OPC UA standards are applied to adapt factories on-the-fly by inserting new manufacturing assets into the factory production with minimum engineering effort.



UNITED STATES' NATIONAL INSTITUTE ON SMART MANUFACTURING

By enabling frictionless movement of information – raw and contextualized data – between real-time operations and the people and systems that create value in and across manufacturing organizations, CESMII is ensuring the power of information and innovation is at the fingertips of everyone who touches manufacturing.

CESMII IS LEVERAGING OPC UA

In an effort to identify common data in machines and processes to accelerate innovation in data science and application development, CESMII is leveraging OPC UA as an industry standard interface. Through the development of an OPC UA Companion Specification, CESMII members identify and articulate important data elements for both new and brown field manufacturing systems.

COMPANION PROFILES ACCELERATE INNOVATION

Once exposed, these “Smart Manufacturing Profiles” become a reliable interface for developers, so they can focus on creating new information value – rather than starting from scratch with individual data extraction. These companion data profiles will remain an open standard the entire industry can benefit from and accelerate innovation, research and development projects supported through the Institute.

CESMII's program and administrative home is with the University of California Los Angeles (UCLA), in partnership with the U.S. Department of Energy's Advanced Manufacturing Office.



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



»Mitsubishi Electric takes the lead on “Monozukuri” with a strong emphasis on reducing TCO through e-F@ctory solutions by integrating Factory Automation and IT to optimize Development, Production and the Maintenance processes.

OPC UA enhances e-F@ctory by providing Multi-Vendor connectivity and furthermore, OPC UA continues to expand TSN technology to new field device level specifications such as OPC UA FLC.

Mitsubishi Electric has adapted TSN that enables rapid IT and OT integration with the release of CC-Link IE TSN in May 2019 as a core network for E-F@ctory. Now, as a key member of the Board of Directors of the OPC Foundation, Mitsubishi Electric is committed to actively participate and contribute to the broader OPC activities. Utilizing its storied success and experience and applying that to the Foundation’s core specifications development, the ultimate benefit will be a better World of Manufacturing and Social Infrastructure.«

Tsuzuki Takayuki, Deputy Senior General Manager, Mitsubishi Electric Corporation Nagoya Works, OPC Board company



The Chinese government put forward a Made In China 2025 plan to facilitate China's transformation from a manufacturing giant with a sole focus on quantity to one with an edge in higher quality products. The central focus of the Made In China 2025 initiative is Intelligent Manufacturing, which is based on deep integration of new-generation information technology and advanced manufacturing technology. It is an effective means to achieve the goals of shortening product development cycles, increasing production efficiency, and improving product quality while reducing operating costs and energy consumption.

Intelligent Manufacturing requires horizontal and vertical integration of all information systems, including IT and OT systems in factories and plants. This not only requires the transmission of raw data values but also semantic-based information exchange. Based on these requirements, OPC UA was adopted because it supports semantic-based communications via information modeling and services based on a services-oriented architecture (SOA). OPC UA was a natural fit for the integration of interconnected networks in digital factory/plant and facilitates 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 and 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



The government of the Republic of Korea announced the vision of “Manufacturing Renaissance: Made in Korea” in June 2019 to make the world’s four major manufacturing powers leap through manufacturing revival. To achieve the Manufacturing Renaissance Vision, Korea aims to accelerate innovation in industrial infrastructure through digitalization, eco-friendliness, and an overall convergence of the manufacturing industry. Korea plans to spread smart factory technologies to SME companies in cooperation with domestic and foreign solution companies. OPC UA technology will be used as a key industrial standard for connecting OT (Operational Technology) and IT (Information Technology) in smart factories.



KETI Korea Electronics
Technology Institute

- »OPC UA is responsible for ensuring interoperability between manufacturing processes/equipment in an Industrial Internet of Things (IIoT) environment. KETI

has organized a Smart Manufacturing Innovation Center since 2014 and is devoted to developing various IIoT standard communication technologies and interoperability technologies including OPC UA, TSN, 5G. KETI is also contributing to OPC UA open source(open62541), and is developing a standard IIoT framework to support automatic recognition and connection between various Factory-Things through OPC UA.«

Byunghun Song, Head of Smart Manufacturing Research 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.«

Dr. Jingu Jeong, Vice President, Samsung Electronics



HANCOM
HANCOM MDS

»OPC UA is helping to overcome various challenges in the digitalization process of the manufacturing site in the past. In particular, it has supported incredible scalability to allow flexible communication of various manufacturing facilities, and it has relieved software developers of the burden of dealing with numerous vendor-specific protocols by providing a single, and standardized communication method. HANCOM MDS has developed “Industrial IoT platform Thing-SPIN®” to generate data sets for use in machine learning and deep learning as well as make it easy to connect, collect, and visualize the state of the production facilities. We are applying OPC UA as the most important data source.«

Sangsoo Kim, Leader of IIoT Platform Team, Hancom MDS



Microsoft

»OPC UA is an essential component of manufacturing and process control technology, it enables the internet of things today, and it is going to enable digital twins and systems based on mixed reality and artificial intelligence on the factory floor. In keeping with our commitment to openness and collaboration, Microsoft is fully committed to supporting OPC UA and its evolution.«

Dr. Holger Kenn, Director AI and MR Business Strategy, Microsoft,
OPC board member



Google Cloud

»Google Cloud's membership reinforces our commitment to openness and industry collaboration. OPC UA will be our way of incorporating machine data into our data analytics and AI capabilities, to ultimately drive new capability and performance within the factory. By driving AI across the value chain, our goal is to provide flexibility and choice at industrial scale.«

Dominik Wee, Managing Director Manufacturing, Industrial and
Transportation, Google Cloud



CISCO

»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



Honeywell

»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



SAP

»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



**Rockwell
Automation**

»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.«

Dr. Jürgen Weinhofer, Vice-President Control Architecture and Technology,
Rockwell Automation, OPC board member



NATIONAL INSTRUMENTS



ABB

»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 inter-connectivity of Cyber Physical Systems (CPS) in the evolutionary process of IIoT.«

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

»In the future, customers across various industries will no longer be bound to suppliers based on the communications protocol used and competition will more strongly focus on creating value. Adoption of OPC UA over TSN will drive this paradigm also into the world of deterministic and real-time communication. At the same time, it will enable using the same consistent information model from the field to the cloud.«

Dr. Bernhard Eschermann, CTO of ABB Industrial Automation Division



YOKOGAWA

»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



GE

»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.«



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

Thomas Hahn, Siemens AG, OPC board member



Schneider
Electric

»In order to reap the benefits of the promise made by Industry 4.0, OPAF, ... Schneider Electric believes that vertical and horizontal communication interoperability across the automation pyramid is a must for industrial customers. The combination of OPC UA Client Server, OPC UA Pub Sub and the extension of OPC UA including TSN down to the field will enable such interoperability. That's why our open EcoStruxure Plant & Machine architecture will standardize on OPC UA over the time.«

Dr. Fabrice Jadot, Next Generation Automation Solution Incubator SVP,
Schneider Electric, OPC Board Member



FESTO

»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



PHOENIX
CONTACT

»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



AIC
艾克信控

»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,
Faculty Mechanical Engineering, AutomationML e.V. Board of Directors



aim
Advancing Identification Matters

»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



QUOTES – ASSOCIATIONS AND ORGANIZATIONS



»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 standardized information model for exchanging sub-surface and platform information in the Oil & Gas industry. This OPC UA information model was developed by a consortium of Oil and Gas Operating companies, sub-sea vendors and DCS platform vendors. The certified OPC UA interfaces along with standardize exchange of configuration information and communication, greatly reduces engineering and testing costs, which is a real win for all parties.«

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



»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 – retired



Thomas J. Burke
President 2000 – 2018

Presidents OPC Foundation:
1996 – 1998 David Rehbein
1998 – 2000 Dr. Gil Pareja
2000 – 2018 Thomas Burke
2018 – present Stefan Hoppe

How OPC began

OPC FOUNDATION HISTORY

The OPC Foundation's forerunner – a task force composed of Fisher-Rosemount, Rockwell Software, Opto 22, Intellution, and Intuitive Technology – was able to develop a basic, workable, OPC specification after only a single year's work. This standard was named "OLE for Process Control" as it was built on Microsoft COM/DCOM technology and acted like a device driver to enable PLC controllers to deliver live data, alarms and historical data. A simplified, stage-one solution was released in August 1996.

The members of the task force included: Al Chisholm, David Rehbein, Thomas Burke, Neil Petersen, Paul van Slette, Phil White, Rich Malina, Rich Harrison, and Tom Quinn. While each of the members worked for competing companies, they quickly established great relationships and focused on the task of developing a specification that was built on solid technology for interoperability. Sample code came first, followed by the specification. The OPC task force made sure that everything was feasible and exceeded the expectations of all the (competing) vendors since the goal was to develop technology that multiple vendors would quickly adopt in the interest of multi-vendor interoperability.

In 1997, the first Board of Directors was comprised of Siemens (Dr. Reinhold Achatz), Emerson (Dr. Gil Pareja), Rockwell (Rich Ryan) National Instruments (Don Holley), Honeywell (John Usakai), Intellution (Al Chisholm) and Toshiba (Yoh Shimanuki). Over the years the Board of Directors changed. The today called "OPC classic" became defacto standard and formed the successful base of worldwide adopted interoperability standard and constantly increasing membership of OPC Foundation.

The chronological order of the OPC Foundation developments can be found here:

<https://opcfoundation.org/history>

THE NEW OPC GENERATION: OPC UA

In 2003 OPC Foundation started separating services from data and the OPC Unified Architecture (OPC UA) was created as a service-oriented architecture. It was designed to seamlessly deliver secure and reliable information exchange from sensors through to IT enterprise independent of operating systems, vendors and markets.

The challenge to adoption was a huge install base of existing OPC products based on OPC Classic which needed to migrate to the next generation OPC UA technology. As such, OPC UA had to take into account back-ward compatibility. After verification and implementation in 2006 and 2007 the OPC UA specification was finally released in 2008.

To better facilitate global adoption, the OPC UA was designed to become an IEC specification. Work on making the OPC UA standard compliant with IEC rules and templates commenced in 2010 and was completed in 2012. As a result, the OPC UA standard is now a full-fledged IEC standard known as IEC62541. In addition, the OPC UA standard has also been localized in different part of the world like China and Korea.

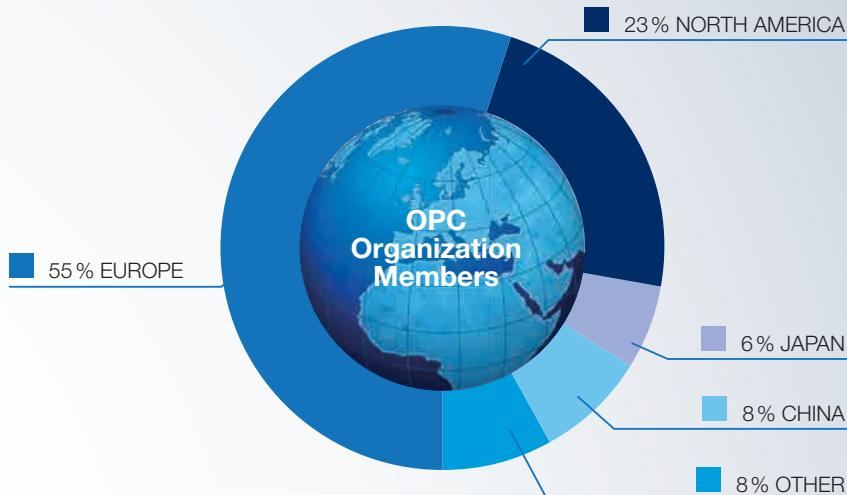
CERTIFICATION & PRODUCT QUALITY

Since the early days OPC Foundation is dedicated to maximize product quality. OPC Classic certification was first started as a self-testing activity via the OPC Foundation supplied certification tool. With the advent of OPC UA technology and its broader scope and complexity – the OPC Foundation determined it was necessary to formalize OPC product certification to help ensure OPC product implementation quality in the marketplace. The first OPC Foundation certification lab was opened at Ascolab in Erlangen, Germany. Over the years, labs in US, Germany and China were also opened.

The first OPC Foundation interoperability workshop (IOP) was hosted by Rockwell in Cleveland, Ohio in January 1996 – today the OPC Foundation offers yearly IOP events in Europe, US and Japan.



