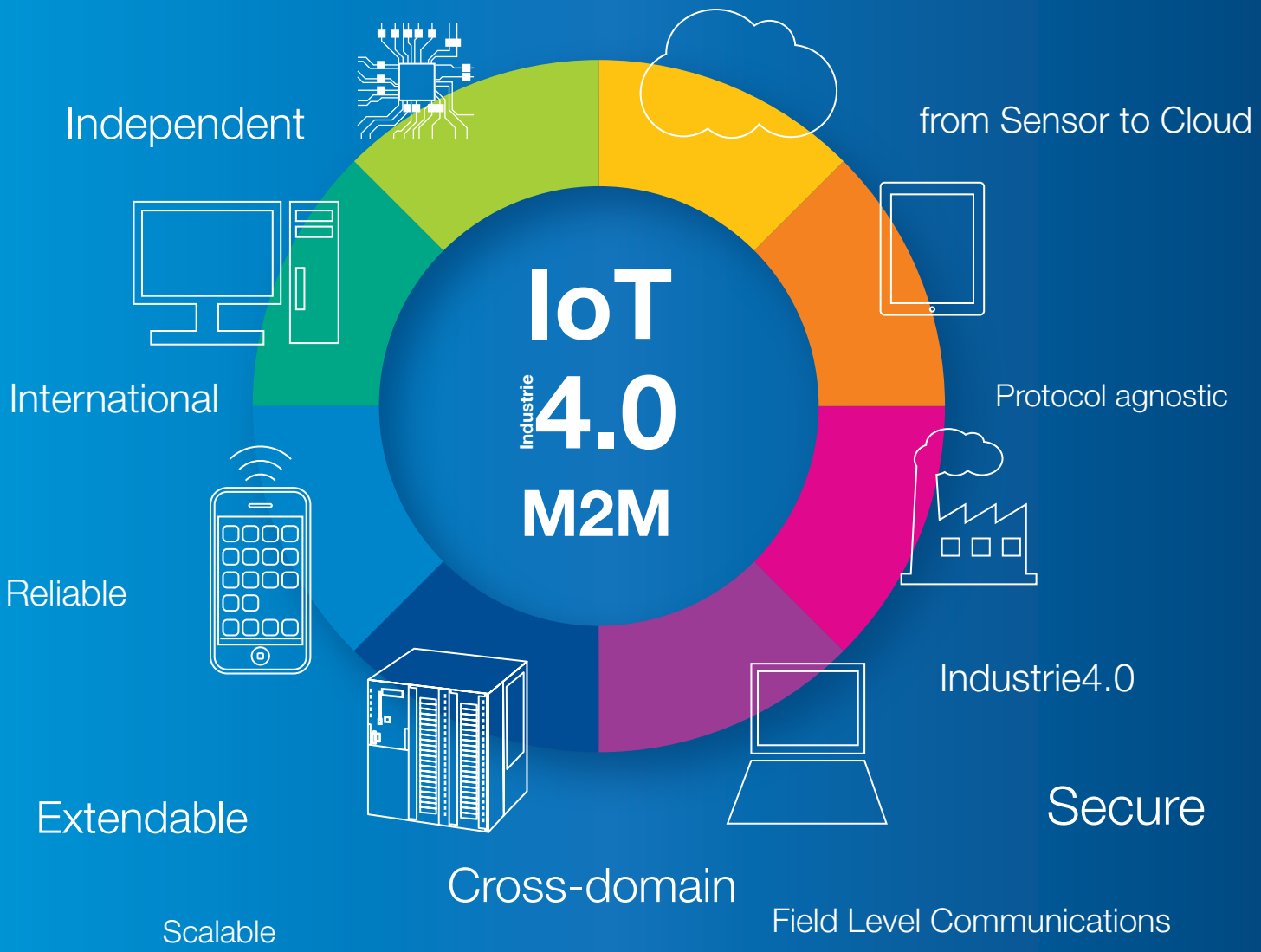
The Industrial Interoperability Standard

OPC UA Users and Experts – Conveying Knowledge and Experience

Fourth Edition
November 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.



