OPC FOUNDATION®

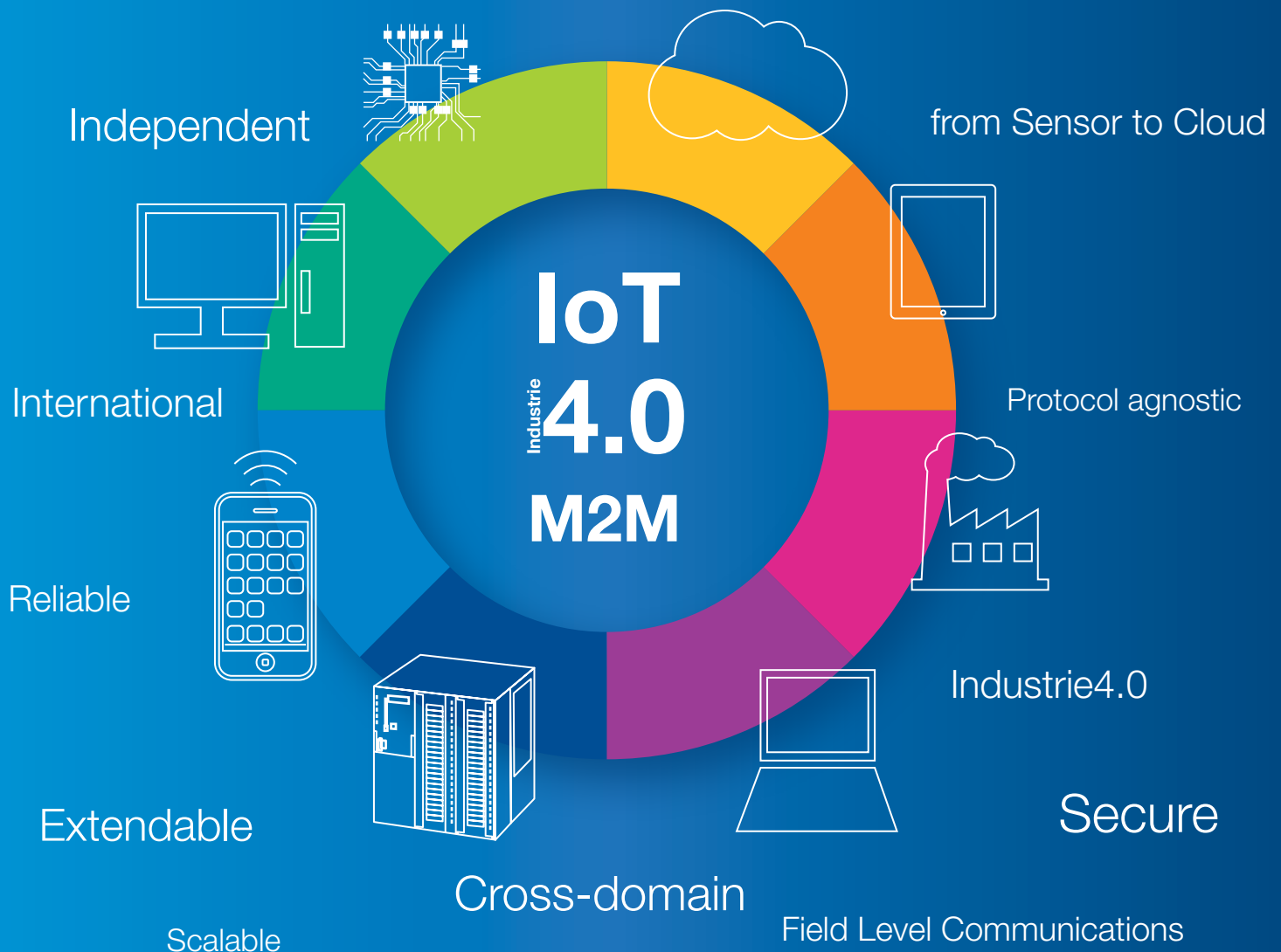The Industrial Interoperabolity Standard

OPC UA Users and Experts – Conveying Knowledge and Experience

Second Edition March 2021

The OPC Foundation publishes a series of interviews with experts, market leaders and think tanks in communication, automation and industrial IT to highlight the benefits and the potential of the OPC UA technology for end users, system integrators, operators in the world of industrial IoT.

Independent

from Sensor to Cloud

International

Protocol agnostic

Reliable

IoT
Industrie 4.0
M2M

Industrie4.0

Extendable

Secure

Cross-domain

Field Level Communications

Scalable

Contents

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For any further questions please send an email to office@opcfoundation.org and let's stay in touch.

OPC FOUNDATION

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OPC DAY
INTERNATIONAL
IT meets Automation
JUN 08–10, 2021
3 HOURS A DAY
EACH DAY: 2H CONFERENCE – 1H Q&A

DIGITAL EVENT

Join this digital event free of charge
"OPC Day – International"

Agenda:

- **Day: Keynotes Level**
  Target Group: Management, Product Managers & Architects

- **Day 2: Technology Update Level**
  Target group: Implementers, Developers, Product Managers, Program Managers

- **Day 3: Adaption & Solutions**
  Target Group: End-Users

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Learn more about OPC technology with these free webinars and videos provided by the OPC Foundation and its members.

Listen to short technical OPC UA explanation videos by **Uwe Steinkrauss,** CEO of Unified Automation

▶ OPC UA Concept **https://youtu.be/E2XJfmAEdqw**

▶ OPC UA Transport **https://youtu.be/E2XJfmAEdqw**

▶ OPC UA Security **https://youtu.be/z4zNgNdauLY**

▶ OPC UA Profiles **https://youtu.be/CCvILASACjE**

▶ OPC UA Discovery **https://youtu.be/1NlbUAlOdcA**

Security is a key requirement in a digitalized world. OPC UA is not only "secure by promise" instead the open source framework has been rewieved by international security experts.
Listen to **Randy Armstrong,** chairman OPC UA Security team about the multiple built-in by design security concepts and features.

▶ **https://youtu.be/pa82WydVtPY**
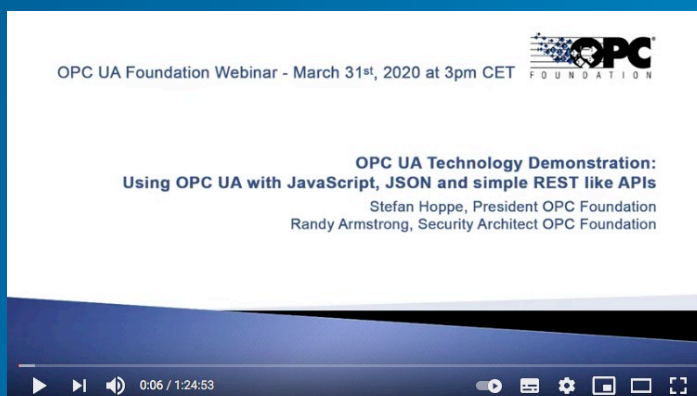
Did you know that OPC UA already has built in REST-like API? Remember OPC UA is not just a protocol – instead OPC UA is transporting standardized information via different protocols like UDP, TCP, MQTT, AMQP, … and will be extended with APL, TSN, 5G, WiFi6 and more. Follow Randy Armstrong and his hand on lab demo how to handle (get/put) data via REST API inside OPC UA

▶ **https://youtu.be/fiuamY0DzLM**

AVOID CLOUD VENDOR LOCK-IN!

With cloud services becoming more popular, it is time to ensure that the industry does not repeat the mistake of vendor lock-in with respect to the cloud. Just imagine the effort it might take to switch your cloud provider 5 years from now, when you are using customized information models in communication and storage today…

STEFAN HOPPE,
President and Executive Director OPC Foundation
stefan.hoppe@opcfoundation.org

Many years ago, users put pressure on control vendors to agree on one single, secured access to solve their vendor/protocol lock-in. While this was a question of "which protocol to use?", for the cloud, this question is not the primary aspect.

MQTT is currently the most popular and widely adopted – which is why OPC UA makes use of it too! Of greater importance is the standardization and unification of data and its meaning. The OPC Foundation, along with strong industry partners and their members, has already defined 65+ so-called Companion Specifications for different markets. This combination of OPC UA + Companion Specs is precisely the key to digitization of the industry.

Using OPC UA means transporting standardized information from as near as possible to a source (like the flow meter) up to the cloud (and back to IT systems), via standardized interfaces, independent of underlying protocols (like TCP, UDP, MQTT, AMQP, etc.), but with end-to-end security. It's a powerful proposition.

Sure, each of the hyperscalers have their own internal data format – but all of them should support the import/export of Companion Specs via OPC UA as an enabler for "cloud interoperability"!

OPC Foundation Ecosystem

After surpassing the 800-member milestone, with Shenzhen Inovance Technology at the end of 2020, The OPC Foundation is looking forward to many more new members this year. Recent, new Class-A members who we would like to welcome include ifm electronic gmbh, Microchip Technology, Thermo-Fisher, Weatherford, SUPCON, and the cloud provider AWS.

With Microsoft Azure, Google Cloud Platform, and now Amazon Web Services, there are 3 major hyperscaler members of the OPC Foundation – as well as Intel, NXP, Microchip, and Qualcomm as chip manufacturers – who would have imagined this 6 years ago?

June 8 –10, 2021 OPC Day International (virtual)

Register today, free of charge, at https://opcfoundation.org/eventdetails/?ee=257 for three 3-hour days (running twice per day to cover all time zones) of "firsthand OPC Foundation and OPC UA information". The first day includes keynote addresses including foundation outlook and cloud strategies. The second "technical day" features reports from OPC UA core leadership, including a presentation on the IIoT Starter Kit, which is based on OPC UA over MQTT.

On third day we address end users providing information about migration steps but also success stories around the world provided by other end-users.

We are experiencing an incredibly exciting time right now – enjoy red-ing this new edition! I wish us all the best; and please stay healthy!

DIGITAL EVENT – Register today!
June 8 –10, 2021
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COMPANION SPECIFICATIONS

IN THIS SECTION: Learn from an interview with Karl Deiretsbacher of the OPC Foundation about Companion Specifications; the different types of Companion Specifications that exist; what Joint Working Groups are; and how the OPC Foundation guides the development and maintenance of Companion Specifications.

KARL DEIRETSBACHER,
Director of Technology and TAC chairman
OPC Foundation
Karl.Deiretsbacher@opcfoundation.com

MICHAEL CLARK: Karl, please introduce yourself to our readers and tell us a bit about yourself and your involvement with OPC technology and the OPC Foundation.
KARL DEIRETSBACHER: Sure, my name is Karl Deiretsbacher. I am the Technical Director for the OPC Foundation, and Chair of the Technical Advisory Council. My involvement with OPC technology began in 1995, and, for more than 20 years, I have been part of the core OPC Specification teams. I am still active as editor of several parts of the standard.

CLARK: The OPC Foundation closely cooperates with organizations and associations from various branches. What role do Companion Specifications play with regard to these co-operations?
DEIRETSBACHER: In short, with OPC UA, we define the mechanisms for "HOW" to move data; however, the knowledge of "WHAT" type of data is needed, for specific application domains, exists in numerous other organizations or branches; these are the organizations with whom we want to cooperate.
A companion specification formally defines a branch-specific information model and assures that implementations, from a variety of vendors, all look and behave the same. By combining the UA communication infrastructure with domain specific data, the end user is assured robust and secure data exchange, at a semantic level, between products of different vendors.