OPC Foundation – organization



With more than 730 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 cyber physical systems (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. The OPC Foundation together with its member companies offers events and training programs for end users of the OPC technology to help market the technology to users in potentially new markets. 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. The OPC Foundation encourages end users to join working groups to help ensure that the practical requirements and feedback are factored into the specification development process, especially for information model companion specifications.

INDEPENDENCE

The OPC Foundation is a non-profit organization that is independent of individual manufacturers or special technologies. Members of the working groups come

from 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 (above 50 %) are based in Europe. Around one third of the members are based in North America. All main 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 to exchange information and to network. Multiple times each year, at various locations around the world, a week-long interoperability workshop (IOP) is held, at which the latest products and their interaction are tested.

OPC-Foundation Working Groups

The OPC Foundation working groups (OPC-F WGs) are essential for the development of industry-leading specifications, technologies, certification and processes. The focus of these working groups is to provide the deliverables that are adopted by the OPC community into real-world products and services. Meetings are generally conducted online and occasionally in person.

Members can participate in Working Groups to ensure that their unique technology needs are considered by the industry-at-large. This approach allows the OPC Foundation, through the participation of its members as marketing and engineering resources, to move the standard forward to meet the technology challenges of tomorrow. See the FAQ for details on how to join a group.

WORKING GROUPS

→ Unified Architecture Working Group

Responsible for defining, maintaining and improving the OPC UA specifications. Additionally, base architecture enhancements are evaluated for extensibility into other companion specifications (e.g. information modeling; adding native OPC UA data types). The core UA working group has weekly electronic meetings and 3-4 Face2Face meetings per year. A number of expert sub-groups support the UA working group:

- **Security Sub-Group** assures that OPC UA security mechanisms are always up to date. It also assesses security alerts or warnings. Membership includes OPC UA stack developers to assure that any issues are handled in a timely manner.
- **PubSub Prototyping Sub-Group** strives to assess and improve the specified PubSub model with prototype implementations. This includes jump-start meetings with interoperability tests.
- **TSN Sub-Group** does the groundwork for PubSub over TSN so that TSN streams can be configured for deterministic controller to controller communication.

→ Compliance Working Group

Responsible for the OPC Foundation Compliance program. This group analyzes OPC specifications to determine how products are to be tested for compliance. The group meets weekly to discuss test procedures, Compliance Lab standard operating procedures, and to continually update and enhance the Compliance Test Tools.

→ UA for Devices Working Group

Responsible for defining, maintaining and improving the OPC UA for Devices (DI) specification. DI specifies a generic data model to represent devices. Parameters as well as control functions can be exposed and grouped according to their purpose (e.g. configuration, diagnosis, and statistics).

→ Field Level Communication Initiative

The vision of the initiative is to strive for an open, uniform, secure and standards-based IIoT communication solution between sensors, actuators, controllers and the cloud that meets all the requirements of industrial automation – factory automation but also process automation. For factory automation special requirements like deterministic communication, functional safety and motion are optional features.

→ Harmonization Working Group

In this working group members of various companion specification working groups and modelling experts meet to harmonize the way companion specifications model things. The working group is responsible for the companion specification template and forms sub-teams to define common modelling constructs usable in a generic way.

→ Semantic Validation Group

This group strives to translate semantic rules that are currently specified in natural language into a format that can be processed programmatically. This allows tooling to check semantic inconsistencies, or other rule violations.

OPC UA COMPANION SPECIFICATIONS – OVERVIEW

21

■ public available

■ under construction

Generic Device Models (Controller, Field Device, Process Device)			
Device Model (DI)	Generic representation of devices, e.g. Field devices, controllers, robots, machine tools		
Analyzer Devices (ADI)	Representation of analyzer devices like Particle Size Monitor, Gas Chromatograph, and others		
PLC model based on 61131-3	Representation of control program, tasks, controller variables, structured data, function blocks		
PLC Client FunctionBlocks	PLC controller acting as Client initiates to read, write, invoke methods and more		
Autoid Devices (Autoid)	Identification devices comprising barcode, OCR, 2D code, RFID, NFC, RTLS, sensors and mobile computing		
Process Devices (FCG PA-DIM)	Representation of devices used to measure pressure, temperature, flow, level, etc.		
Oil & Gas			
MCS and DCS (MDIS)	For Subsea Production Control System with a Master Control Station (MCS) or a distributed Control System (DCS).		
Energistics ProdML, WitsML	For Oil & Gas drilling systems and Oil & Gas production systems (drilling – WITSML, producing – PRODML).		
Manufacturing Devices, Robots, Machines, Machine Tools			
umati (Universal Machine Tool)	Interface of machine tools towards communication partners like MES, ERP, cloud, automation system.		
CNC systems	Representation of the CNC kernel.		
MTConnect	Maps the MTConnect data standard to OPC UA. Data sources includes sensor packages, and other hardware.		
Plastics and rubber machinery	Multiple specifications for Plastics and Rubber machinery (e.g. injection moulding, extrusion).		
Machine Vision	Integration of machine vision systems into production control and IT systems.		
Robotics	Robotics stands for a complete system. E.g. industry robots (stationary), mobile robots service robots and more.		
Weighing	To transport condition data of a weighing instruments into manufacturing systems (MES; etc.).		
End-of-arm Tools	Examples are grippers, screwdrivers, welding machines and exchange units.		
High Pressure Die Casting	Devices of a "High Pressure Die Casting Production Cell".		
Powertrain	Aa system that includes the motor starter, complete drive module, electric motor and transmission elements.		
Surface Technology	Models for surface treatment machinery and supporting systems (e.g. technical ventilation, conveying systems).		
Woodworking Machinery	Woodworking machines and equipment used in primary and secondary wood processing.		
Pumps and Vacuumpumps	Condition and operation data of pumps and vacuum pumps.		
Glass Industries	Glass production and processing equipment and a basic description of the flat glass cutting equipment.		
Mining	Mining machinery and equipment.		
Enterprise, Asset Mgmt, Packaging			
ISA-S95	Flow of information between Manufacturing Operations Management and ERP systems		
Mimosa CCOM	Maps the MIMOSA CCOM (Common Collaborative Object Model) for the exchange of asset information.		
Product Serialization (Open-SCS)	Addresses the Healthcare Industry's Product Serialization Regulation Wave of the next decade.		
OMAC PackML	Reflects the ISA88 Technical Report (TR88.00.02). Defines StateMachines for the PackML states.		
Weihenstephan Standards	Maps the existing "Weihenstephan Standards", e.g. WS Food, Pack, Bake, Brew.		
Asset Administration Shell	Exposes I4AAS information to exchange asset information between Industrie 4.0 components.		
Engineering			
DEXPI	Model for Piping and Instrumentation diagrams (P&IDs) based on DEXPI.		
AutomationML	Data exchange in the engineering process of production systems (e.g. CAD, electrical/mechanical planning).		
Field Device Integration			
Field Device Integration (FDI)	Integration of field devices described with EDDL in an FDI host system.		
Field Device Tool (FDT)	Integration of devices represented by a Device Type Manager (DTM).		
Field Communication Mappings			
SERCOS	Powerlink	IOLink	ISA 100
Csp+ForMachine (CCLink)	PROFINET		
Building and Energy			
BACnet	Gateway interface between the BACNET object model and OPC UA.		
IEC 61850	Represent electrical substation automation systems.		
Wind Power Plants (IEC61400-25)	OPC-UA access to exchange wind power domain data according to the IEC61400-25.		
Miscellaneous			
TMC Tobacco	Represent tobacco industry machine information to higher-level manufacturing systems (MS/MOM).		
Professional Kitchen Devices (HKI)	Examples are Fryer, Combi Steamer, Convection Oven, Cooking Kettle, Coffee Machine, Dishwashing Machine.		

OPC UA at a glance

SECURE, RELIABLE INTEROPERABILITY

OPC UA is the latest generation of OPC technology from the OPC Foundation. OPC UA rewrites the original OPC standard from the ground up and extends its relevance by addressing a broad range of modern communication requirements. As such, OPC UA delivers a secure, reliable transport of data and information from sensors and the shop floor to control systems, production planning systems, and beyond.

PLATFORM AND VENDOR-INDEPENDENT

OPC UA is an open standard without dependence on or binding to proprietary technologies or individual vendors. Hence, all OPC UA communications are 100% independent of the vendors who implement them, the programming languages used, and the platforms those products run on.

USES THE LATEST OPEN STANDARDS

OPC UA is based on a various types of standards and protocols carefully chosen based on their ability to meet the needs of specific OPC UA use cases. For example:

- For OPC UA Client-Server communications, OPC UA uses an optimized TCP based binary protocol for data exchange over the IANA registered port 4840.
- For Cloud-based communications, OPC UA uses popular protocols like MQTT and AMQP.
- For communication in the field OPC UA uses UDP and specialized protocols like TSN or 5G for deterministic communication.
- Web Sockets may also be used to support browser-based OPC UA Clients. New protocol bindings like QUIC (UDP-based Internet protocol) can be integrated easily without breaking existing functionality.

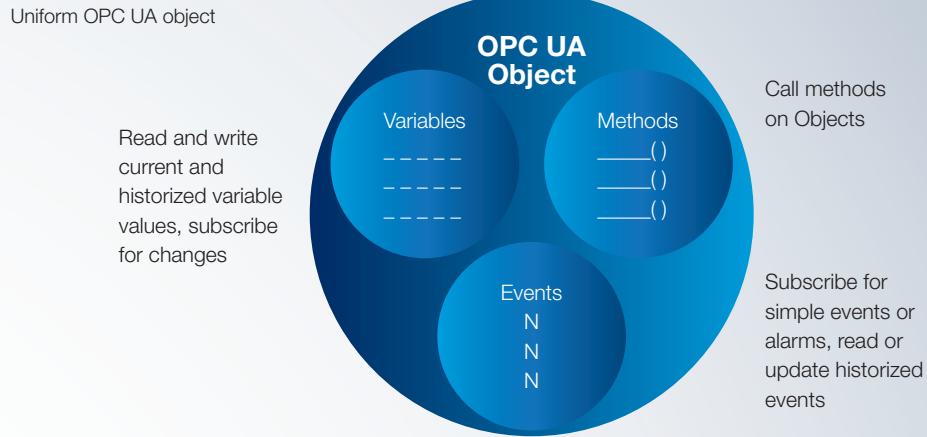
ROBUST INFORMATION MODELING

Robust information modeling (IM) is built into the heart of the OPC UA standard. OPC UA defines base building blocks and consistent rules to build object-oriented models with them. In OPC UA it is possible to expose and discover information models in a consistent and universal manner between all OPC UA entities. OPC UA defines a few industry agnostic IMs that other organizations use as a common starting point to define their own OPC UA based IMs. OPC UA also defines the mechanisms needed to facilitate dynamic discovery and access to OPC UA IMs. This is crucial for 3rd party interoperability because different OPC UA implementations will natively implement different IMs. Key OPC UA functions include:

- Browsing: A look-up mechanism used to locate wobject instances and their semantics
- Read and write operations: used for current and historical data
- Method execution
- Notification for data and events

CLIENT-SERVER

OPC UA Client-Server communications are based on the service-oriented architecture (SOA) paradigm. Therefore, information model access is defined via services. Unlike classic Web services which describe their services using the xml-based Web Services Design Language (WSDL) which allows each service provider's implementation to be different and hence not directly interoperable, OPC UA predefines generic standardized services to ensure all OPC UA implementations are compatible. A WSDL definition is not required in OPC UA, 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.



PUBLISH-SUBSCRIBE (PUBSUB)

PubSub provides an alternative mechanism for data and event notification. Unlike Client-Server communications, PubSub is optimized for many-to-many interactions where multiple clients may receive broadcasted notifications in a fire-and-forget fashion. With PubSub, OPC UA applications do not directly exchange requests and responses. Instead, Publishers send messages to Message Oriented Middleware without any knowledge about the Subscriber(s). Similarly, Subscribers express interest in specific types of data and process messages that contain this data without knowledge of the Publisher(s). PubSub and Client Server are based on the OPC UA Information Model. Publishers are typically OPC UA Servers and Subscribers are commonly OPC UA Clients. Local OPC UA Client-Server communications are used to setup PubSub components.

STRONG SECURITY THAT IS SCALABLE

OPC UA is based on accepted security concepts and standards that are also used for secure internet communications. Examples include SSL, TLS and AES. OPC UA offers protection against unauthorized access, sabotage, modification of process data, and careless operations. OPC UA security mechanisms include: user and application authentication, signing of messages, and data encryption. While users are free to choose which OPC UA security functions they want to use based on their infrastructure and context, vendors are obliged to implement all of them depending on the OPC UA profile they want to support. This ability to choose which security features are used makes OPC UA usable (scalable) in all types of environments (e.g. limited computing resources vs. large computer systems).

ACCESSIBILITY AND RELIABILITY

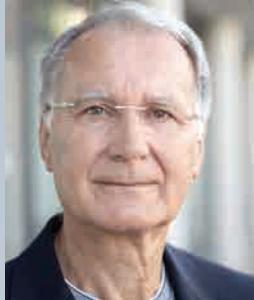
OPC UA defines a robust architecture with reliable communication mechanisms, configurable timeouts and automatic error detection that restores communications between OPC UA Clients and Servers without data loss. In addition, OPC UA redundancy functions for both client and server applications make OPC UA suitable for high-availability applications.

SIMPLIFICATION BY UNIFICATION

OPC UA defines an integrated address space and a unified information model that supports process data, alarms, historical data, and function calls (methods). Beyond OPC classic functionality, OPC UA also supports the description and use of complex procedures and systems in uniform object oriented components. Hence, OPC UA clients which only support basic rules can still process data from OPC UA Servers without any knowledge of the complex data structures residing in the OPC UA Server.

GROWING AREAS OF ADOPTION

The functional breadth of OPC UA makes it universal and applicable for use in an ever growing list of new markets and applications. From local plants to remote field stations behind firewalls – OPC UA is the right choice to standardize on. Other standards bodies increasingly use OPC UA as an interoperability platform for defining and implementing their own information models. Currently, the OPC Foundation cooperates with over 52 such groups from various industries, including: discrete and process automation, energy, engineering tool manufacturers, industrial kitchen equipment, and many more.



OPC UA technology in detail

Karl-Heinz Deiretsbacher, Technical Director, OPC Foundation
Dr. Wolfgang Mahnke, Unified Automation, Senior Consultant

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

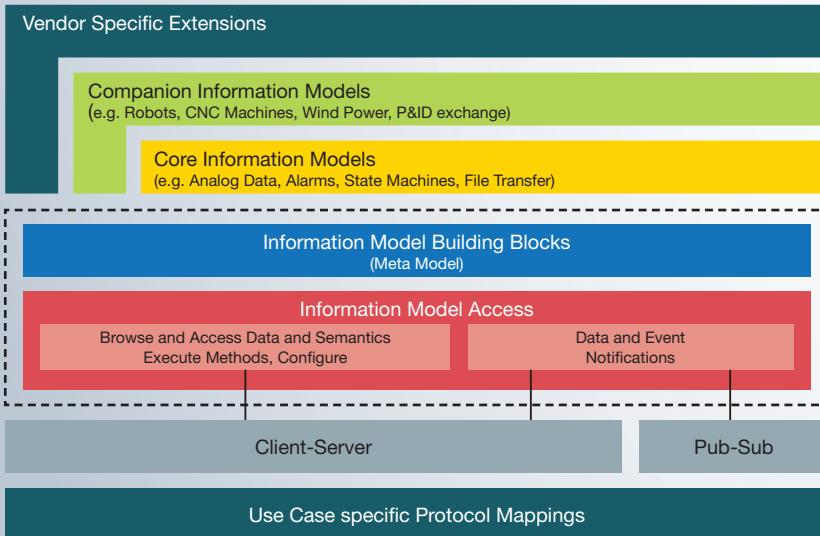
The trend in automation is towards inclusion of communication data semantics in the standardization. Standards such as ISA 88 (also IEC 61512, batch processing), ISA 95 (also IEC 62264, MES layer) or the Common Information Model (CIM) with IEC 61970 for energy management and IEC 61968 for energy distribution 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.

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:

- **Information Model (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.
- **Information Model Access** – specifies the mechanisms to access information models via OPC UA.
- **Client-Server** – Services constitute the information model access between a server as information provider and clients as users of this information. Application and user authentication, full access to instances and meta information and robustness are key attributes for this communication model.
- **PubSub** – provides a message-based notification of data or events. It specifies the rules to combine data into a DataSet, to construct and publish messages with DataSet payload. It can be enhanced with message security.
- **Use Case specific Protocol Mappings** – To support the required use cases, a few different protocol mappings exist in OPC UA
 - **Client-Server:**
 - UA TCP with UA Binary is optimized for speed and throughput
 - HTTPS / WebSockets + JSON for web browser access
 - **PubSub:**
 - UDP for best effort, secure multicast
 - MQTT for use of brokers with store-and-forward functionality
 - TSN or 5G for deterministic transport



OPC UA layer model



Information models follow a layered approach. Core Information Models are already defined as part of the OPC UA specification. 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.

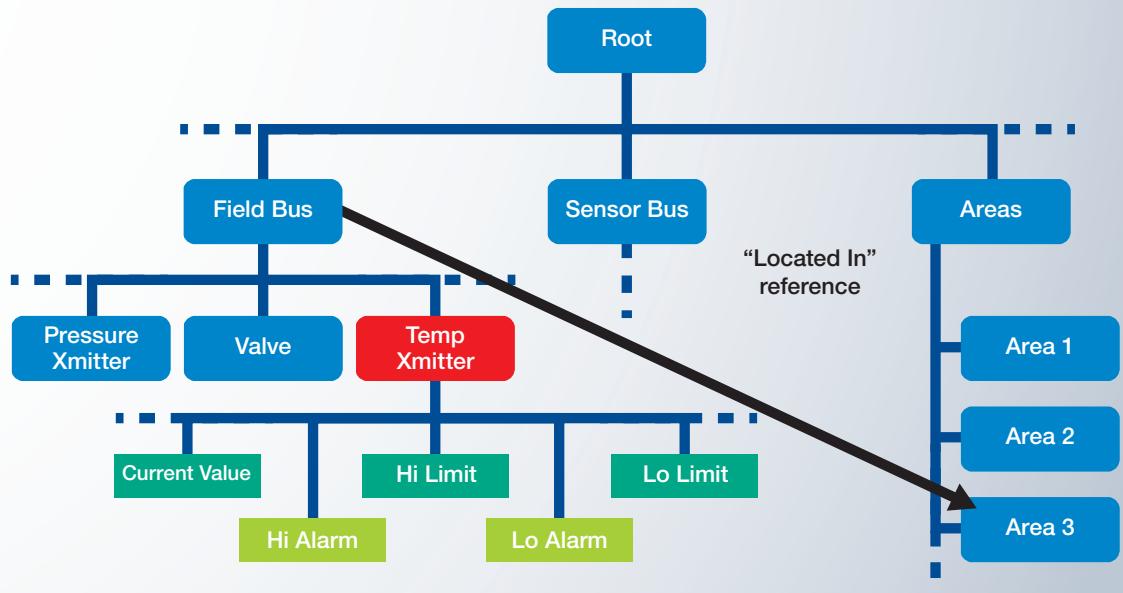
Although they don't understand the deeper relationships, they can navigate through the address space and read or write data variables, execute methods or receive notifications.

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 clients 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).



INTEGRATED SERVICES

For the Client-Server communication model, 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. 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.

PUBLISH SUBSCRIBE

The following figure provides an overview of Publisher and Subscriber and illustrates the flow of data and event notifications as messages from a Publisher to one or more Subscribers.

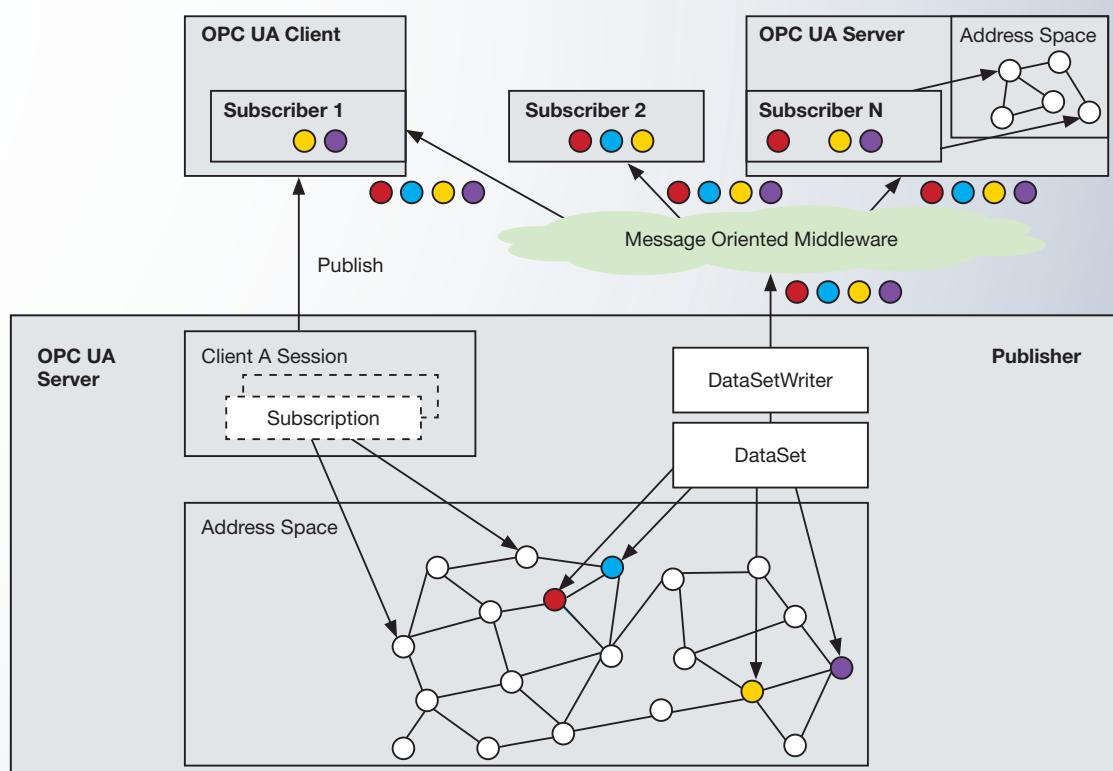
The PubSub communication model supports many other scenarios; for example, a Publisher may send a messages to multiple Message Oriented Middleware and a Subscriber may receive messages from multiple Publishers. Message Oriented Middleware is software or hardware infrastructure that supports sending and receiving messages between distributed systems. It can be, for example an MQTT broker or network infrastructure that supports UDP multicast.

Publishers and Subscribers are loosely coupled. They often will not even know each other. Their primary relation is the shared understanding of specific

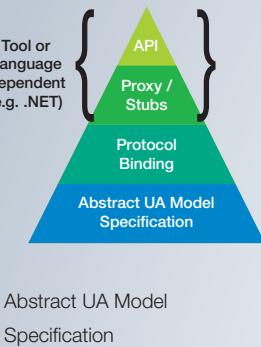
types of notification data or events (represented by DataSets), the publish characteristics of messages that include these data, and the Message Oriented Middleware.

A DataSet can be thought of as a list of name and value pairs representing an Event or a list of Variable Values. DataSet fields can be defined to represent any information, for example, they could be internal Variables in the Publisher, Events from the Publisher or collected by the Publisher, network data, or data from sub-devices.

Message security in PubSub concerns integrity and confidentiality of the published message payload. It is end-to-end security (from Publisher to Subscriber) and requires common knowledge of the cryptographic keys necessary to sign and encrypt on the Publisher side as well as validate signature and decrypt on the Subscriber side.



Overview Publisher and Subscriber message flow



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.

- **At the lowest level** are the abstract model, the Client-Server services and PubSub messages, including the whole address space model, different object and variable structures, alarms and more.
- **The next level** (Protocol Binding) is used to specify how services and messages are to be mapped to certain protocols. In the future – once new technologies become established – further mappings can be specified without having to change the abstract model, services or messages. 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 provides open source implementations, see <https://github.com/OPCFoundation/>.

PERFORMANCE

For optimal support of different usages, OPC UA has defined mappings to different technologies. Mappings on top of advanced Ethernet technologies ensure highest performance. Client-Server services and PubSub messages are designed for high data throughput. An individual read call can access thousands of values, for example. Subscription services enable notification when values are changed and exceed configured thresholds. “PubSub messages have been designed for optimized hardware augmented processing.”

INFORMATION MODELS WITH OPC UA

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 realtime data, i.e. data that represent current state and behavior 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.

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.

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?

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.