CLARK: Which OPC UA features can be used for Companion Specifications?
DEIRETSBACHER: The first, and most important feature, is the OPC UA address space model. You can think of it as a language to design object-oriented information. We call it address space model because all information elements – also called meta information – are available in the server address space and can be discovered and used by clients. In other words, quite similar to the definition of a library in object-oriented programming, an information model defines object types with variables and methods which can be sub-typed and instantiated. In addition, these types can be semantically enriched by using specific reference types to other nodes.
But, the OPC UA standard not only provides the language to design object-oriented information, it also includes a basic information model with widely applicable object types, variable types, reference types, and data types.
So, in summary, each companion specification uses the address space model to extend the OPC UA base types with custom, branch-specific types.

CLARK: Can you please describe for our readers what an information model looks like?
DEIRETSBACHER: Like in object-oriented programming, all standard types and instances have to be defined with their attributes, components, methods, and their relationships. We have formal tables that are used in the documents, but, in addition, a machine-readable version has to be provided. It is an XML document that conforms to the information model XML schema, the so-called NodeSets. There are several tools on the market that allow the creation and processing of such NodeSets. For instance, tool kit vendors provide code generators for their development kits that use NodeSets as source.

CLARK: Who can develop a Companion Specification? Is that a privilege for OPC Foundation employees or members? Or can anyone interested start one up?
DEIRETSBACHER: Anyone is permitted to develop companion specifications. The OPC UA standard is a public standard and can be downloaded from the OPC Foundation website. No membership is required, only registration.

CLARK: The OPC Foundation differentiates between types of Companion Specifications. Can you please explain?
DEIRETSBACHER: The differences arise from the way the OPC Foundation gets involved. We differentiate the various companion specification types as either Internal, Joint, or External.
An internal companion specification is developed by an OPC Foundation working group. No other organization is involved.
The opposite extreme is an external companion specification that is developed without OPC Foundation involvement.
Joint development is considered to be the most important type. Here, the OPC Foundation and another organization (or perhaps a few organizations), sign an agreement for certain work items. The members of all involved organizations are invited to participate. We call this a joint working group. The work-results will carry the logos of the participating organizations and will be published on the OPC Foundation website. The OPC Foundation further supports such joint initiatives with marketing efforts.

CLARK: It seems that Joint Working Groups are the most common way to develop Companion Specifications. Can you tell us more about them? How do they get initiated?
DEIRETSBACHER: Yes, it is true that most active working groups are joint working groups. As already mentioned, OPC UA is an infrastructure to exchange complex information models. There are many organizations actively developing and maintaining models for specific branches. And with the increasing popularity of the OPC UA standard, we constantly receive enquiries to collaborate. So, when we get an inquiry, we check to see whether such a collaboration might be useful for both organizations.
OPC Foundation and the collaborating organizations sign the so-called "Multi-Org-Agreement" (MOCA) including a charter document where purpose, goals and roadmap are detailed. Once approved by the OPC Control Board, a kickoff date is scheduled, where the new joint working group is officially launched. Both organizations then invite their member experts to participate in this new joint work.

CLARK: And how do the Joint Working Groups operate?
DEIRETSBACHER: The mode in which working groups operate is quite similar across most organizations and in most areas throughout the world. OPC Foundation, based on their successes and experience with working groups, suggests some key points to include as part of the charter. Number one, a group needs to have a chairperson that is responsible for the operation, along with one or more editors that develop the specification. Number two, the group will hold regular web meetings (Biweekly is quite common). Additionally, meetings should be recorded for traceability and for those group members who were unable to attend. Face-to-face meetings are also common, but

with less frequency. Number three, the chairperson participates in the OPC UA harmonization group. This ensures that there is exchange between OPC UA experts and other working groups. Number four, when finished, the companion specification will be submitted to the OPC Foundation for review and approval.

CLARK: So, how many Joint Working Groups exist? Where can I find out more about them and their work?
DEIRETSBACHER: At the end of 2019 we had about forty groups in different stages of development. Some of them had just started, while others have completed a specification release and are in a so-called maintenance mode. Over the last few years, we've installed about five to ten new working groups each year. An overview of these working groups, with a short description of their charter and other details, can be viewed on the OPC Foundation website.

CLARK: I assume that commonalities exist amongst the Joint Working Groups. For example, it's perhaps likely that more than one Joint Working Group may need a data type for, let's say, GPS coordinates. How is something like that handled?
DEIRETSBACHER: There are different opportunities. First of all, the core specification already provides several widely acceptable and applicable models for individual types. Examples are, the file type; the folder; a state machine model; and a device model. But, OPC UA also specifies a number of variables and alarm types that are common among many industries. In that context, I wish to mention the Online Reference, which is an online version of both the OPC UA Standard and the Companion Specifications. It allows for easy and powerful searches across all information models. From within the search dialog, enter the term for which you are searching. If your topic exists, you will get a list of page links that define and describe the requested feature.
The second opportunity is the harmonization working group that I already mentioned. Here you can explain and discuss your needs and check for similar, existing solutions.

CLARK: You mentioned that models defined in Companion Specifications are governed by namespace, but what if I want to use models from different companion specifications in a single implementation?
DEIRETSBACHER: Actually, this is a fundamental issue which had to be addressed right from the beginning. Implementations will often use multiple namespaces. For instance, a server that implements PLCopen needs the namespace for the OPC UA core standard, the UA for devices namespace, and the PLCopen namespace. In implementations you will find that the identifier for nodes in the address space includes an ID for the suitable namespace so that it can be easily identified.

CLARK: When a companion specification has been completed, what are the next steps?
DEIRETSBACHER: When finished, the companion specification will be submitted to OPC Foundation bodies for review and approval. The OPC Foundation established a formal release process, which is used

for both internal specifications and for joint specifications. As part of this process, all members are granted a ninety-day period wherein they can submit comments and opt-out claims according to the OPC Foundation's intellectual property policy. When the comments have been resolved, the specification will be published on the OPC Foundation website and integrated into the Online Reference.

CLARK: Is there any activity or development you wish to mention, or perhaps a final thought that you would like to share with our readers?
DEIRETSBACHER: Let me reiterate that the combined efforts of the OPC Foundation and various branch-specific organizations is unique and has enormous potential. I am convinced that it will be a key driver for the ongoing industrial revolution.
On a final note, I very much wish and hope that this article, not only explains, but also motivates other groups. •

Embedded Links:
"these working groups" =
https://opcfoundation.org/about/working-groups/joint-working-groups/

"the Online Reference" =
https://reference.opcfoundation.org/v104/

ABOUT ABOUT THE INTERVIEW PARTNER – KARL DEIRETSBACHER:

Karl Deiretsbacher is Technical Director for the OPC Foundation. He is responsible for the technical operations and the processes related to working groups and specification releases. Karl has been contributing as an expert and editor to OPC Foundation working groups since 1995. Before becoming an OPC Foundation staff member, Karl worked for Siemens AG as Principal for Industrial and Internet Communication.

OPC UA®

The Industrial Interoperability Standard   **www.opcfoundation.org**

OPC UA:
The Framework for
Industrial Interoperability

NEW VERSION V11

nified Architecture
ability for Industrie 4.0 and the Internet of Things

PC UA

IoT
4.0
M2M

→ Modeling of data and interfaces for devices and services
→ Integrated security by design with confi gurable access rights
   for data and services – validated by German BSI security experts
→ E xtendable transport protocols:
   Client/Server and Publisher/Subscriber and roadmap for TSN / 5G
→ Scalable from sensor to IT Enterprise & Cloud
→ Independent from vendor, operating system, implementation language and vertical markets
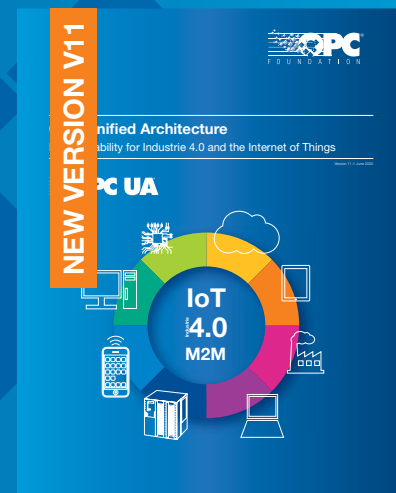
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SAP BUSINESS SOFTWARE

IN THIS SECTION: Learn from an interview with Veronika Schmid-Lutz and Rüdiger Fritz from SAP about the importance of OPC UA for business software. They will tell us what value SAP sees in OPC UA and will describe the concept of business-context-driven control loops and the benefit of Service Oriented Architecture (SOA) on the shop floor.

MICHAEL CLARK: Please introduce yourselves to our readers and tell us a bit about yourself, your company, SAP and your involvement with OPC technology and the OPC Foundation.
VERONIKA SCHMIDT-LUTZ: My name is Veronika Schmid-Lutz and I am Chief Product Owner at SAP for Manufacturing. Chief Product Owner means that I am in the standards development organization of SAP for Manufacturing, making me responsible for the team of product managers guiding our standard products.
I have been involved with the OPC Foundation for several years as a representative of SAP. For the last two years I have been elected as the Chairperson of the OPC Board of Directors. That's it from my side, turning it over to Rüdiger.

RÜDIGER FRITZ: Thanks. I'm Rüdiger Fritz. I've been with SAP for 19 years now. I am also responsible for product management. I take care of our software product called Plant Connectivity, which is actually the OPC UA client, which also contains an OPC UA server.
With regard to the OPC Foundation, I am supporting the board as a member of the Marketing Control Board (MCB). This group discusses strategy and provides advise to the Board of Directors.

CLARK: What is the importance of OPC UA for business software in general?
SCHMIDT-LUTZ: OPC UA is an enabler for interoperability, including horizontal interoperability between devices on the shop floor, as well as vertical interoperability between those devices and business software. Industry 4.0 is a very important topic these days; the whole convergence between IT and OT. Integrating business software with devices on the shop floor is one of the key elements of Industry 4.0. I personally think there is a high potential for manufacturing companies to improve their business processes when they have connectivity to the shop floor. They can gain value out of OT data when combining data from the business side with operational information.

CLARK: How does SAP support or leverage OPC UA?
SCHMIDT-LUTZ: SAP is using OPC UA as an important enabler with its safe connectivity between our business software and devices on the shop floor. We have included OPC UA in our on-premise offering, which is called the SAP Manufacturing Suite. We have also incorporated OPC UA into our cloud solution for manufacturing, which is called SAP Digital Manufacturing Cloud. Both solutions use SAP
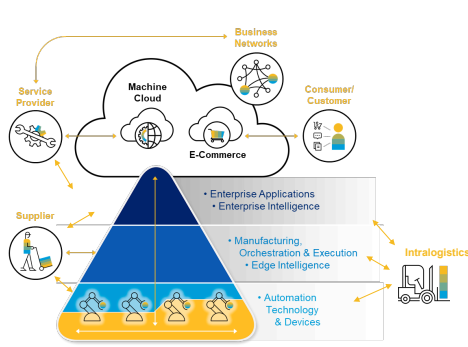
Industrie 4.0 is pretty much about the **industrial transformation** using new **digital technologies** …

… that makes it possible to **gather and exchange data** across machines and business systems …

… **enabling faster, more flexible and more efficient end to end processes** to produce higher-quality (individualized) goods at lower cost and lower carbon footprint.