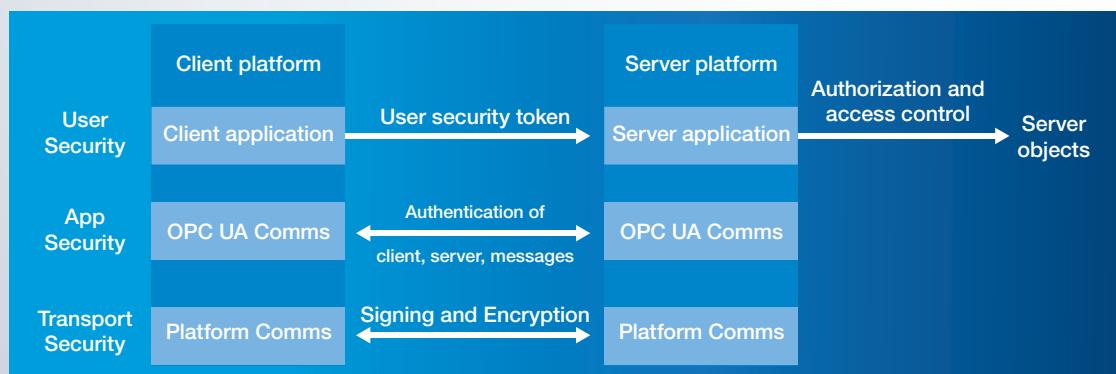
→ **3. OPC UA Transport level security** can be used to provide integrity via message signing and confidentiality via message encryption. This prevents message tampering and eavesdropping respectively. The OPC UA security mechanisms are realized as part of the OPC UA stacks, i.e. they are included in 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.





SECURE CHANNEL

The OPC UA SecureChannel is characterized by a Security Mode and a SecurityPolicy.

- **SecurityMode** specifies which of three security levels is used to secure OPC UA messages. The options are: "None", "Sign", and "SignAndEncrypt".
- **SecurityPolicy** specifies what encryption algorithms are employed by the SecurityMode. Current options include: RSA and AES for message encryption and SHA for message signing.

SECURE CONNECTIONS

To establish secure connections, bi-directional trust must be obtained using Public Key Infrastructure (PKI) which utilizes asymmetric key exchange between the OPC UA client and server. By using standard X.509v3 certificates, OPC UA built its security infrastructure on well-established IT standards.

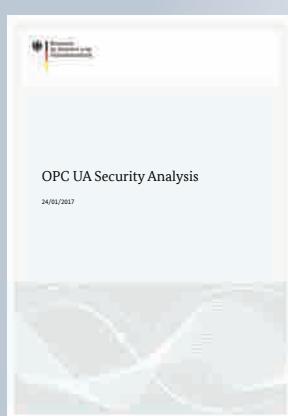
USER AUTHENTICATION

Beside the SecureChannel used for application authentication, user authentication may also be employed to provide maximum security. The OPC UA client can provide user credentials during session establishment (e.g. either user/pwd, user certificate, or single sign on token), which will be validated by the OPC UA server when granting access to individual elements within the server's address space.

GLOBAL DISCOVERY SERVER

To manage the system wide rollout and update of OPC UA certificates, trust, and revocation lists, OPC UA also includes the concept of a Global Discovery Server (GDS). All OPC UA enabled servers and clients register themselves with the GDS and obtain regular updates of their trust and revocation lists. In addition, the GDS may also serve as a Certificate Authority (CA) which can handle signing requests and certificate updates of its registered servers and clients.

Security analysis by German Federal Office for Information Security: »OPC UA ... does not contain systematic security vulnerabilities.«



OPC UA Security Analysis

24/01/2017

Download:

www.opcfoundation.org/security/

OPC UA is one of the most important modern standards for industrial facilities and many further scenarios in an intelligent and connected world. OPC UA is considered a central building block on the way towards Industrie 4.0. It enables integration between various layers of the automation pyramid from sensor up to the ERP system. It is the first time a unified, worldwide recognized industrial protocol can be employed that allocates necessary cryptographic mechanisms for a secure smart factory. In order to assess the quality of the security mechanisms of OPC UA BSI has conducted a comprehensive and independent security check.

An extensive analysis of the security functions in the specification of OPC UA confirmed that OPC UA was designed with a focus on security and does not contain systematic security vulnerabilities. Additionally a selected reference stack (ANSI C, Linux, Intel-32bit, single thread) was assessed regarding the implementation of the security functionality. No crash could be generated during many tests of the communication stack. A list of security enhancements of the reference implementation was submitted to the OPC Foundation. At all time the OPC Foundation supported BSI in their security check effort.



OPC Foundation extends OPC UA down to field level including Deterministic, Safety and Motion

Peter Lutz, Field Level Communications Director, OPC Foundation

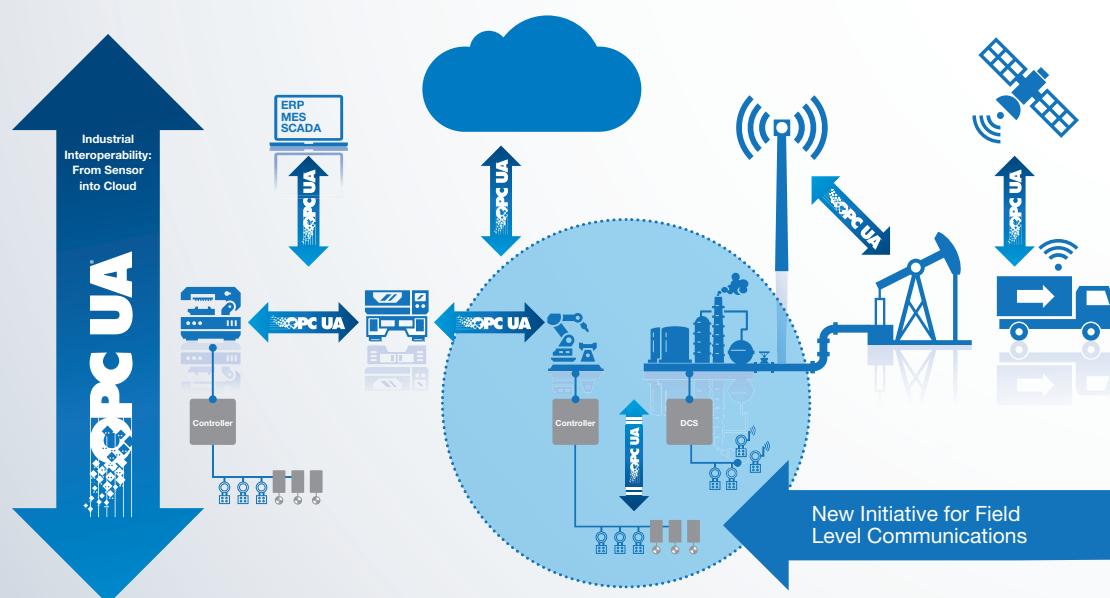
At the SPS IPC Drives fair 2018 in Nuremberg/ Germany the OPC Foundation has officially launched the Field Level Communications (FLC) Initiative. This initiative aims for an open, unified, standards-based Industrial Internet of Things (IIoT) communication solution addressing all requirements of industrial automation in discrete manufacturing and process industry. Consequently, the OPC Foundation vision of becoming the worldwide industrial interoperability standard is advanced by integrating field devices and the shop floor. Vendor independent end-to-end interoperability into field level devices is provided for all relevant industry automation use-cases requiring safe, secure and deterministic information exchange:

The FLC-related technical work includes the following topics:

- **harmonization and standardization** of application profiles like IO, motion control, safety, system redundancy
- **standardization of OPC UA information models** for field level devices in online and offline scenarios e.g. device description resp. diagnostics
- **mapping of OPC UA application profiles** related to real-time operations on Ethernet networks including TSN
- **definition of certification procedures**

MEMBERS OF THE STEERING COMMITTEE:

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Rexroth
B&R
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Festo
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Huawei
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Scope of the Field Level Communications (FLC) Initiative

SOLUTION APPROACH

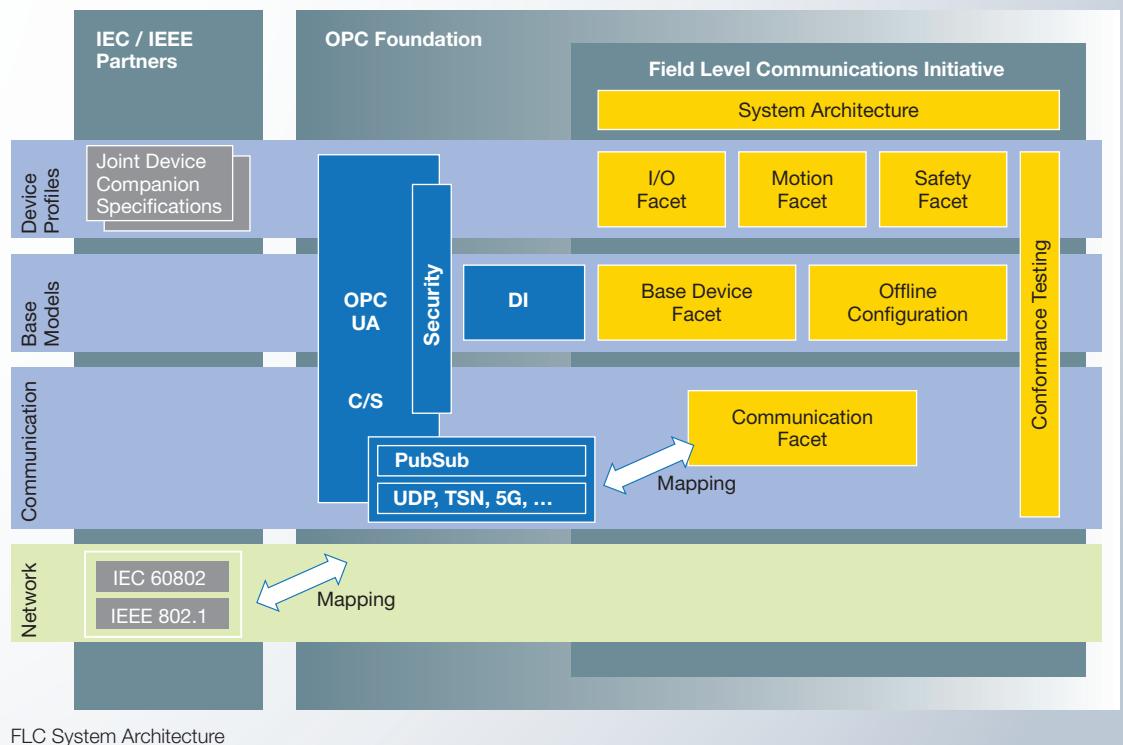
The solution approach for bringing OPC UA down to the field level is to use unmodified OPC UA technology with its built-in security capabilities, the PubSub extensions and the Device Integration (DI) model on which so-called device facets and other device companion specifications are built upon. The Base device facet defines interfaces, behaviors and state machines that are common to all controllers and devices. It also provides the structure for device- and application-specific facets, such as Motion, Safety and I/O.

The Communication facet defines the communication interfaces and behaviors (protocols and services) of the lower layers of the OSI model for devices that operate on Ethernet networks with and without TSN capabilities. It is based on the OPC UA PubSub extensions with network mappings (bindings) to

Standard Ethernet (UDP) and Deterministic Ethernet (TSN). The concept is prepared to support redundancy concepts and other emerging communication standards, such as 5G. The communication facet for TSN closely aligns with the TSN Profile for Industrial Automation (TSN-IA-Profile) which will be standardized by the IEC/IEEE 60802 standardization group. This will help ensure that a single, converged TSN network approach is maintained so that OPC UA can share one common multi-vendor TSN network infrastructure together with other applications.

PARTICIPATION

All members of the OPC Foundation are invited to contribute to the technical working groups. The management and coordination of the FLC initiative is exclusive to members of the Steering Committee provide extra contributions.



OPC Foundation provides specifications and information

WEBSITE AND EVENTS

A key source of the most current information about everything OPC UA is the global OPC Foundation website (www.opcfoundation.org) along with localized versions in Japan and China. Here, beyond the complete OPC specifications, you can also find member listings and their OPC product offerings, certification results, collaboration updates, events, and much more. Information on technology and collaborations is provided in different languages.

ABUNDANT RESOURCES

The rate of adoption of a technology like OPC UA depends on market demand which, in turn depends on end-users' understanding of the technology, its benefits, ease of implementation, and availability of verification and certification of products based on that technology. For this reason, the OPC Foundation offers users and particularly its members a rich set of information sources, documents, tools and sample implementations.