"Playground" – interoperability across layers and networks beyond Automation Pyramid

Plant Connectivity, which Rüdiger mentioned earlier. SAP Plant Connectivity is the "last mile" between our business software, the machines, and sub-plant connectivity supporting OPC UA. You can see that OPC UA is strategically embedded throughout our SAP products for manufacturing.

FRITZ: Allow me to add here that the thinking behind these solutions is to support data exchange in any direction; it's not just about a data acquisition scenario for the purpose of performing big data analytics somewhere in a business application. We are also equipped to talk in the other direction; to feed machines with information. So, whenever we are talking about bidirectional communication – not the classical top-to-bottom hierarchy – our SAP Plant Connectivity is ready to talk among the servers. It's important that we think not only about pure, mass data and data acquisition stories, but that we also think in terms of control loops.

CLARK: Why does SAP see so much value in OPC UA?
SCHMIDT-LUTZ: First of all, I think everybody knows that SAP is, traditionally, originating from the top floor, meaning from the business environment and business systems, but what we are now doing is using OPC UA in the end processes that span from the top floor to the shop floor – end-to-end processes. Let's consider an example in terms of a customized product. Let's say that a customer's request will be entered in the system by a purchase order, by web channel, or by entering it in the SAP software. Then, this unique order needs to be adapted, because it's a customized product; adapted so that the machine knows what to produce. This is what I mean when I say end-to-end processes between the top floor (the enterprise business system) and the end (the devices on the shop floor) or the automation level. This is a very significant topic for SAP, and this is why OPC UA is very important to us.

Secondly, since OPC UA makes it easier to integrate the top floor with the shop floor, it further helps our customers – the manufacturing companies – gain insight and value by combining data from across the spectrum. The power of combining business data with contextual OT data means that we get greater value by turning data into information.

FRITZ: Please allow me to add something more, Veronika. You see, back in 1972, when SAP was first started, one of the success stories

was that it was possible to standardize Enterprise Resource Planning, starting with accounting and financials. But, to be honest, if you look into the manufacturing world and the automation pyramid, we don't see this kind of standardization – OPC UA is the answer to this. Even though there is a good chance that machines and devices inside a production facility are capable of talking similar languages, this is only seen as a basic standard. From here, we can begin to communicate between these systems. When you think about the multiple flavors of software that you find on the shop floor – the closer you come to the machines – the more differences you find. This argument of trying to have standardization, deep down from the top floor down to the shop floor, well, the only real chance to do this is via OPC UA.

CLARK: What do you mean when you say, "gaining value from data"? What does that mean in the context of OPC UA?
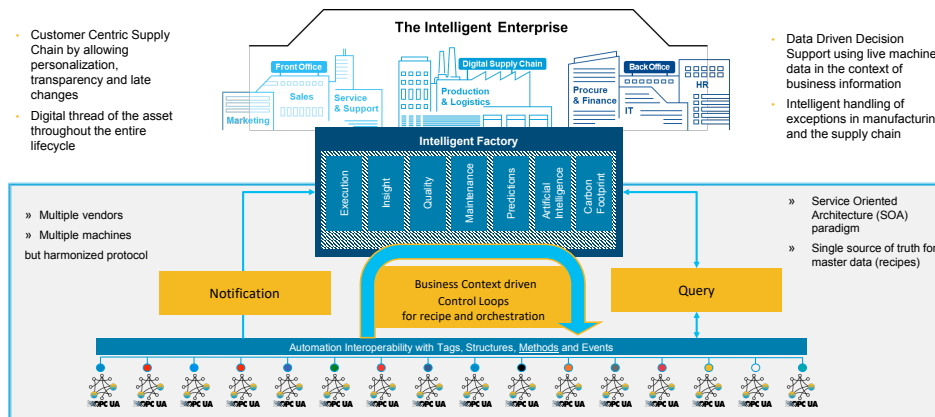**SCHMIDT-LUTZ:** These days, it's clear that new IT and OT technology allows us to collect a huge amount of data. You can collect data from almost every machine, including the smallest sensors. You also have quite a lot of data from the business side. So, what I mean when I say gaining value from the data is, yes you can collect all the data, and you can store the data, but what do you do with the data. I believe that bringing all of this information together, from the machine side and the business side, then applying new algorithms on top of those data, these algorithms can then interpret information out of the data.

Let me give an example; let's say we are logging parameters of temperature, pressure and velocity during a production process. Combining these data, with the product configuration that the customer had ordered, and with the information from the quality of the components used to produce it, then correlating it all with the final product, we may find a pattern that, under specific circumstances, when a customer orders a very high-quality product, and the quality-parameters of the components used were perhaps in the lower range, there just may be a special condition detected during the manufacturing process wherein, under all these circumstances, the quality went down instead of improving.

Let's assume there are algorithms out there – artificial intelligence, neural networks, or other deep-learning algorithms – that can judge whether there is, indeed, a correlation. If we can measure or compare, based on some input data, it is further possible to train these models. Then, when a similar kind of condition arises, the automation system
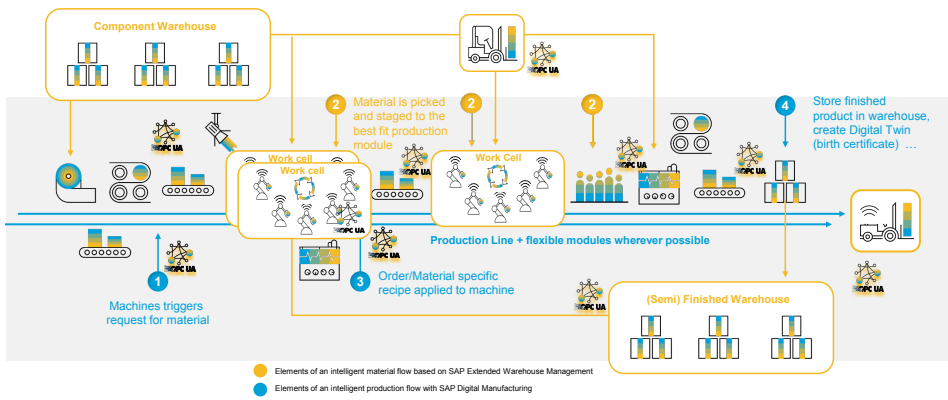
Need: intelligent and flexible factory based on OPC UA
Configurable interoperability and orchestration + standardized information models

- Customer Centric Supply Chain by allowing personalization, transparency and late changes
- Digital thread of the asset throughout the entire lifecycle

- Data Driven Decision Support using live machine data in the context of business information
- Intelligent handling of exceptions in manufacturing and the supply chain

The Intelligent Factory managing the industrial landscape
Connecting the heterogeneous automation floor to the business floor by a single means: OPC UA

can raise a flag and say, "oh be careful; there's a high likelihood that quality will go down". This is what I mean when I refer to getting value from the data; being able to check correlations in the data, observing patterns that impact the quality of an output, or even the need for maintenance of a machine.

FRITZ: I would further add that even the simplest processes require certain configurations, like detailed data directly from a sales order, or perhaps, data that is needed from the material master, like a set point or a recipe for the machines. If combining all of this information in a smart way – thinking more in alignment with business-context-driven control loops – then, from our perspective, there's a good chance that factories can become more flexible and more efficient in the future.

CLARK: You just mentioned "business-context-driven control loops". Can you please explain what you mean by that?
FRITZ: In the automation world, there are classic control loops where you get sensor input values sent to control logic, and then a setpoint is sent to actuators. But this is hard-coded or hardwired behavior inside a PLC or DCS. Sure, it works perfectly, but this kind of behavior is predictable or, as I said, hard-coded; but I don't say that it's useful in every case. There are opportunities to influence the physical control loop, like the material master or the sales order that Veronika mentioned in her example. In such a case, where a particular customer prefers a specific quality, you might instruct a robot to modify a certain job or perform an extra quality check that isn't done on standard products.

This directly influences the production process. There can be many touchpoints, where information coming from master data across the business system, can influence the automation process. Direct integration, based on a standardized approach like OPC UA, makes it much easier to nest these two worlds together. From my perspective, this is the essence of IT-OT convergence.

CLARK: This sounds like Service Oriented Architecture; but isn't that a pure IT topic?
FRITZ: The world of IT and business software have been thinking along the lines of web services for a long time, but why not think of a machine as a service provider. Robots, production machines, even injection molding machines or CNC machines are actually, from an abstract perspective, nothing more than a service provider. You ask a robot to execute a job, and it does it. It does pick-and-place, it takes something from the left and puts it on the right, or whatever; it's now a question of how to orchestrate these different services. As I said before, you can hard-code automation behavior under certain conditions and based on certain sensor values, but why not think about the flexibility of independent service providers which you could orchestrate. When thinking about this lightweight orchestration of different service providers, from our perspective, there's a good chance that industry can build up factories that can easily react to market changes.

Let's say that, today, you are specializing in producing green and yellow products, everything is perfect, overall equipment effectiveness (OEE) is perfect, and so on. But, tomorrow, the market is asking for

pink products with purple dots. So, what do you do? How do you adjust the entire factory to produce pink products with purple dots? Perhaps, you already have all the assets, it's just a question of a different composition, or a different orchestration of these assets. If our mindset, from the beginning, was to build the factory with service-oriented architectures – the ability to call methods, or to call services, to instruct a machine to do something – then it's much easier and faster to rearrange and re-orchestrate the factory. Today, you produce green and yellow products, but, tomorrow, it's easy to switch the factory to produce pink products with purple dots. From our perspective, the idea of a service-oriented architecture, powered by OPC UA, with all its concepts of calling methods, which, by the way, has been a part of the specification for years, is something we should be leveraging.

SCHMIDT-LUTZ: Perhaps, you would allow me to add more here. Service-oriented architectures have been used in the IT world for over a decade. It has helped to simplify programming in the IT world. Having that kind of service-oriented architecture, as a layer on devices throughout the OT world, makes it much easier for the two worlds – IT and OT – to talk to each other. Simply put, it's the same language, sharing the same paradigm of communication.

CLARK: Do you see any limitations regarding the future success of OPC UA?

SCHMIDT-LUTZ: You're asking about limitations; let me start by saying that I personally think OPC UA will gain more and more momentum, more and more adoption, and more importance in the market place. Coming back to possible limitations, we have heard that there are limits when attempting to implement OPC UA into brownfield applications, primarily because there is no installed OPC UA features from which to gain leverage; brownfield machines may not talk OPC UA. I agree that it's more difficult, but there is always a way to use OPC UA in a brownfield area, like retrofitting OPC UA capabilities into existing machines. Arguably, this is more expensive at the beginning but, in the end, I think that it will pay off for the company if they implement a similar approach when connecting to machines, a similar approach for collecting data, and a standardized way of talking to the machines.

Supporting and using not only OPC UA as an architecture, but using the new semantic models, the companion specifications for the various devices, and standardized device types on the shop floor, will play an important role in harmonizing communications and providing more value from each implementation.

CLARK: In closing, can you share any success stories involving SAP business software and OPC UA?

SCHMIDT-LUTZ: Well, in an article such as this, I think it would be best to avoid using the names of our customers, but what I can clearly state is that we are embedding OPC UA throughout our SAP manufacturing products and, because of this, we have a large number of customers using, and leveraging, OPC UA technology. These implementations span different industries including, automotive manufacturing, automotive suppliers, consumer products, industrial machinery, and even the fashion industry. I think it may be interesting to point out that, in just the last few years, we have been quizzed by our pros-

**ABOUT THE INTERVIEW PARTNER –
VERONIKA SCHMIDT-LUTZ:**

Veronika joined SAP in 1995 as a developer in manufacturing and contributed to several applications in ERP Production Planning (PP) and Advanced Planning & Optimization (APO).
After leading various development organizations within SAP Veronika took over the role of Director Solution Management and Development Industry Business Unit Mill Products in 2003. In 2008 Veronika assumed the role of Head of Delivery Management Manufacturing.
From May 2010 until July 2020 Veronika was the Chief Product Owner for Manufacturing at SAP and in this role responsible for the roadmap as well as the success of the manufacturing products of SAP.
Veronika holds a Diploma of Precision Engineering from the University of Applied Sciences in Ulm/Germany.
In 2015 Veronika was elected as a board member of the OPC Foundation. Since March 2018 Veronika is the chair of the board of directors of the OPC Foundation.

**ABOUT THE INTERVIEW PARTNER –
RUEDIGER FRITZ:**

Ruediger Fritz is an Industrial Engineer and has been with SAP since 2001. He started as Developer and Development Architect for Logistics Applications and has held various roles in the Manufacturing Domain, in particular being responsible as Product Owner for SAP Plant Connectivity (a Gateway tool and OPC UA Client and Server). Recently, Ruediger took on the role as Director Product Management "Standards and Digital Supply Chain Innovations" and serves as a member of the OPC Foundation Marketing Control Board.

pects as to how strongly we support OPC UA in our products. It is one of the main capabilities for which our customers and prospects are asking before they decide which manufacturing solution they will be using on the shop floor. We see that there is a growing need in the market; customers are requiring that we supply it.

FRITZ: As Veronica said, we are not allowed to mention names, but there are definitely products around you, maybe even right now as you are reading this article, which were produced based on our software; software that integrates devices from the shop floor with machines and enterprise systems, all based on OPC UA. There is big momentum behind this technology; many see the value and are strongly supporting it. •

PROSYS OPC

GETTING STARTED WITH OPC UA

IN THIS SECTION: Learn from an interview with Jouni Aro of Prosys OPC how developers and end users alike can get started using OPC UA. Jouni shares information about off-the-shelf products, software development toolkits, open source options, training and support, as well as product certification.

JOUNI ARO,
OPC & OPC UA product development, project work and customer support
jouni.aro@prosysopc.com

MICHAEL CLARK: Jouni, please introduce yourself to our readers. Tell us a bit about yourself, your company, Prosys OPC, and your involvement with the OPC Foundation.
**JOUNI ARO:** I am the CTO of Prosys OPC. I've been responsible for our OPC product development for a long time. We have over twenty years of experience in OPC development. We started with OPC classic, and, since 2006, we've been partnering with the OPC Foundation, bringing OPC UA support for Java. I've spoken at OPC Foundation events for several years, and I've been hosting the OPC-Day Finland, which has been a successful event for over ten years.

CLARK: In previous OPC Foundation articles, we have learned a lot about theoretical topics surrounding OPC UA. For those readers that have already decided that OPC UA is for them, how shall they get started?
ARO: That depends on what you are actually doing; whether you wish to start developing OPC UA or if you just want to use applications that are available in the market. In either case, I would recommend that you start learning more by getting your hands dirty. You need some applications to start playing around with.

CLARK: Can you recommend any specific demo or sample applications for "getting your hands dirty" to start learning the in's and out's of OPC UA in practice?
ARO: Yes, for sure. Samples are a good way to start, and the OPC Foundation is providing good sample applications from their website. Additionally, I would recommend downloading some sample client and server applications from companies that specialize in OPC UA development.
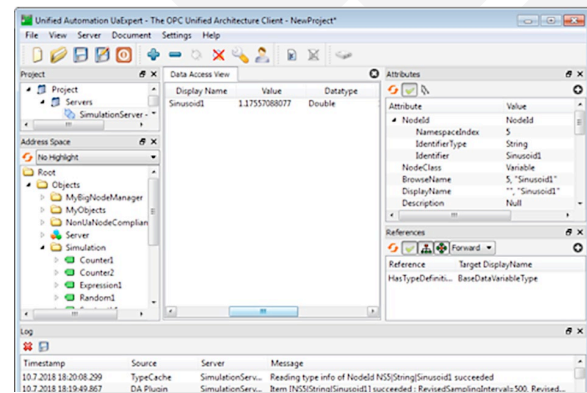

Screenshot from UaExpert software application

For example, Prosys OPC provides a great simulation server and UA browser. With these two free applications, you can play on your own computer, independent of the operating system, and this will help you understand OPC UA in practice. Unified Automation is another company that has a long-term dedication to the details of OPC UA. They provide a demo server and UA Expert which, you could say, is the de facto client application that almost everybody in the field is using. Of course, other companies are providing similar samples along with their toolkits and other products.

CLARK: What can readers actually do with these demo or sample applications? Are they really free of charge?
ARO: Yes, they are, indeed, free, and the intention is that you need to have something to play with. If you have a real server for example, you need a real client to play around with. The UA Browser and UA Expert
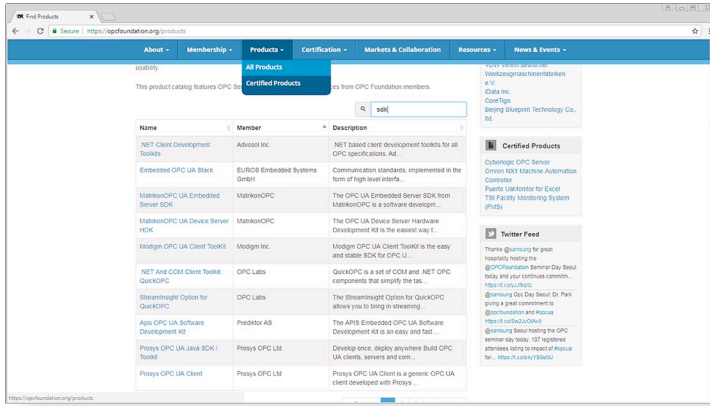
OPC Foundation Product Catalog Webpage

Prosys OPC UA Simulator Server Software Application

applications will help you with viewing an existing server. You can find out what data is in the server and then you can read, write, monitor data changes, and do additional things like that.

If you don't have an actual server, and you are developing a client, for example, then you might have a look at a simulation server. This enables you to run a client against the simulation server.

CLARK: Do these sample applications help you explore the high-level security options built into OPC UA?

ARO: Yes, definitely. With these demo applications, you can see how OPC UA security works in practice. You can configure the security options on both the servers and the client side. Whenever you are initiating a client connection, you are choosing which security mode you want to use. With the client application, you can also see how it works in practice and you can learn the details of dealing with the application instance certificates that are used for authentication of the client and server. Security is a crucial part of OPC UA, and it is demonstrated well in these applications.

CLARK: Would the sample applications also be good for something else – like testing connections?

ARO: Yes, they are. Testing real applications with your own system is a very practical thing to do once you've learned to play with demonstration tools. If you have any troubleshooting issues, these are the first tools that you want to turn to in order to find out what is going on with communications. You can replace your actual server with the Simulation Server to see how the real client application is communicating. Or the other way around, you can use the UA Browser or UA Expert to communicate with any server to test whether you can communicate. Then, you can also check the data in the server, to see if you can monitor data changes or even monitor events or read history from it.

CLARK: So, what's next? Once you have experimented with the sample or demo applications, how can you start implementing OPC UA at your production site?

ARO: First of all, you will need to look for applications at your site which are supporting OPC UA. For example, there are already quite a bunch of applications within many brands of PLC's. You should find support very easily for OPC UA within other automation systems as well.

CLARK: How do you find products supporting OPC UA?

Aro: Initially, you should contact your system providers to learn what they have already included within your installed systems. Additionally, you may want to consider upgrading your existing software or hardware to enhance them with newer versions that support OPC UA. Arguably, this is not necessarily easy if you don't want to change an existing system. In some cases, you might consider using other applications that help with brown field solutions. It depends on whether you're building a completely new site or modifying an existing system.

CLARK: Can you explain the difference between implementing OPC UA as part of a new solution versus deploying OPC UA into an existing brownfield solution?

ARO: Of course, if you are building a completely new production site, you are free to choose new equipment, like new controllers and end devices, that already have OPC UA built in.

If you are upgrading a brownfield solution, then you are likely to be more careful with what you want to change. Your options may be limited by what each vendor lets you do with their existing system. However, a fantastic option, specifically for brownfield solutions, is the use of additional hardware or software components called gateways; they can convert existing protocols to OPC UA. This might be a very good solution for you.

CLARK: OPC UA is all about interoperability – after all, we are the Home of Industrial Interoperability! Can you please share your experience regarding how OPC UA products inter-operate in practice?

ARO: Let's remember that OPC UA was developed over ten years ago. The first public release of OPC UA came out in 2009. Since then, the products have been tested for interoperability very extensively. The OPC Foundation is running interoperability workshops, in several locations, every year. They also maintain a laboratory where they are constantly testing and certifying new products for interoperability. This has resulted in outstanding interoperability of products in practice. We can just simply plug-and-play OPC UA products together, without any issues.

CLARK: Suppose I have an existing product in which I would like to incorporate support for OPC UA. How do I proceed?

ARO: If you wish to incorporate OPC UA functionality within your

product, which may already support certain protocols or some native communications, you will need additional components that perform the OPC UA functions for you.

I should explain that there are two levels of components. First, there is the stack layer, which is actually the communication layer of OPC UA, which is very important for ensuring interoperability. Generally speaking, this is not quite enough for a good level of application development support.

Secondly, to complete the development cycle, there are numerous software development kit (SDK) products. These are available from several companies, featuring different programming languages and various operating systems. I should also mention that, in addition to Prosys OPC, other member companies of the OPC Foundation, such as, Unified Automation, Matrikon, OPC Labs, Softing, and Software Toolbox, for example, are providing toolkits which are recommended. You might now be wondering whether these are commercial or free toolkits. These are, indeed, commercial ones; and the costs can range from $1500 to $15,000, all depending on the service package. This reflects the extensible functionality of OPC UA. It depends on what kind of features you really want to target.

CLARK: Software Development Toolkits are one way to go. How about open source? Isn't that the solution many readers today are looking for? Did not the OPC Foundation and other institutions release open source implementations of OPC UA?

ARO: OPC UA is very extensive and I have already mentioned the different layers and different functionalities that your applications may need to support. As you mentioned, depending on what kind of organization you are dealing with, whether you are just doing academic research or whether you want to really develop a reliable product for the industrial marketplace, your choices can be quite different.