OPC UA SPECIFICATIONS AND IEC 62541

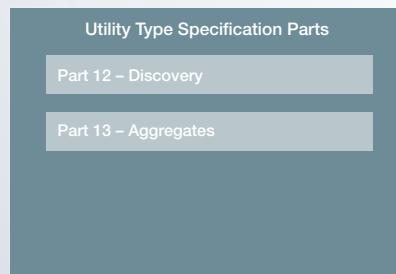
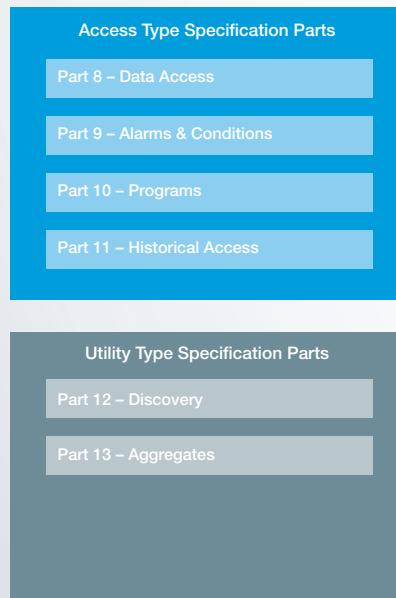
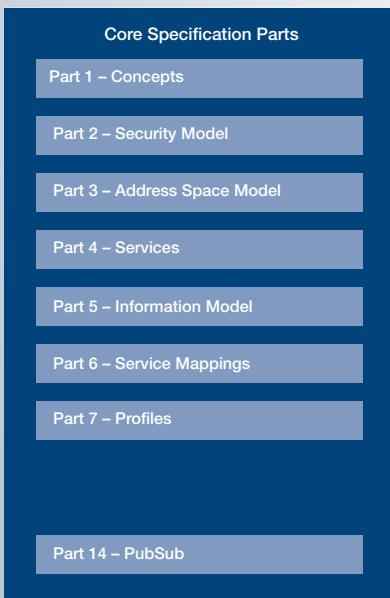
The main sources of information are the OPC UA specifications themselves. They are publicly accessible and are available as an IEC standard series (IEC 62541). Currently, the OPC UA standard is comprised of 14 parts which, are available to the public. These parts are subdivided into three groups:

→ **1. Core specifications.** These contain the basic concepts of the OPC UA technology, the security model, and an abstract description of the OPC UA metamodel and the OPC UA services. In addition, these specifications also describe:

- the core OPC UA information mode, its modeling rules, and concrete mapping at the protocol level
- the concept of profiles for scaling the functionality
- the Client-Server and Publisher-Subscribe Models
- protocol mappings and encodings

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

→ **3. Utility type specifications.** 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.



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.

Communication stacks have been developed 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. Communication stacks ensure the basic communication in the network. As there are several open source and commercial implementations available, only the C# stack is maintained by the OPC Foundation.

→ 2 . Example Code.

Besides the communication stacks, which basically contain only the protocol implementation, the OPC Foundation also 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 recommends the use of commercial Toolkits and Software Development Kits (SDK) which, are offered by various OPC member companies.



→ 3 . Certification program.

For testing and certification of compliant behavior, the OPC Foundation offers a software Compliance Test Tool (CTT). The CTT can be used to verify the compliant behavior of an OPC UA application. In addition, the OPC Foundation offers a certification program that provides independent certification laboratories where manufacturers can have their OPC UA products certified. Certification extends the testing of the CTT and includes Interoperability testing, stress testing, usability testing, and performance testing in environments the product will be typically used in.

→ 4 . Interoperability workshops.

The OPC Foundation holds at least three week-long interoperability workshops (IOP), where companies can test the interaction of their products. The European IOP event is usually held in the Autumn at Siemens AG in Nuremberg. The North American IOP is usually held in the spring at Honeywell in Phoenix and the OPC Japan organization usually holds an IOP in the Summer. These events include OPC Foundation support and are a great precursor to vendors' product certifications.



The OPC Certification Program's primary goal is to set the bar for the quality of OPC UA products released into the market with respect to their implementation of the OPC standards.

As a best practice, End-users and integrators should demand vendors certify their OPC products for the end-users' maximum safety and infrastructure reliability. Certification is best verified by an accredited 3rd party test lab. Products that passed testing by independent certification laboratories are recognizable by the "Certified" logo.

All recognized 3rd party OPC test labs must be accredited by the OPC Foundation and follow the defined test process and test scenarios to guarantee that the product complies with the following:

- **Compliance** to the OPC Specifications
- **Interoperability** with other vendors' products
- **Robustness** and recovery from error conditions
- **Efficiency** of product under load
- **Usability** ensures a good user-experience



»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.«

Paul Hunkar, Director of Certification, OPC Foundation

 A screenshot of a software application window titled "OPC Unified Architecture Compliance Test Tool - D:\work\UACTT_OPCF\ServerScripts\trunk\Unified Automation DemoServer.ctt.xml". The interface includes a menu bar (File, View, Project, Test Run, Help), a toolbar with icons for Open, Save, Run, Stop, and Help, and several toolbars for Conformance Units, Test Cases, and Profiles. The main area shows a code editor with a script named "002.js" containing JavaScript code for testing OPC UA endpoints. The code includes functions like "getEndpointsAt202012()" and interacts with local sessions and channels. To the right of the code editor are two panes: "Objects" listing OPC UA data types and "Objects Properties" showing specific properties for the selected object.


```

function getEndpointsAt202012()
{
    // need the local session
    var localSession = new UaSession();
    var localeChannel = new UaChannel();
    var localeSession = new UaSession(localeChannel);
    if (!connect( localeChannel, localeSession ))
    {
        addError("Connect()");
        return;
    }

    if (!activateSession( localeSession ))
    {
        addError("Unable to activateSession");
        return;
    }

    var localeReadRequest = new UaReadRequest();
    var localeReadResponse = new UaReadResponse();
    var succeeded = true;
    localeSession.buildRequestHeader( localeReadRequest.RequestHeader );
    localeReadRequest.Header = 0;
    localeReadRequest.TimestampToReturn = TimestampToReturn.Both;
    localeReadRequest.NodeIdToObject = new UaNodeId( Identifier.Server_Server );
    localeReadRequest.NodeIdToObject.NodeId = new UaNodeId( Identifier.Server_Server );
    localeReadRequest.AttributeId = Attribute.Value;

    var uaStatus = localeSession.read( localeReadRequest, localeReadResponse );
    disconnect( localeChannel, localeSession );
    if ( uaStatus.isBad() )
  
```

TEST TOOLS AND QA

The OPC Foundation provides a series of test tools to verify functionality of all of the OPC Foundation defined interfaces. These test tools include not just base OPC specification testing they also support companion specification defined information model testing and are available to all OPC Members. The tools can be used in an automated build process or interactively by a tester or developer. The OPC Compliance Test Tool (CTT) implements over a thousand test cases and provides a functional test with enormous test coverage. The script based tool is always being enhanced with new test cases to cover specification enhancements, new information model specifications (Companion Specifications) and to generally improve testing performance. Additionally it can be extended with vendor specific/product specific test cases. The CTT is a test platform which can be easily integrated into a company's automated system and regression test environment.

Integration – Toolkits and Books

CODE AND ADVICE

The OPC Foundation initially developed 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.

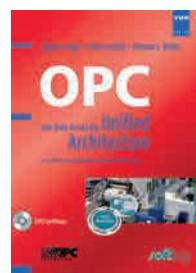
EXPERT KNOWLEDGE

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.



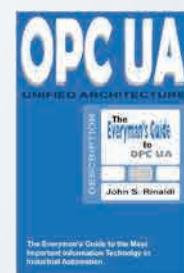
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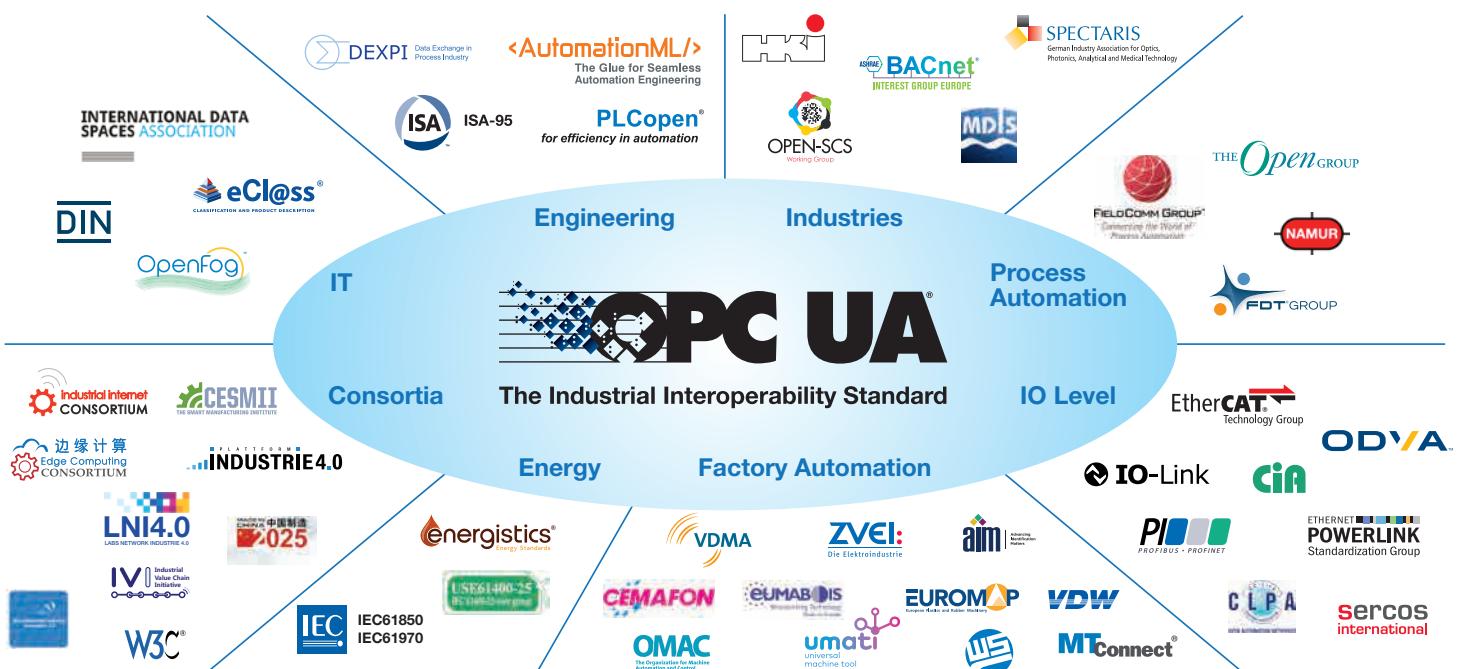
FURTHER INFORMATION ABOUT TOOLKITS IS AVAILABLE FROM ...

- Matrikon, 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

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- 39 PLCopen – Client and server in controller
- 40 AutomationML – OPC UA for engineering
- 41 AIM – RFID and other AutoID systems
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- 43 VDMA – Robotics

44 Euromap – Plastics and Rubber Machinery

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- 46 FDI – OPC UA in Process Automation
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- 49 HKI – OPC UA for Commercial Kitchen Equipment



COLLABORATIONS

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Integration: OPC 3000x – OPC UA Client and -Server in controller

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

Elco van der Wal, Managing Director PLCopen

PLCopen

for efficiency in automation



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.

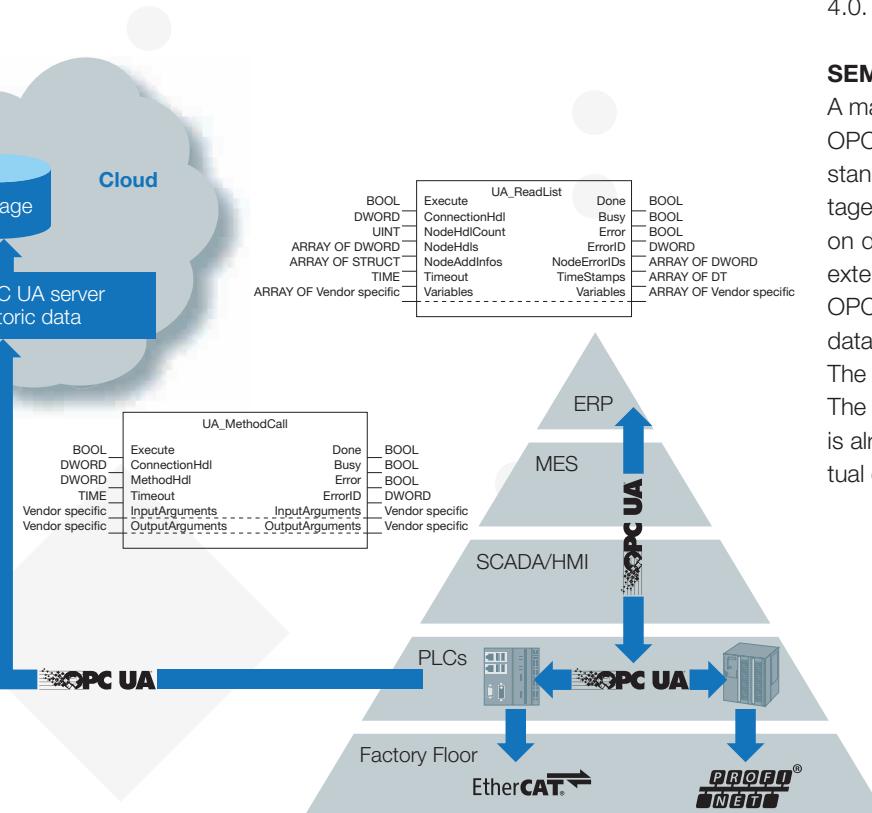
With Industrie 4.0 this strict separation of the levels and the top-down approach of the information flow will start to soften and mix: In an intelligent network each device or service can autonomously initiate a communication with other services.