The OPC Foundation has open source stack layer implementations for .NET, C++, C, and Java. They've ensured that these are interoperable. On top of that, the SDK products – which are typically commercial products – are providing the most reliable and fastest way to the market for a reliable implementation of OPC UA.

CLARK: Please share some advantages and disadvantages of using an SDK versus open source. I mean, open source is about free use of software, but not about free beer, right?

ARO: Traditionally, open source has been very important for development of many technologies including OPC UA. With open source components, you always have to remember that you should be prepared to adjust the codebase to your likings. There is no one behind the product to really guarantee that you get everything right for your application.

With commercial support that comes with the SDK's, you get a better guarantee that with whatever problems you are facing, you will have someone to rely upon for support. You could think about it like you are mostly paying for the support. I think that's the major difference.

So, with whatever solution I choose, what happens if I have a problem and need support?

ARO: With open source, you have the responsibility to check the code-base yourself, and be able to modify it to your needs. There

**ABOUT THE INTERVIEW PARTNER –
JOUNI ARO:**

Mr. Jouni Aro is the CTO of Prosys, responsible for OPC and OPC UA product development and is also the main architect of most of the Prosys OPC products. He is the Chairman of the OPC Committee in Finnish Society of Automation. He is also a member of the Technical Advisory Council at OPC Foundation and has been an active member in several OPC Foundation working groups since 2006. Jouni Aro is currently a member of the IEC TC 65/SC 65E/WG 8 (OPC UA) standardisation committee.

may still be a community behind the open source code that might be available to support you, but there's no guarantee of that. With an SDK, or commercial support, you can simply contact the provider, and they are, typically, very quick to respond to issues. They want to work on interoperability proficiencies and they want to improve the libraries, in general. I would also like to mention that these commercial companies are guaranteeing you access to future expansions of OPC UA, because OPC UA is being improved all the time. Therefore, it's very important to have a dedicated team that is ready to support all of the new features that are coming up in OPC UA.

CLARK: How about training? Do companies provide workshops and training sessions? Where can we find them?

ARO: Yes, there are a lot of companies that are providing OPC UA training, especially for developers. We, at Prosys OPC, have also started doing more and more end user training. There are also companies that have specialized in end user training only. However, since the OPC Foundation is not listing the training companies on the website at the moment, you need to do your own research to find out which companies are closest to you. I see that there is more demand for training coming. We need to add more training options in the future, because people want to be educated.

CLARK: Regarding OPC UA in today's industrial market, what developments have you've seen taking place?

ARO: Well, this year we've seen more and more end users coming up and asking for training and information. They've learned about the benefits of OPC UA and they've also found more products in the market – there are a lot of PLC's and SCADA systems that are supporting OPC UA these days.

There's also a lot of information modeling work happening and we've seen end user companies in pharmaceuticals, automotive, and other industries starting to look for the benefits of OPC UA in practice. We're not talking about technology that much anymore; we're talking about what can we do to improve our production systems in general. These operating companies are talking about the plug-and-produce principle. They would like to be able to purchase new equipment, plug it into their production line, and just let it run without spending days of configuration effort to get everything connected to their historian and MES systems. I think this is the most welcome advancement that we've seen lately. •

Matrikon®

OPC UA
AND SECURITY

IN THIS SECTION: Learn from an interview with Darek Kominek of Matrikon about the concepts of built-in security, the IT-OT gap, protecting against hacker/malware attacks, and many other features that have made OPC UA the secure data-exchange standard it is today.

DAREK KOMINEK,
Marketing Director at Matrikon (Honeywell)
darek.kominek@matrikonopc.com

MICHAEL CLARK: Darek, please introduce yourself to our readers: Tell us a bit about yourself, your company, Matrikon and your involvement with the OPC Foundation.

DAREK KOMINEK: My background is in computer engineering. I did software development for the first ten years of my career before shifting into marketing and product management.

I've been with Matrikon for sixteen years. As their marketing director, I look after strategic marketing and product positioning activities. I also run the technical solutions consulting group, which assists our direct and partner sales channels who work with OPC-based solutions. I also run an equal partner program that deals with our partners who use the Matrikon Flex OPC UA SDK.

Outside of Matrikon, I'm a member of the OPC Foundation's Marketing Control Board. There, I get to take part in shaping the OPC Foundation brand and working with OPC UA. I enjoy seeing all of the exciting initiatives that are being undertaken around the world.

CLARK: Security is a big topic nowadays; what role does OPC UA play in it? What does OPC UA help protect?

KOMINEK: Great question. We hear in the news all kinds of things that are happening around the world – all kinds of threats that we have to deal with, including threats against network communications. Since everybody is relying on networks, there's a lot more that's threatened. When we talk about industrial automation – whether it's the excitement of Industrie 4.0 in Europe, or the Industrial Internet of Things [IIoT] – everything is based on the information that's coming from the underlying data sources. OPC UA is right in the sweet-spot of this topic, because it focuses on moving data from point-A to point-B.

When talking about security and what happens with data, data is basically in three states:

→ The first state is data-at-rest. This includes storing it in databases, historians, or within a device.

→ The second state is data-in-process. This describes data as it's being used.

→ And, lastly, is the concept of data-in-motion. This is the event of transferring data.

OPC UA focuses primarily on the third state, data-in-motion. It looks at data holistically, not just how data may be encrypted as it moves across the wire, but also, who should have access to the information, and what they are permitted to do with it.

What does OPC UA protect? Well, all industrial data – starting from sources at the lowest levels of the shop floor, all the way up to data stores within cloud applications.

CLARK: It is said that OPC UA has "built-in" security – what does that mean?

KOMINEK: That's an essential ingredient within OPC UA; it was built secure-by-design from the ground up. Its security aspects are based on lessons learned over the past twenty-plus years. One key principal, that OPC Foundation realized, is that the goal is not just about connectivity; security is an integral part of the mission. This is especially true in an industry in which IT departments are trying to protect their networks, while OT guys are trying to keep their plants running. The path forward has to include the best IT practices built into OT standards for communications. Of note, based on these objectives, the OPC UA standard has fourteen core parts; of those, six are directly influenced by security principals.

The first category has three aspects called the triple "A" of security – Authentication, Authorization, and Auditability.

→ **Authentication** is what is used to confirm that device-A is really A and that device-B is really B when communicating between A and B. This is where PKI (Public Key Infrastructure) is used to establish trust between the two entities, or applications, that intend to communicate with one another.

→ **Authorization** deals with who is allowed to do things with the data once they've been authenticated on a system.

→ And lastly, **Auditability** is the ability to trace what actually happened. For example, if you're doing a post mortem analysis, you can see who made which requests, when they were made, and from where.

CLARK: How well suited is OPC UA for Industrial IoT, also called Industrie 4.0? Does OPC UA address the IT-OT gap, as far as security is concerned?

KOMINEK: Absolutely! The OPC Foundation didn't invent how it bridges IT and OT. Instead, it leverages best practices from both disciplines to provide end-to-end security, ensuring we know where the data originated and where it's going.

OPC UA security incorporates know-how from other groups. For example, the NSA [National Security Agency], and their concept of defence-in-depth, ensures there are multiple layers of security so that users aren't simply depending on one gate. It's kind of like a castle structure comprised of multiple moats and walls. Another example is NIST [National Institute of Standards and Technology], when dealing with algorithms. Even though encryption may be solid today, things continue to evolve. Certain departments are monitoring which algorithms are starting to become vulnerable or no longer effective.

Since OPC UA has the ability to continue to evolve, it's not tied to any particular technology; it's more global in its scope. Whether we're talking about small microprocessors – things that don't even have operating systems onboard – or large servers and cloud-based systems, each has the ability to use certificates. This includes some of the latest advancements in role-based security, which makes it easier to minimize the headaches of configuring a secure system. The list goes on, and all of these best practices have been built into the OPC UA standard.

CLARK: Let's get into a bit more detail. What are some key security concepts?

KOMINEK: The topic of security is so huge that people are sometimes overwhelmed by the breadth of things one must know. Since OPC UA limits its scope to data transfer – the data-in-motion aspect to which I referred earlier – I would suggest we talk about the broader concept of trustworthiness.

So, what are the aspects that make communications trustworthy? There are seven general security principles which neatly breakdown into three categories.

The next set of security principles is the CIA triad, which stands for Confidentiality, Integrity, and Availability with respect to data.

→ **Confidentiality** deals with keeping the information sent between entities private.

→ **Integrity** means that the data is not being changed.

→ **Availability** is ensuring that communications stay online as much as possible.

The final aspect of security is called Nonrepudiation. By signing transmitted data, recipients are assured of the integrity and origin of the data and that it is not spoofed.

CLARK: How do users know which security functions are implemented in a given product?

KOMINEK: If the product is OPC UA enabled, users will recognize that the OPC UA server exposes endpoints to which clients can establish secure connections. When we talk about endpoints, an OPC client, seeking to establish a connection with an OPC UA server, will see, within that server, a list of which security mechanisms are available for establishing such connections.

CLARK: You mentioned endpoints. Can you share some examples of endpoints with our readers?

KOMINEK: For those who are familiar with security concepts, they may know some of the names that are used to identify various algorithms and security systems, but for others it might sound a bit more

OPC UA the secure data-exchange standard today

cryptic. The endpoints that a server might expose may include encryption like AES-128, SHA-256, AES-256 and so on. These endpoints reflect various security policies that a server can implement.

Just to give some insight, we could compare this to a menu board at a drive-thru restaurant. You can either openly choose those things you want to eat and drink from the entire menu or you might, instead, order a combo meal – Combo 1 or Combo 2. Compare this to security policies in OPC UA servers; they combine – or create a combo – of different types of algorithms and exchanges that can be established between a client and a server to mutually prove their identity. Next, it's necessary to establish the encryption standards of how clients and servers are going to sign messages; how they are going to encrypt and subsequently decrypt the data.

This combo of different algorithms, used to create tokens and hashing values, comes together under what is called a security policy. Endpoints are what expose these combinations. It ultimately comes down to whether you choose to sign the data, encrypt it, or to do both. The worst-case scenario is to do neither of them – something called none-none – neither signing nor encrypting the data. Obviously, this is the least secure implementation.

CLARK: How do users know which endpoints are available in a given OPC UA Server?

KOMINEK: When a user begins to establish a connection from an OPC UA client, the server will advise the client of its available endpoints – it will advertise it. The user can then choose which of those features (endpoints) they want to use. Of course, the vendor documentation will specify which security options are available in the OPC UA server.

CLARK: How does OPC UA protect against common hacker or malware attacks?

KOMINEK: There are ten common attack types; each one attempts to breach the security features I mentioned earlier. I'll give a few examples: Message flooding is a denial of service (DoS) attack. This kind of attack tries to affect "availability", as defined in the CIA triad. OPC UA servers combat this by processing incoming packets as minimally as necessary. If information in the packet doesn't immediately align, the server simply drops it. It doesn't try to recover the data, try to figure it out, or try to have further exchanges with that client – it just drops it. This feature minimizes OPC UA server processing, which preserves the resilience of the server.

Another type of attack is message spoofing or, in other words, forging of messages. This is sometimes called a man-in-the-middle attack, wherein messages are manipulated to appear as though they are authentic, when in reality, they're not. Since OPC UA packets utilize encryption, certificates, embedded Session ID's, and Channel ID's, fake messages have a snowballs chance in hell of actually making it through – so long as you've chosen to apply these security measures. Message alteration, or replay, is another way in which hackers try to take a valid message and attempt to replay it a number of times. Imagine if this message was a command to activate a valve positioner. If permitted to pass, it could have disastrous effects. OPC UA session ID's, channel ID's, timestamp sequence numbers, request IDs, and so forth, all take these things into account, thus preventing replaying of messages.

Lastly, the most obvious breach, is eavesdropping. By using data encryption, OPC UA removes that possibility. The list of preventative measures goes on, but those are a few effective examples.

CLARK: Does every OPC UA enabled product have to implement all security profiles?

KOMINEK: No, it's not necessary. For the OPC UA standards to be applicable, it was necessary to define specific profiles for servers with differing capabilities – profiles like nano, micro, embedded profiles, and standard profiles. Usually, the compute power will be proportional to the complexity of what is being processed by a particular subcomponent.

If you have something so small that it can't run a full implementation of OPC UA security, then reflect back to the idea of defence-in-depth. Steps must be taken to ensure that IT (or OT) personnel properly isolate these devices, mitigating risk by using other protection methods around the components that don't utilize a full implementation of OPC UA security policies.

CLARK: Does implementing OPC UA security make a product secure?

KOMINEK: That's a very important question and I hope the vendors pay as much attention to my answer as the end users.

If you implement OPC UA security correctly, yes, it is effective, but it is extremely important that vendors properly implement additional aspects of the product. Let me illustrate:

OPC UA uses certificates to establish trust among peer components. Imagine if a product was to store its root certificate in an unprotected area, somewhere onboard the product. Even if this product had properly deployed OPC UA security features, if the product's network presence is compromised in a way in which someone gains access to those root certificates, the security of that product is then jeopardized.

It is so important that manufacturers take a holistic view when building their products. Furthermore, end-user administrators must properly configure their systems and supporting networks.

CLARK: Can you share any empirical evidence about the built-in security of OPC UA?

KOMINEK: Yes. The OPC Foundation has certainly performed testing within its own laboratories, but an example of a more in-depth examination was completed by the German government.

BSI, The Federal Office for Information Security, in Germany, has the obligation to systematically test available standards in support of the Industrie 4.0 initiative. They hired a third-party company to perform thorough testing, which included proofs and implementation validation. OPC UA did very well, passing their rigorous testing. This brought a great boost of confidence to the industry.

Furthermore, testing has been done in other countries. For example, OPC UA is one of China's national standards, which has been woven into their Made in China 2025 initiative.

CLARK: Security is a cat-and-mouse game between hackers and the security community – how does OPC UA keep up?

KOMINEK: It is definitely a never-ending story. The layered approach of defining OPC UA, with its service architecture bridging different layers, was designed to account for continuous evolution. This means that you can continue to use what you have currently implemented, but, when the next product version comes out, it may be necessary

ABOUT THE INTERVIEW PARTNER – DAREK KOMINEK:

Darek helps vendors, system integrators, and end-users best leverage OPC UA technology as the data connectivity foundation for their products, projects, and infrastructures respectively.

As a member of the OPC Foundation Marketing Control Board (MCB), he works with leadership on strategic marketing activities to drive OPC UA adoption, presents globally on behalf of the OPC Foundation, fosters collaboration with other standards organizations, and publishes articles about the advantages of using OPC UA in the IIoT/Industrie4.0/M2M space.

Darek holds a bachelor's degree in computer engineering from the University of Alberta.

to update some of the onboard security features. For example, encryption algorithms may require updating. The OPC UA specification follows NIST guidelines which recommend expiration dates for various algorithms. OPC UA has already deprecated some of these algorithms.

CLARK: What information sources can you suggest for those who want to learn more about the practical implementation of OPC UA security?

KOMINEK: One of the best places to start is the OPC Foundation website. opcfoundation.org. Among the many resources here, you'll find a brochure that describes how to securely deploy OPC UA. There's also a Wikipedia page about OPC UA security, directly accessible from the OPC Foundation website. Furthermore, you can always refer to the OPC UA standards themselves, free of charge. OPC Members can also preview items that are in-progress. I think these would all be great starting points.•

OPC CERTIFICATION PRINCIPLES

IN THIS SECTION: Learn from an interview with Paul Hunkar from the OPC Foundation about certification. He will give us a quick introduction into certification, why certification is important, the end-user and vendor demand for certification, the costs involved, and who can get products certified.

PAUL HUNKAR,
OPC UA Director of Compliance and Certification
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MICHAEL CLARK: Paul, please introduce yourself to our readers.

PAUL HUNKAR: I've been a consultant for the last 10 years. Before that, I worked at ABB for more than 25 years, but I have always been very involved in OPC initiatives.

Currently I'm a member of the OPC Foundation's Technical Advisory Council. I am the editor for several parts of the base specifications. Being very involved in information modeling, I have a number of Companion Specifications that I am either an editor, contribute toward, or act as chair. Additionally, I'm active in the Field Level Communications group, chairing the Information modeling subgroup. Needless to say, I'm very involved in OPC UA.

As a consultant, I have a contract with the OPC Foundation as the Director of Certification, running the certification program for them.

CLARK: Please give us insight into the topic of Certification and what the OPC Foundation does to support it.

HUNKAR: Certification checks to see that developed products meet a standard. It can be either hardware or software, but it's about validating that they're in compliance with the specifications.

The OPC Foundation certification program goes a little beyond that. We are an automation standard, and it's critical that products not only work correctly, as the standard mandates, but that they also have some level of trust in usability. This includes fault testing to ensure devices can handle an environment where other applications are misbehaving, that they don't crash, and that they can operate in this type of environment for an extended period of time. The Foundation maintains a certification program to help with this, to help with interoperability, and to ensure that vendor products are done well. We aren't just generating a "rubber stamp" for certification; we work with the vendors to make their products better; to make sure that they'll work with every other vendor out there.

CLARK: So, why is certification important?

HUNKAR: When OPC started, many years ago, the legacy COM-based interfaces (now called "classic") did not include a certification program. Since the specifications were only written words, they tended not to be very precise. Manufacturers implemented what they thought the specification was trying to convey, but we found that there were interoperability problems – they didn't communicate with other vendor products very well.

Today, even though OPC UA specifications are much clearer, there's still a need to verify whether a product meets the standard, whether products will interoperate, and whether the features, which are supposed to go together, are provided together.

CLARK: Achieving certification is one thing, but users requesting it is another. Does the market demand certification?

HUNKAR: What we're finding is that there is starting to be more demand for certification. Companies are realizing that certified products work better.

I'll share an example from an end user company who runs their own testbed in order to test every product before being deployed in their operating facility. They said to me, "We receive OPC products all the time; whether they are OPC products that we build ourselves or have our contractor build. We also receive products that are commercial products, including products that are certified. When we test a prod-

uct that we've built, it sometimes takes us weeks to get it running correctly in our lab environment. In contrast, a commercial product may do a little better, but sometimes it is still more than a week to get it working; however, the product that has been certified… I simply plug it in and it works – typically, five to ten minutes – and it's running well".

CLARK: What does it cost to get a product certified? Is it expensive?

HUNKAR: We charge fixed-rate fees for certification; only $1900 a day, as shown on OPC Foundation's public website. It depends on the type of product as to how many days it spends in the lab. Servers tend to typically run in the range of three to seven days, where a client may take anywhere from five to nine days. A lot depends on how well the product is prepared.

The quoted price is a flat fee for members and non-members alike; however, members receive a 50% discount, so they're actually only paying $950 a day for lab time. Furthermore, vendors only pay for actual lab time, so if a product runs into issues and the vendor suspends testing while they go fix a few things, upon resuming, they're only billed for the time the product is actually being tested. If the product is in the lab for two months, due to problems or interruptions, it may still only need five or six days of actual test time to complete the certification. It's not very expensive; most test campaigns are usually under $5000. It's very reasonable.

CLARK: In which facilities does certification take place?

HUNKAR: Currently, we have a couple of labs; one in Germany and one in China. The European test facility is our primary lab; however, we have found that products made in China are usually developed for the Chinese market – the interfaces are Chinese, the documentation is Chinese – as a result, the lab in China helps us a great deal with these native Chinese products. The China lab is invaluable for testing.

The Certification Test Lab in China

CLARK: A quick follow-up question: While the documentation may be in Chinese, the product still talks OPC UA to other products from around the world, right?

HUNKAR: Yes. The products still interact perfectly. The concerns rest only with human beings – our test staff – translating Chinese characters into other languages.

CLARK: Getting into some more detail, is certification limited to the interfaces that are exposed by OPC UA?

HUNKAR: No, there is more to an industrial automation product than just specific interfaces. We check usability, and that there's some level of product documentation provided so that users can understand how to install it and use it. We look at interoperability, including the general behavior of the product; not just a specific interface, but that the overall architecture is good and that it performs in an efficient manner.

We look at how it interoperates with other products; checking it against a wide variety of products we keep in the lab. We check performance to some extent; for example, if a vendor claims that they can do 3000 client connections on their server, we will validate that claim. We also do some stress testing. For example, if we are testing a server, the server will be set up on a bench and running for three or four days connected to clients that are misbehaving – clients that are doing wrong things, incorrect things, being bad, encountering network disconnects and breaks – making sure that the server will run for three or four days without memory leaks, or without crashing on its own. We assert that a server should never be able to be crashed by a client or network problems.
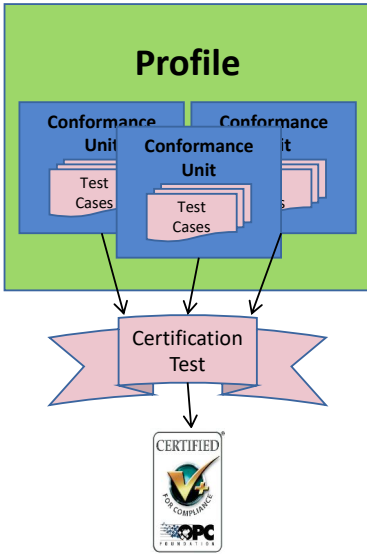
CLARK: When a product gets certified, does it have to support everything that OPC UA provides?

HUNKAR: That is a very good question. The OPC standard is a very big standard; it has functionality for alarming, it has historical capabilities, it has data access capabilities, it has a large array of information models found in myriad companion specifications and, "does a product have to support all that?" – the simple answer is, no.

There is the concept of profiles within OPC UA. These are groupings of functionality that should be tested together. The OPC Foundation generates a fairly long list of profiles for different, smaller sub-sections of functionality.

We certify profiles.

When a vendor brings their product in for testing, they declare which profiles they're supporting. Perhaps they support an embedded device profile, maybe a standard UA server profile, maybe even support for alarming or some other companion specification. The key thing is that, once they declare which profiles they've included, we base the testing on that. This results in a much smaller subset of the full OPC UA functionality.