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.





Engineering: OPC 30040 – OPC UA for AutomationML

»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. If 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?

<AutomationML/>

Semantic description of production plant

COLLABORATIONS



Identification: OPC 30010 – OPC UA for AutoID Devices

»Success: One communication standard for all OPC UA for AutoID devices«

Chuck Evanhoe, Chairman AIM (association for the automatic identification industry)



In 2014, the AIM System Integration working group decided to define a new, forward-looking, technology-independent and manufacturer-independent communication standard for the AutoID industry. Until then, many devices communicated via proprietary interfaces, and various communication standards and technologies.

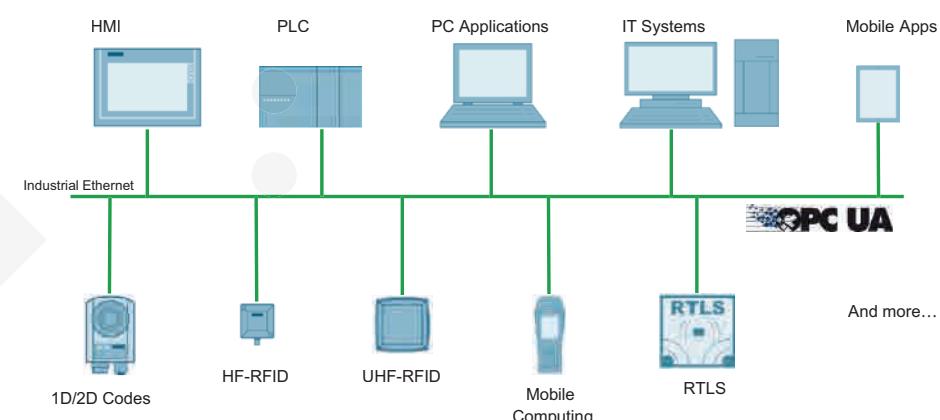
Today, AutoID technology is a self-explanatory tool for implementing an overall solution, e.g. an automatically functioning warehousing logistics centre. Communication barriers are unwanted! The AutoID technology used should be determined by the application and not by the communication interface of the devices. Motivated by these ideas and requirements, the AIM working group decided to define a communication interface based on OPC UA.

Thanks to the object-oriented structure, OPC UA was highly suited to the development of a common communication standard for the various AutoID technologies. Commonalities – like a scan method for simple detection of an ID – can thus be defined in higher-level classes.

In 2016, AIM introduced the new OPC Unified Architecture for AutoID Companion Specification at the

Hannover Messe. The first RFID devices by Siemens and HARTING were launched and presented on OPC Foundation booth. Meanwhile the AutoID Companion Specification has been integrated into devices by many AutoID manufacturers: In November 2018 on SPS Drives trade fair many different barcode, HF and UHF devices with OPC UA interface were from additional companies like Balluff, Leuze electronic, Sick and Turck. Standard, secure data communication with various devices from different manufacturers is based on OPC UA, the future-proof communication standard in the automation industry. AutoID devices still differ, with manufacturer-specific functions and options, but their data exchange is standardized, which greatly simplifies the integration of AutoID technology. The work of the System Integration working group did not end in 2016. The participants continue to work on extending and improving the interface specification.

On Hannover Messe 2019 the latest OPC UA for AutoID Companion Specification was released of the OPC Unified Architecture for AutoID Companion Specification.



AutoID topology with OPC UA



VDMA Forum Industrie 4.0

»Companion Specifications as key to standardized information for mechanical engineering«

Andreas Faath, VDMA Project Manager Interoperability



Further information at:
www.opcua.vdma.org/en/

VDMA IS EUROPE'S LARGEST INDUSTRY ASSOCIATION

With 38 trade associations inside one association and over 3200 member companies the broad range of the mechanical engineering industry is represented by the VDMA globally. In this industry the standard OPC UA has established itself, enabling cross-vendor secure information exchange.

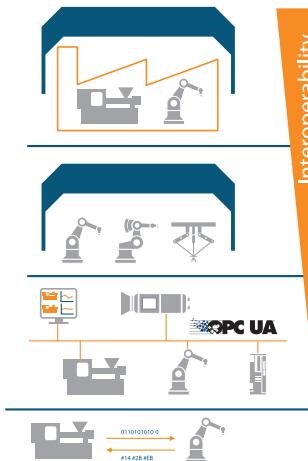
VDMA DEFINES THE VOCABULARY OF PRODUCTION LANGUAGE

Standardized interfaces with OPC UA increase the efficiency for Industry 4.0 use cases such as Plug & Produce and Condition Monitoring. In OPC UA Companion Specifications the vocabulary for domain-specific information exchange is standardized. The VDMA is hosting over 30 domain specific OPC UA Companion Specifications working groups for various sectors of the mechanical engineering industry. With more than 450 companies involved, the VDMA is the worldwide leading organization for OPC UA Companion Specification standardization work in this field.

CROSS DOMAIN INTEROPERABILITY

The development of OPC UA Companion Specifications paves the way for the next level of interoperable communication inside the production – a global production language. This language is being developed, hosted by the VDMA, by different branches of the mechanical engineering industry. The cross-domain usable global production language enables more efficient communication along the entire production process value chain. Especially for small and medium sized enterprises a standardized, simple integration of their products into already existing systems provides the opportunity to acquire new users and to innovate new business models.

Migration path for interoperability



Overview of OPC UA Companion Specification Working Groups

» Agricultural Machinery	» Engines	» Micro Technologies	» Textile Machinery
» Air Conditioning & Ventilation	» Engines & Systems	» Mining	» Thermal Power Plants
» Air Pollution Control	» Fire Fighting Equipment	» Photovoltaic Equipment	» Thermo Process Technology
» Automated Guided Vehicles	» Fluid Power	» Plastics & Rubber Machinery	» Valves
» Battery Production	» Food Processing and Packaging Machinery	» Power Transmission Engineering	» Waste Treatment & Recycling
» Building Control and Management	» Foundry Machinery	» Precision Tools	» Weighing Technology
» Building Materials	» Glass Machinery	» Printing & Paper Technology	» Welding & Pressure Gas Equipment
» Ceramic Machinery	» Hydro Power Plants	» Process Plant & Equipment	» Wind Power Plants
» Cleaning Systems	» Industrial Trucks	» Productronic	» Woodworking Machinery
» Compressors, Compressed Air and Vacuum Technology	» Integrated Assembly Solutions	» Pumps & Systems	
» Construction Equipment	» Intralogistic Systems	» Refrigeration & Heat Pump Technology	
» Continuous Conveyors	» Length Measurement Technology	» Robotics	
» Cranes	» Lifts & Escalators	» Security Systems	
» Die & Mould	» Machine Tools and Manufacturing Systems	» Software & Digitalization	
» Drying Technology	» Machine Vision	» Surface Technology	
» Electrical Automation	» Metallurgical Plants and Rolling Mills	» Testing Technology	
» Electronics, Micro & Nano Technologies		» Textile Care, Fabric and Leather Technology	

Legend for the boxes:

- Light blue box: OPC UA CS released
- Dark blue box: Release Candidate
- Yellow box: Joint Working Group with OPC Foundation
- Orange box: OPC UA CS in work
- Grey box: Aware of OPC UA

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F14 428 KB

COLLABORATIONS



OPC 40010 – OPC UA for Robotics Initiative

»Making Industrial Robots ready for the factories of the future«

Suprateek Banerjee, Standards Manager, Robotics + Automation, VDMA



Further information at:

www.opcua.vdma.org/en/
www.robotik.vdma.org/

COMPANIES:

ABB
Beckhoff
Epson
Engel
Fortiss
Fraunhofer IIGCV
Keba
Kuka
Krauss Maffei
Mitsubishi Electric
Unified Automation
Siemens
Volkswagen
Yaskawa

The VDMA OPC Robotics Initiative was established in 2017 to bring together robot manufacturers with the aim to discuss and develop a common, usable, future-proof interface for industrial robots. OPC UA was identified as the obvious choice for the creation of such a standard since it provides feature-rich standardized mechanisms to describe vendor-independent interfaces supported by a strong information model.

As a joint working group, the initiative is organized by VDMA Robotics + Automation and supported by the OPC Foundation. Over the last two years, the core working group of this initiative, a group of experts from 14 companies, have developed Part 1 of the VDMA OPC Robotics Companion Specification. Part 1 is the first step towards the gradual design-in to a fully connected Industrial Internet of Things (IIoT). It enables vertical provisioning of information from the lower (Sensor/Actuator) to the higher (Control, SCADA, MES, Cloud) levels of the automation pyramid.

THE OPC ROBOTICS INFORMATION MODEL

Describes all current and future robotics systems

- industrial robots
- mobile robots
- additional axes
- control units
- peripheral devices, which do not have their own OPC UA server

USE CASES AND THEIR BENEFITS

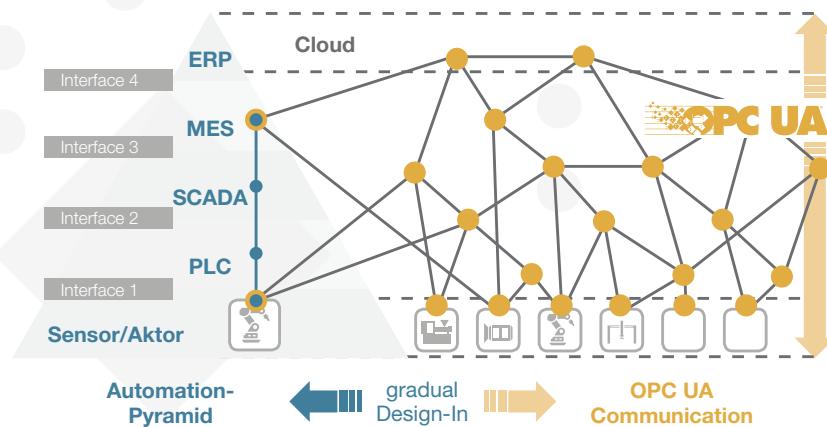
Asset Management

- Vendor independent access to asset information of all integrated robot systems and their components
 - Access to identification-data for machinery and equipment management: Manufacturer, Product Code, Model, Serial Number and more, based on OPC UA for Devices (DI)
 - Access to versioning data of the system parts: Versioning of software and hardware parts based on OPC UA for Devices (DI)

Condition Monitoring

- A comparison of the status and parameters over many installed systems allows to identify "black sheep" or anomalies
 - For example checking the correct robot-payload, comparison of time in motion or other deviating operating parameters of the robot system

A gradual design-in into the IIoT





OPC UA for Plastics and Rubber Machinery

»From Standardized Hardware Plugs to OPC UA Information Models«

Dr. Harald Weber & Marc Schmitt, VDMA Plastics and Rubber Machinery



EUROMAP is the umbrella organization of the powerful European plastics and rubber machinery industry. It provides technical recommendations for plastics and rubber machines developed from the industry for the industry. Coming from standardized hardware-based interfaces, bus profiles and interfaces for data exchange via text files, the existing plugs and protocols reached their limits for the desired advanced networking of the machines. This is why, EUROMAP started in 2014 to develop OPC UA based interfaces to make use of state-of-the-art technology for state-of-the-art machines.

Where appropriate, a modular approach is followed to cover the existing variety of configurations of production lines.