With that said, if a vendor exposes some other functionality, even if they tell us that it isn't something they want tested, we test it anyhow. So, if a vendor claims that they only want to support an embedded UA server profile, but they're also exposing alarms in their product, we will certainly see it, and we will test the exposed alarming function-

Profiles and Certification

**ABOUT THE INTERVIEW PARTNER –
PAUL HUNKAR:**

For ten years, Paul Hunkar has served as President of DS Interoperability, independent consulting firm, specializing in design and development of software systems. He has extensive knowledge OPC, especially related to the Unified Architecture (UA) standard. He is Director of Compliance and Certification for the OPC Foundation and chair of the OPC Foundation Compliance Working Group. He is an active participant of the OPC Foundation UA working group and many sub groups (Security, Harmonization, TSN….). He is an editor of multiple parts of the OPC UA standard and serves as chairman or editor on multiple Companion working groups. He is the technical lead on the MDIS OPC UA companion specification. He is a member of OPC Technical Advisory Council (TAC). He had previously worked for ABB in the Process Automation Division, for more than

ality. We want to make sure that, when an end user sees that a product is certified, it's paramount that every UA interface or information model exposed is, indeed, certified; not just the ones the vendor wanted us to test.

CLARK: What is the result of the certification? Do vendors merely get a pass/fail, or do they get a detailed report from which they can learn what to improve?

HUNKAR: We are highly interactive with the vendor during their testing process, providing a daily summary of things we've found so they have a chance to fix it. Once testing is completed, we generate a very detailed report for them. We show them graphs of the general performance of their product with respect to memory and CPU usage during our long-term tests. By the way, this is a private report issued to the vendor; they can do with it as they please. Since some end users are aware that there is a report, they may ask to see it, but it is up to the vendor to choose whether to provide it.

What is publicly available is the certificate, which shows all the profiles and optional conformance units that were passed. This certificate is posted on the OPC Foundation website, identifying that the product is certified. Furthermore, a special logo, which indicates product certification, is granted to the vendor for use in their documentation.

CLARK: What is the best way for an end user to learn which products have been certified?

HUNKAR: The OPC Foundation maintains an online product catalog. It includes both certified and uncertified products. The product catalog is continually improved, providing enhanced searching capabilities and so on. Systems Integrators (SIs) are commonly the ones accessing the product catalog because a lot of end users (their clients) are mandating that the SIs use only certified products. This is an important thing for an end user to remember; systems integrators make choices based primarily on cost. It's true that certified products sometimes cost a little bit more, but the benefits of a certified product far outweigh the slight increase in cost.

CLARK: How long does certification remain valid?

HUNKAR: The products are certified for three years. After that, the vendor can submit paperwork indicating that the product is still ac-

tively selling, and request an extension of the certification, so long as the product has not changed. If changes have been made, the vendor must retest the product. A retest costs a lot less because it's easier due to the fact that we have a record of what we tested before. We look at which components were updated and focus the testing on that. Then we run some of the long term or purely automated tests again. The automated tests take 20 – 30 minutes and the long-term test is designed to ensure that leaks or problems haven't crept into the product

CLARK: In closing, are there any final thoughts that you would like to share with our readers?

HUNKAR: Industry is showing demand for certified products and there is further demand with respect to information models, many of which have mandated that products implementing the companion specification be certified. In addition, Field Level Communications (FLC) items will also mandate certifications. It's clear, from feedback that we have received, that the process automation world is requiring that their suppliers use certified products.•

The OPC Certified Products Catalog

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JOERG WENDE, Hybrid Integration and Industrie 4.0 Consultant at IBM, joerg.wende@de.ibm.com

IBM APP CONNECT
FOR MANUFACTURING

IN THIS SECTION: Learn from an interview with Mithun Katti and Joerg Wende of IBM about OT/IT Integration, specifically, App Connect for Manufacturing. They will talk about IBM Industry 4.0 solutions, their Plant Service Bus, and the role OPC-UA plays in the IBM reference architecture for manufacturing.

MICHAEL CLARK: Mithun, please introduce yourself to our readers.

MITHUN KATTI: I am Mithun Katti from IBM Cloud Integration in Hursley, UK. I have been with IBM for 13 years since joining them straight out of an engineering degree. I'm now a product manager in the application integration portfolio with a primary focus on expanding connectivity options. I specialize in connectivity needs for the manufacturing and healthcare industry, along with emerging cloud and SaaS ecosystems. Before addressing industry-specific focused offerings, my major work was around building the low code/no code kind of tooling for business associates and integrators.

CLARK: Joerg, similarly, please introduce yourself to our readers.

JÖRG WENDE: My name is Joerg Wende and I've been working for IBM, Germany for nearly 30 years. Like Mithun, I joined IBM directly after my University studies. I have been working on the IBM integration portfolio for 25 years. I have also been working with the Industry 4.0 initiative since its inception, representing IBM at various external

organizations, including leading the Bitkom working group for Interoperability, Platform Industrie 4.0, and the OPC Foundation.

CLARK: What is IBM's perspective on Industry 4.0 and how are they helping customers stay ahead in their Industry 4.0 journey?

KATTI: With increased customer expectations, we see the need for manufacturing to be more flexible while adding complexity. This requires more transparency and control of the production processes in order to produce at the same cost with a similar or higher quality product. To fulfill this vision of self-optimized processes, leading manufacturing processes, combined with the current Industry 4.0 technology, can help overcome the technology gaps.

When we refer to OT, we are referring to operation technologies or the operations side of things, and IT refers to the information technology systems, like ERP, data analytics, and so on.

OT/IT integration is a key enabler for systems integrators and Industry 4.0 Intelligent Workforce. IBM has been playing a key, pioneering role in establishing the architecture and implementation platforms for OT/IT integration.
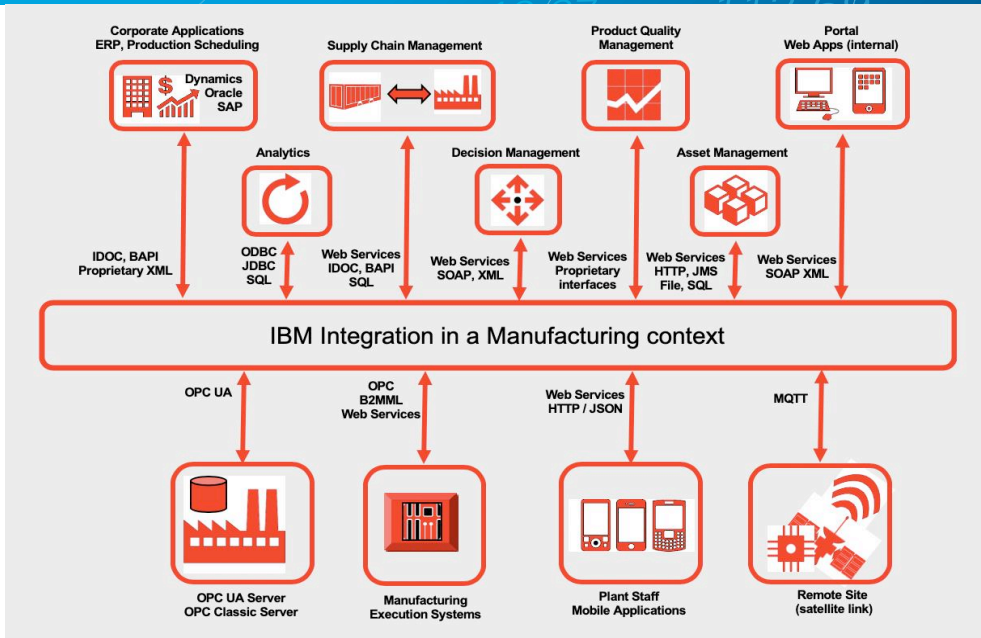
IBM Integration in a Manufacturing Context

CLARK: Where does the demand for OT/IT integration come from? And what are the challenges to achieve OT/IT integration?

KATTI: If you compare it to a common analogy, OT/IT integration is like a heart pumping data between various machines, applications, and human operators within an industrial plant or factory. Many of us have faced challenges converging two traditionally disconnected things, which work at various speeds, on various innovation cycles, with various security mechanisms. To make matters worse, we now are adapting to what we call "the new normal" with social distancing rules, performing remote work; all of which is very challenging for industries to keep their operations up and running with increased demand, or even fluctuating demand, while operating with a reduced workforce. That is where the OT/ IT integration plays a key role.

OT/IT integration is one of the first steps in achieving a full Industry 4.0 implementation. There have been several approaches to implementing OT/IT integration. In the past, this was based on the automation pyramid, where it was primarily focused on MES systems, mostly database-centric. We have observed that this approach had some limitations or restrictions regarding real-time scalability and flexibility, especially with rich machine data.

With Industry 4.0, there are several hyper-scalers brought in the concept of a pure cloud-centric approach by using IoT devices to push the collected data to the cloud, and then, generate insights from the cloud data and carry on further. Nevertheless, when data needs to be moved from the plant to the cloud, there needs to be data preparation, specifically cleansing, filtering, and enriching the data. Unfortunately, a majority of the data becomes obsolete after just a few seconds, so this approach of hyper-scaling, and moving everything to the cloud, is not entirely efficient. It is also costly and usually requires inter-factory communication.

The IBM Industry 4.0 Business Unit and its architects have come up with a unique concept of a service bus. We infer that a service bus architecture is a preferred way of combining the local, unified integration with secure cloud and centralized communications; reducing the number of connections to the machines as well as connections outside of the production zone. This concept of a plant service bus is the approach IBM has been taking to enable multiple factories across the world, modernizing their whole automation infrastructure, and adapting to the "new normal".

CLARK: Joerg, perhaps you can share more details about this plant service bus concept?

WENDE: Let's go back to the Industry 4.0 reference architecture, which we provide with our manufacturing reference architecture. This architecture has three layers: the edge layer, represented by the devices, including PLCs; the plant layer, which includes MES systems; and the enterprise layer, where we have the ERP systems or the logistic systems. The plant service bus addresses the integration challenges between OT and IT on the plant level with a number of driving factors.

First, we deal with the end-to-end complexity that is typically seen on the shop floor. We have a service bus layer between the sending components and receiving components where we reduce the number of interfaces that are required.

Secondly, we provide non-intrusive integration between machines and IT systems, so we don't have to install additional components. This increases flexibility and also standardization. It gives customers the opportunity to have centralized control and management of all their components. Here, we also address data privacy concerns for cloud connections, since they can be managed from the service bus layer. We have also stabilized operational costs, independent of the number of interfaces that you are running on the service bus. Furthermore, we can extend the service bus with a rules-based configuration so it can be managed by non-IT staff. And, lastly, we can dramatically reduce the turnaround time for change-management.

PSB Architecture Overview
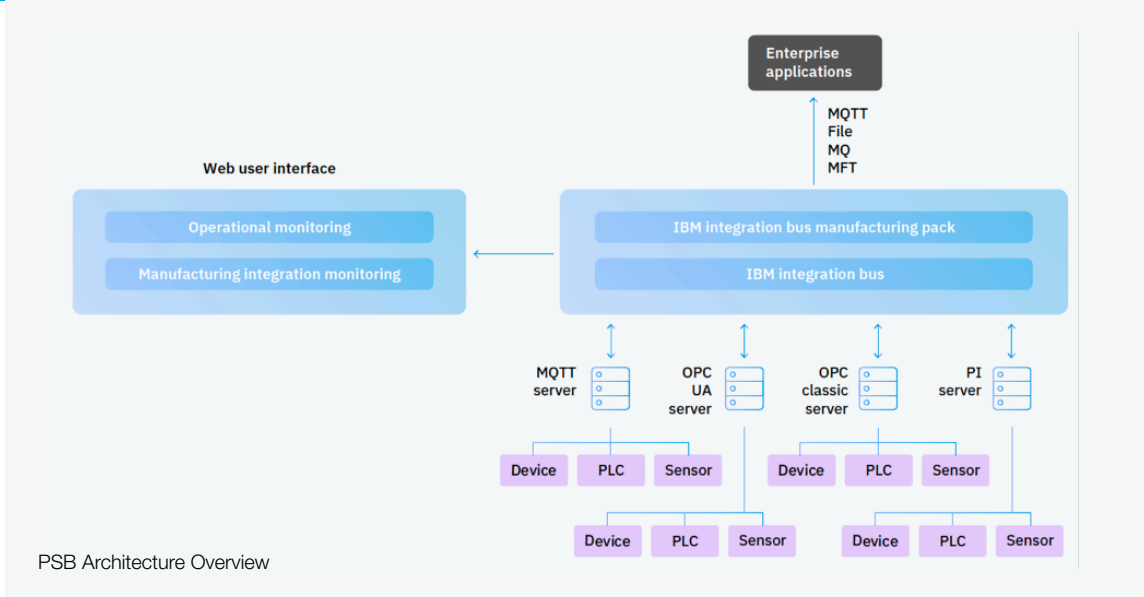
CLARK: What role does OPC UA play for the IBM reference architecture for manufacturing?

WENDE: We see OPC UA as a state-of-the-art interface for manufacturing. Nearly every modern automation control system will have OPC interfaces. Leveraging the work done on the development of these companion specifications, we have very good implementation of semantical interfaces. The service bus that is implemented by IBM – called App Connect for Manufacturing – will provide first-class integration to existing OPC UA infrastructures.

CLARK: Mithun, can you tell us more about IBM App Connect for Manufacturing?

KATTI: As Joerg mentioned, App Connect for Manufacturing is IBM's integration platform, which helps in connecting, transforming, and routing data from the OT side of things to the IT side. App Connect for Manufacturing includes built-in adapters of nodes to connect to various systems, including connectivity to OPC UA servers. To accommodate this, there is an OPC UA client which communicates with OPC UA servers, which then relays the information from devices, like PLCs, sensors, and robots. Once the data is in App Connect for Manufacturing, we can format or transform the data as necessary and

then send it to any other IT systems before we use the cloud for real time analysis, or software productive analysis, or any other ERP systems for demand-management.

Typically, we see our customers using OPC UA specifications for three kinds of use cases:

1. The first is an augmented product, where technical capabilities of a product are related directly to the marketing team for product promotion. Here is where MES systems are using OPC UA servers to transmit the data to the cloud.
2. The second is an augmented equipment use case, where we collect data from PLCs and publish it in real-time to a dashboard, which can then perform data analytics, correlation analysis, root cause analysis, and predictive maintenance.
3. The last use case, where folks are using OPC UA connectivity, is the augmented operator; to improve agility in production. For example, if the operator wants to do a short production run, App Connect for Manufacturing, with the ability to connect to OPC UA servers, is a key bridge between connecting the two sides of things by helping our customers achieve improved day-to-day operations.
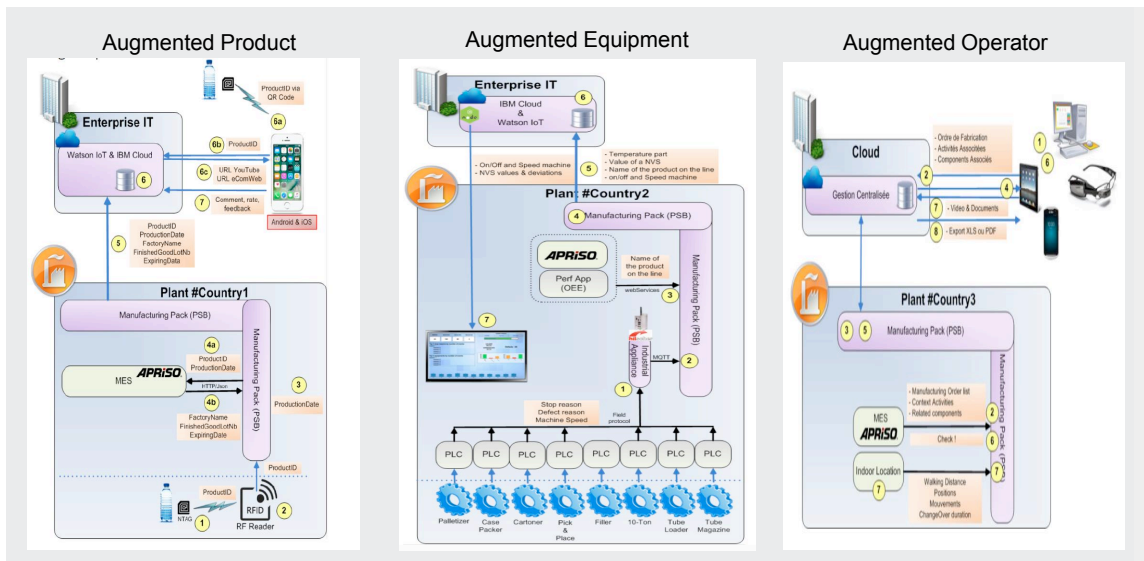
Typical Integration Use cases in a Manufacturing Plant

CLARK: What value does OPC UA and the OPC Foundation provide to IBM?

WENDE: I know I'm repeating myself a bit, but we see OPC UA as the de facto standard for many automation companies offering controller implementations, so, for that reason, it is very important to us. And, since the OPC Foundation maintains this standard, they too, are very important to us.

In recent years, the OPC Foundation has moved to an open approach, inviting community development in order that the standards represent a broad range of interest across different companies and different communities. That is very important to us, as we stand for open standards and open approaches.

CLARK: What are the most important parts of the OPC UA spec from an IBM perspective?

WENDE: I see three main important parts for me. The first, being a clear separation between the communication protocols, the data formats, and the semantics. This means that the communication exchanges, between differing protocols, possess the same data format and semantics, based on the companion specifications. This gives us great value, from an implementation perspective, especially if we go to the higher levels of data analytics.

The second thing is the standardization with regard to the OPC Companion Specifications. They represent excellent knowledge from a wide range of industrial sectors, which gives us a very good abstraction layer on which to implement something on top.

Lastly, from a communication perspective, we see the extending of OPC-based protocols to support messaging and Pub/Sub, which is outlined in Part 14 of the Standard. This permits scaling beyond traditional peer-to-peer and client-server communication.

CLARK: In closing, are there some final thoughts you'd like to share with our readers?

KATTI: Anyone who is interested in learning more about IBM, Industry 4.0, or App Connect for Manufacturing can go to ibm.biz/industry40 where they will find most of what we referred to in this interview. The reference architecture and the next steps are clearly documented there.

I want to thank the OPC Foundation for the support they have extended over many years. We are currently in the process of certifying App Connect for Manufacturing and the certification process itself has been very tidy and helpful.

WENDE: I would like to draw attention to the OPC Foundation Joint Working Group for cloud-based repositories; I see this as a very useful extension. Applications that are using OPC Companion Specifications and Data Models can reach out to the repositories and retrieve the metadata about implementations on different parts of the infrastructure.

In addition, I see development in areas like industry edge, and the clustered infrastructure based on containers, as a very important part to consider for future development. We are currently implementing our Service Bus patent as part of our OpenShift journey, so we can scale that with the infrastructure based on the needs of customers. •

ABOUT THE INTERVIEW PARTNER – JOERG WENDE:

After completing his university studies in Advanced Electromagnetics in 1990, Joerg Wende joined IBM in the same year. Joerg held positions as technical consultant for midrange systems before joining the IBM Software Group in 2001. He currently supports national and international customers in the field of messaging and application integration. He represents IBM within Platform Industrie 4.0 working groups, standard bodies and industry groups (BITKOM). Additionally, Joerg contributed to the OPC Foundation working group for Part 14 (pub/sub).

ABOUT THE INTERVIEW PARTNER – MITHUN KATTI:

Mithun Katti is an Offering Manager in IBM Application Integration. He has around 13 years of experience in integration domain. Mithun has Offering Management responsibility for IBM App Connect for Healthcare and Manufacturing, and focuses on connectivity needs to emerging SaaS ecosystems and industry-specific connectivity. By teaming with SMEs from across IBM, he defines and manages the delivery of key product capabilities to enable our customers to address and overcome their integration challenges.

LINKS

ibm.biz/industry40:
https://www.ibm.com/cloud/architecture/architectures/iot_industrie_40/

OPC UA-based Industrial Interoperability

## INTEROPERABILITY ROBUSTNESS & SECURITY

→ Vendor, Platform, Market and OS agnostic
→ Specifications open available / Open Source on GitHub
→ Certification: OPC Labs open to everyone
→ Scalable From Sensor to Cloud (and back)
→ Discoverable Services Oriented Architecture
→ Independent of transport protocol (TCP, UDP, MQTT, …)
→ Extendable for TSN, SPE, APL, 5G, Wifi6
→ Widely adopted: > 50 M installed base
→ Security Designed from the Ground up:
   • Security on 3 layers: User / Application / Transport
   • Security includes: Authentication/Signing/Encryption
→ OPC Foundation: Non-Profit with modern IPR policy also protecting implementers and users

65+ JOINT WORKING GROUPS DATA MODELLING / HARMONIZATION

65+

→ **Graph Support,** preserves source context
→ Vendor **extendable** data model via Companion Specifications
→ **Relevant:** Enables domain specific information models
   • **Discrete:** Robotics, Machine Vision, …
   • **Process:** O-PAS, MDIS, NOA, FDI, FDT, PA-DIM...
   • **Energy:** IEC61850, …
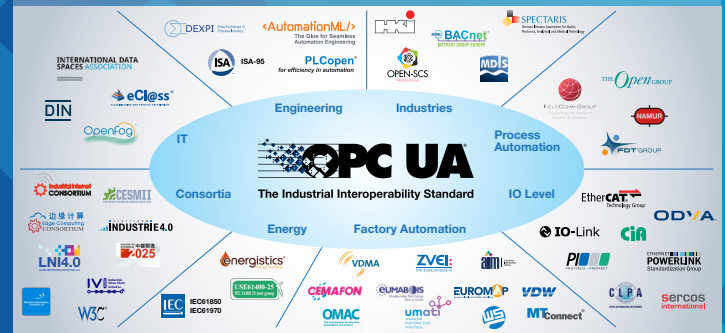
VALIDATION / CERTIFICATION

Validation of OPC UA and Companion Specs Compliance Test Tool (CTT):
→ Openly available
→ 1800 test scripts for the OPC UA core functionality and for the Companion Specifications – available now PA-DIM / PLCopen / MDIS

CS Template   Validator   OPC UA CTT

Base for writing CS

NodeSet-File

Electronic description of Model

Check if NodeSet and Spec are in sync

ONLINE REFERENCE

→ Public reference with all specifications and all models **www.reference.opcfoundation.org**

→ Online searchable to simplify reuse of modeling concepts

Online Reference

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