USE CASES

- General information about the machines and components
- Status and error information
- Management of jobs and machine settings
- Monitoring and partially setting of process values
- Information about maintenance intervals
- Energy consumption

Further information at:
www.euromap.org/i40
www.opcua.vdma.org

COMPANION SPECIFICATIONS BY OPC UA PLASTICS AND RUBBER MACHINERY

Release Candidates

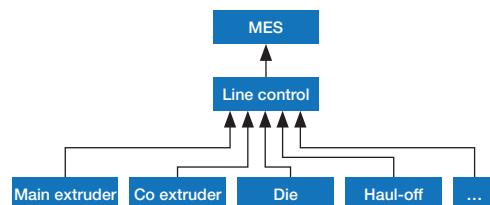
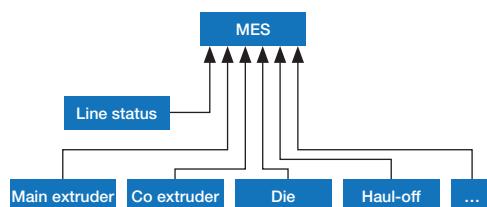
- OPC 40083: General Type definitions*
- OPC 40077: Data exchange between injection moulding machines and MES*
- OPC 40082: Peripheral devices
 - Part 1: Temperature control devices*
 - Part 2: Hot runners
 - Part 3: LSR dosing systems
- OPC 40084: Extrusion

Under development

- OPC 40079: Data exchange between injection moulding machines and robots
- OPC 40082-x: Further peripheral devices
- OPC 40086: Material supply systems

* = already published as EUROMAP recommendations

Meanwhile, EUROMAP and OPC Foundation have established the Joint Working Group "OPC UA Plastics and Rubber Machinery" and the existing and future EUROMAP recommendations will become OPC Foundation Companion Specifications.





COLLABORATIONS



OPC 40100 – OPC UA for Machine Vision Initiative

»Taking Machine Vision to the forefront of Industrie 4.0«

Suprateek Banerjee, Standards Manager, Robotics + Automation, VDMA



Further information at:
www.opcua.vdma.org/en/
www.ibv.vdma.org/en/

COMPANIES:

Asentics
 Bosch
 Isra Vision
 Kuka
 SAC
 PeerGroup
 SiliconSoftware
 Stemmer
 Unified Automation
 Vitronic

The VDMA OPC Machine Vision Initiative, conceived in January 2016, recently released Part 1 of the OPC Machine Vision Companion Specification. As a joint working group, the initiative is organized by VDMA Robotics + Automation and supported by the OPC Foundation.

- The core working group, that developed Part 1 of the specification, consists of 17 experts from 10 companies.
- Due to the enormous variations in machine vision systems all over the world, it is very hard to generalize vision system data. Therefore Part 1 focuses on data management methods without restricting the content of the same. Behavior control and observation of a vision system are the key objectives solved in Part 1. The generic state machine approach introduced in Part 1 of the specification, enables monitoring and control of system behavior. The initiative is currently at the helm of development of Part 2 of the specification which aims to define a generic structure and the components of a machine vision system.

OPC MACHINE VISION OFFERS METHODS FOR THE HANDLING OF:

Configuration Data

- Enables the vision system to work and makes sure a recipe yields the same results on different systems.

Recipe Data

- Defines what the actual application is and what result data should be created by the vision system.

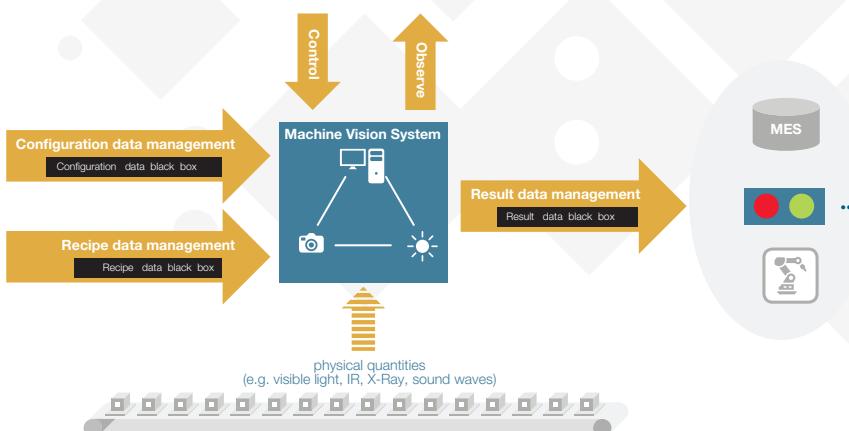
Result data

- The information extracted from the acquired sensor data, often enriched by meta data or statistical information.

Jobs

- The act of performing the image processing. Jobs may be processed in series, overlapping, in parallel or any other possible sequence. Jobs may be self-terminating or run continuously till stopped externally.

The OPC Machine Vision Blackbox approach



Benefits for vendors

- Add-on to existing system platforms
- Modular scaling to system performance
- Gradual phase-in possible
- Keep proven interfaces

Benefits for users

- Reduced implementation costs
- Uniform interface for different systems
- Easy access to important data
- Access information from multiple clients



Integration: OPC 30080-x – OPC UA for Field Device Integration (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 Process Automation Device Information Model (PA-DIM) 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.

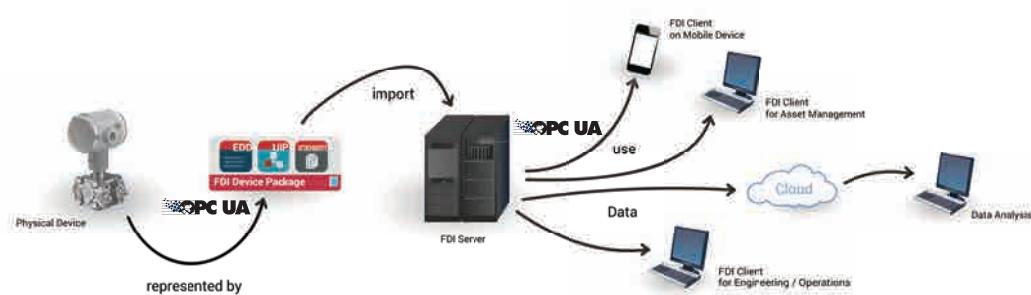
EDDL MAPPING

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 EDD 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.





COLLABORATIONS



Offshore Oil & Gas: OPC 30020 – OPC UA for Subsea (MCS and DCS) – 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
CSE W-Industries
Dril-Quip
Emerson
Equinor
ExxonMobil
TechnipFMC
BakerHughes (GE)
Honeywell
Kongsberg
OneSubsea
Petrobras
Proserv
Rockwell Automation
Schneider Electric
Shell
Softing
Siemens
Woodside
Yokogawa



© Georg Lehnerer – fotolia.com

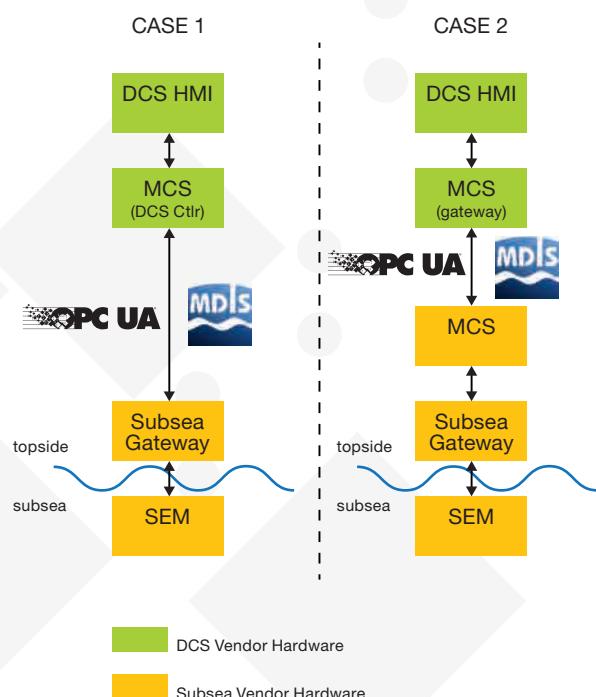
In the oil and gas industry the major operating companies, oil & gas service companies, DCS vendors, subsea equipment vendors and systems integrators all have their unique requirements and rules when it comes to their own software and hardware systems. But on the offshore oil and gas platform all of 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 an 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.

The Version 1 and version 2 of the Companion standard has been released and is being used on multiple projects.





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)



Further information at:
<https://www.open-scs.org/>

MEMBERS:

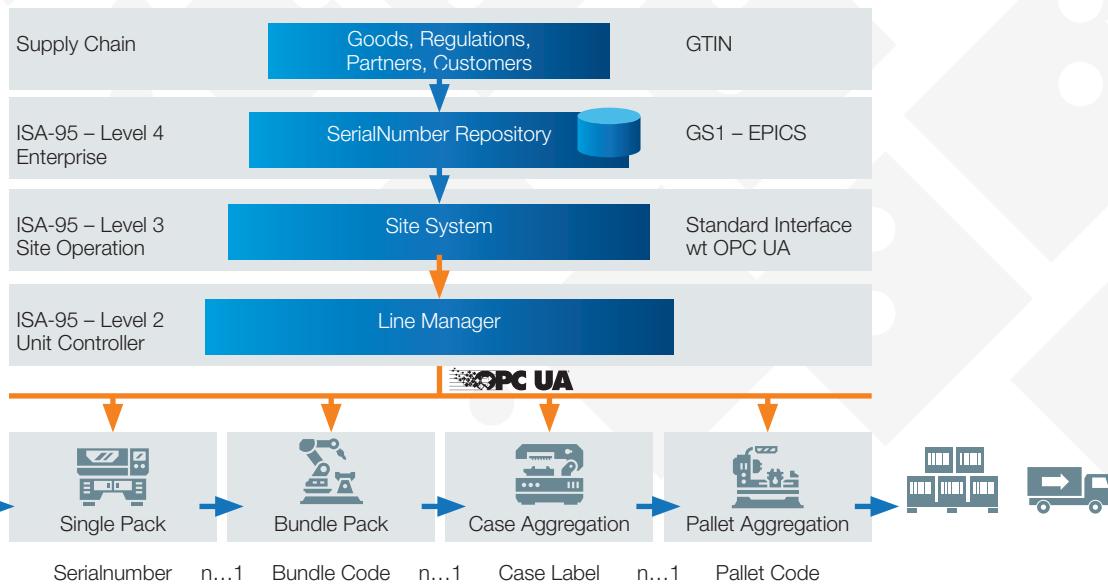
Abbott
ACG
Advanco
Antares Vision
Arvato Sytems
facilityboss
NNIT
Laetus
Mettler Toledo PCE
Optel Group
Pfizer
Roche
Rockwell
SICPA
Systech International
Tracelink
Traxeed
Uhlmann
Verifarma
Werum
WIPOTEC-OCS

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 product Track & Trace use cases for implant, 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 (GTIN, expiry date, batch number) to a data matrix code printed on the package, the medi-

cine 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, at the point of dispense, 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 specification for OPEN-SCS.





OPC 30200 – OPC UA for Commercial Kitchen Equipment

»Standardized Communication Interface for Commercial Kitchen Equipment«

Fabian Anzmann, HKI industrial association of House, Heating and Kitchen Technology

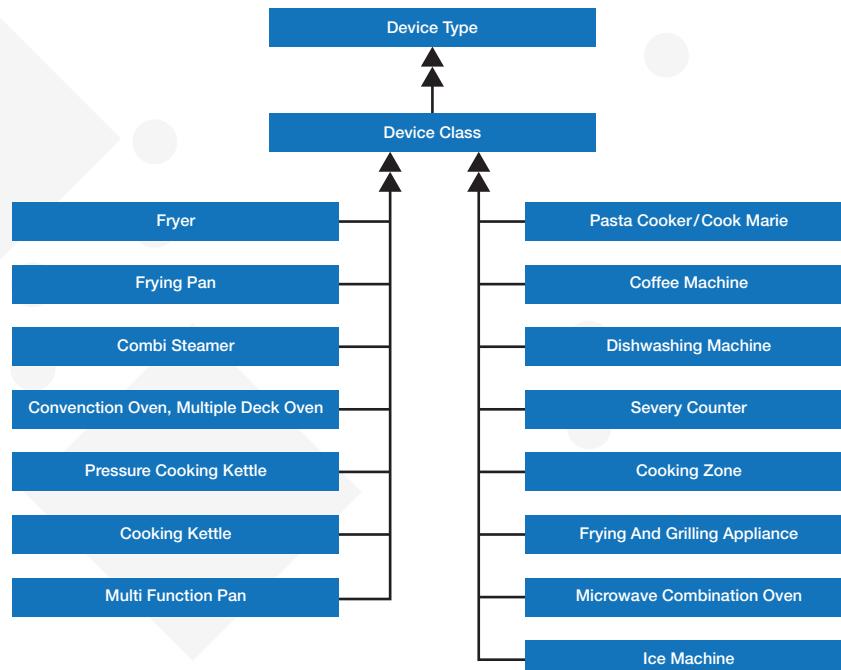


Further information at:
<http://hki-online.de/en>

The HKI Industrial Association for House, Heating and Kitchen Technology represents the interests of manufacturers of commercial kitchen equipment as well as those of domestic heating and cooking appliances. Under the umbrella of the HKI Industrial Association about 50 different companies have worked together to develop a uniform and standardized communication interface for catering equipment. The design of the standardized communication interface is based on the industrial communication standard of OPC-UA. The working group communication interface of the HKI Industrial Association developed the information models for a large number of different catering equipment. The graphic [...] shows which catering equipment was modelled.

The developed OPC UA Companion-Specification "OPC 30200 OPC UA for Commercial Kitchen Equipment" lays the foundation for a data exchange that is manufacturer-neutral and cross-device. The standardization creates the basis for non-proprietary communication protocols in the industrial kitchen sector. This results in a multitude of application possibilities that bring added value for the operator of industrial kitchens like:

- Documentation and archiving of time and temperature curves
- Monitoring and visualization of processes
- Transmission of error and alarm function
- Remote service





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:

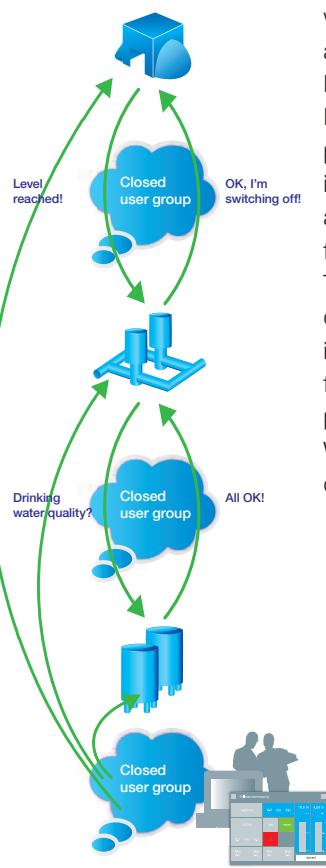
Real objects (e.g. a pump) were modeled in the IEC61131-3 PLC as complex objects with interactive possibilities; thanks to the OPC UA server integrated in the controller these objects are automatically available to the outside world as complex data structures for semantic interoperability.

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.



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



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. ...«

Dipl.-Ing. Dr. techn. Bernhard Reichl, Managing Director ETM

SIEMENS

ETM professional control GmbH –
A Siemens Company

...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 his 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

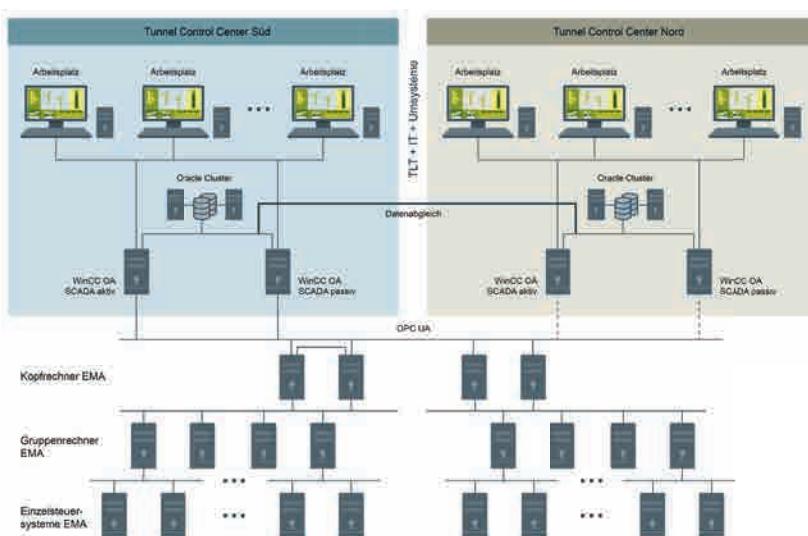
- Redundant configuration set up both for the OPC UA client and server
- OPC UA Heartbeat used for monitoring the connection in both directions

→ 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





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

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.

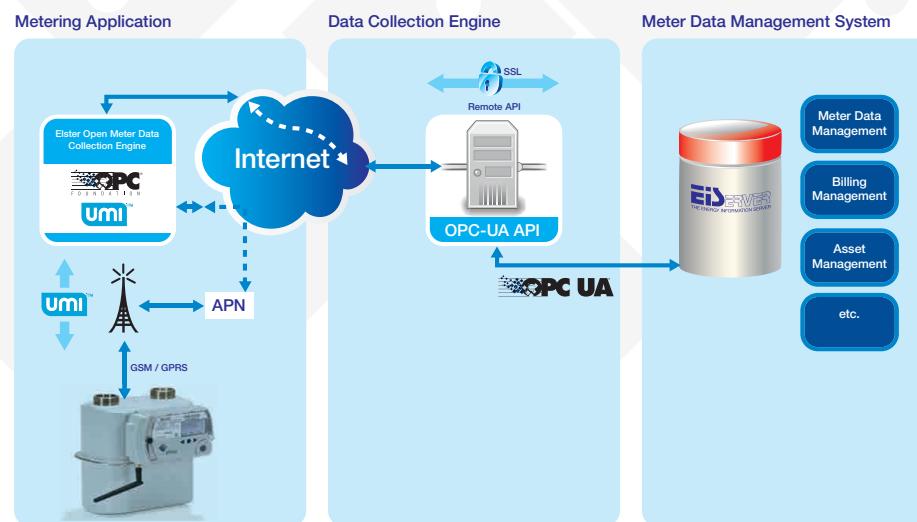
- At Honeywell, we offer a software with OPC UA interface for our own systems as well as other head-end systems, since many systems used by supply companies already support this established standard. Integrated encryption of sensitive meter data is an important argument for OPC UA".

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
Member OPC Foundation Marketing Control Board

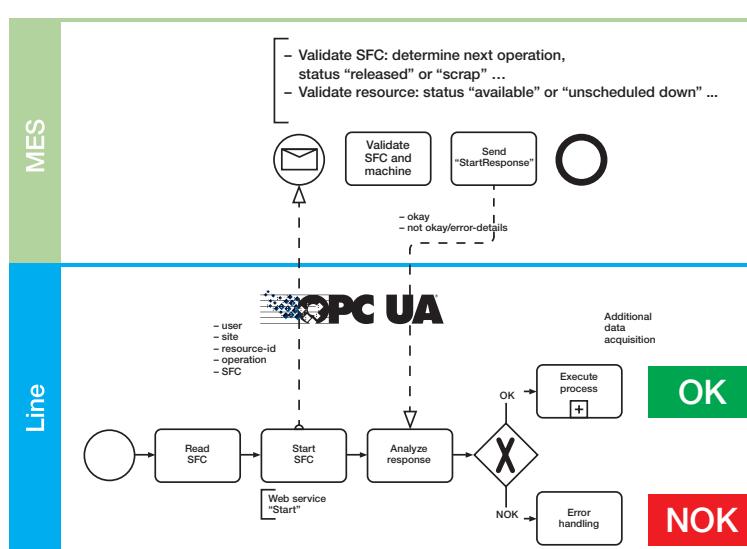
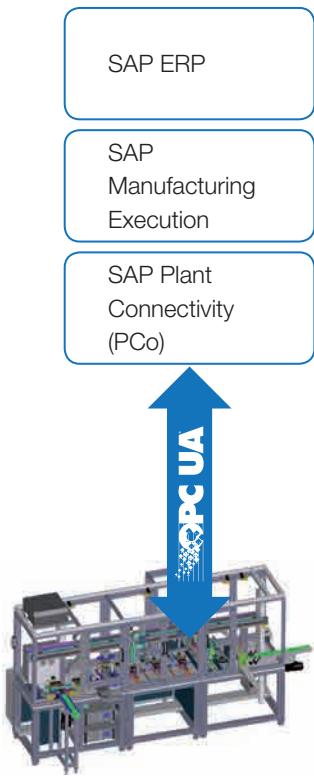


The product itself determines the way it should be produced. Ideally this enables flexible production without the need for manual setting up. Elster has successfully implemented this Industrie 4.0 concept in productive assembly lines.

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 consis-

tent data transfer, even for complex structures. The MES system receives the QM specifications via orders from the ERP and reports the finished products back to the ERP. 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 e.g. work schedules, parameters and quality limits onto the product, in order to enable autonomous and individualized production.

Vertical integration is therefore not a one-way street, but a closed loop. 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





OPC UA SOLUTIONS



OPC UA for IoT to the cloud and back

»OPC UA is the established, worldwide data modeling standard for Industrial IoT«

Erich Barnstedt, Head of Azure Industrial IoT, Microsoft Corporation,
Platform Industrie 4.0 Member and OPC Foundation Technical- and Marketing Control Board Member



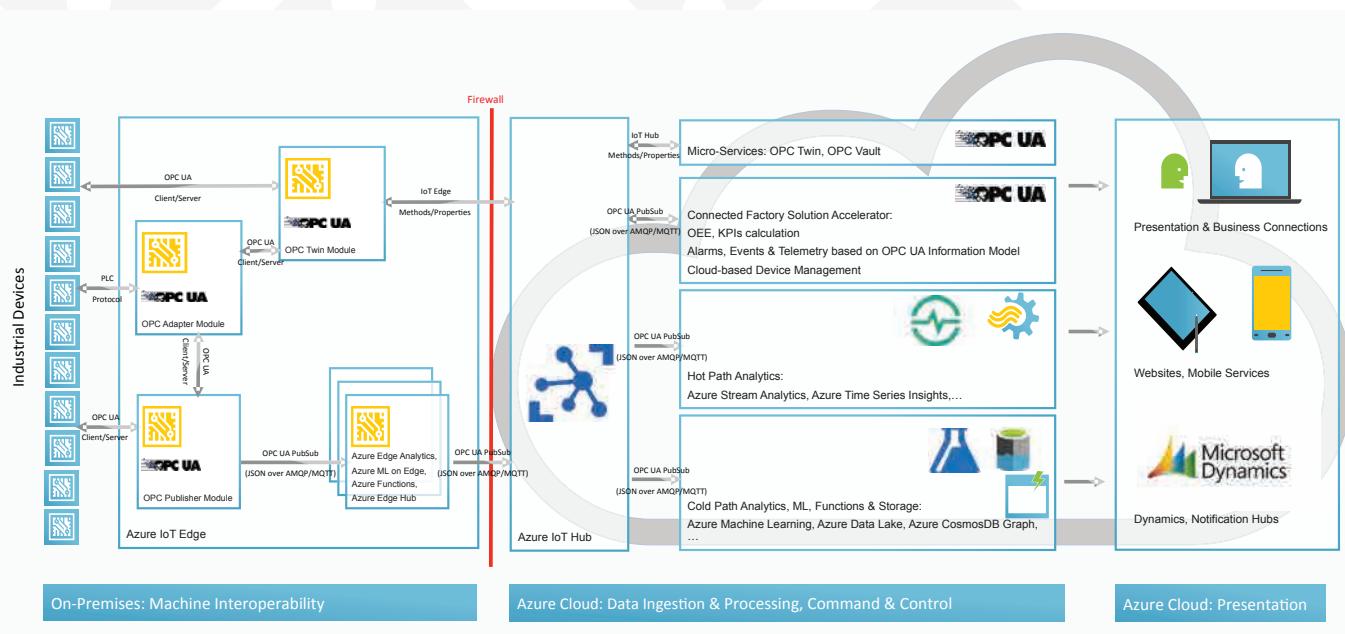
Microsoft Azure

- OPC UA is an essential foundation for the convergence of OT and IT, providing the most popular open and standardized data modeling for industrial equipment. From an IT perspective, OPC UA is the programming interface of the connected plant and the connected factory and a critical enabler for Industrial Internet of Things (IIoT) applications.
- OPC UA also serves as a gateway technology to securely 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 factories, OPC UA is enabling digital transformation simply and easily. Microsoft's leading support of OPC UA will reduce barriers to IoT adoption and help deliver immediate value.

Azure Industrial IoT Cloud Platform





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