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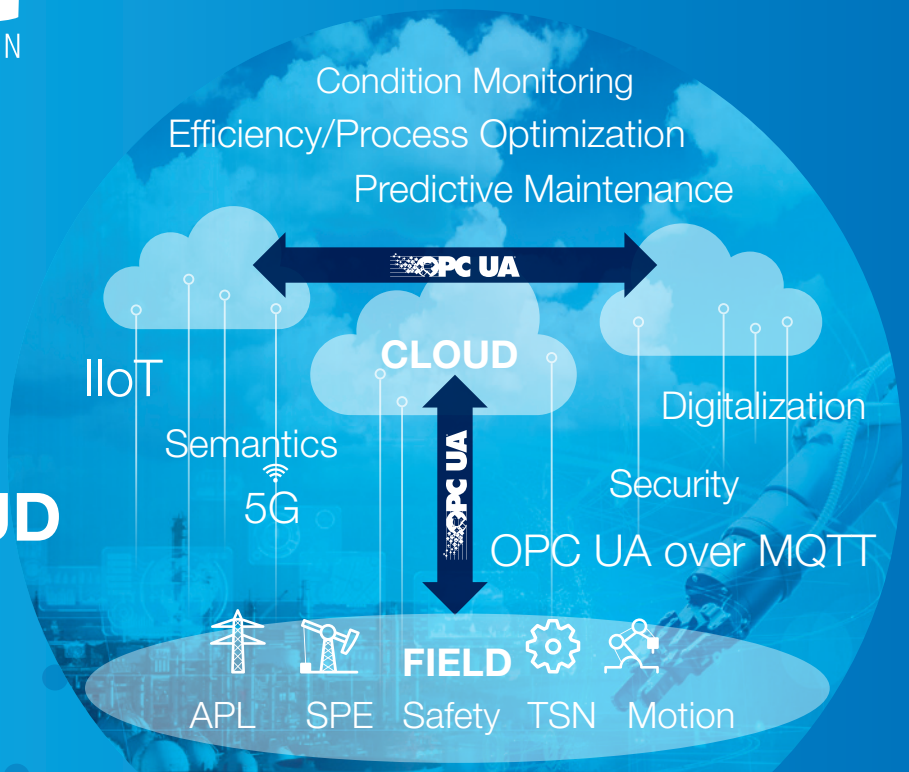

OPC UA

OPC UA
FOR CLOUD

ONE HARMONIZED SOLUTION
FOR PROCESS & FACTORY
SCALING FROM FIELD TO CLOUD

OPC UA
FOR FIELD

Factory Automation

Process Automation

First live demo on the
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OPC Foundation
Public Press Conference

→ Nov 23rd, 2021 – 16:45h – 17:45h CET
→ Onside: SPS show, Nuremberg,
NCC Ost, Room Istanbul
→ Remote access available

Register here to attend remotely
https://opcfoundation.org/event-detail/sps-2021/

„Please join our press conference!“
Stefan Hoppe, President and Executive Director OPC Foundation

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THE STATUS AND FUTURE OF OPC UA IN CHINA

ALBERT ZHANG,
General Manager of the OPC Foundation China
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IN THIS SECTION: Albert Zhang provides an update on the current status of the OPC Foundation's activities in various regions around China, highlights the adoption of the OPC UA specification as a Chinese national standard, and shares the status and preparations for the "Made in China 2025" activities.

OPC UA status and influence in China

Before 2015, not many people or companies in China knew about OPC UA. When people think of OPC, most of them still understand it as the Classic OPC DA. Since 2016, with the popularization of Industrie 4.0 concept of Industrial IoT, the promotions and activities of the OPC Foundation, and most importantly, the acceptance of OPC UA as a Chinese National Standard, the popularity and attention on OPC UA has increased by leaps and bounds. Thus, many companies, research institutions, and industry associations in China are becoming increasingly interested in OPC UA as the interoperability standard that will enable all industrial communications from sensors to the cloud.

Starting in 2020, as more and more factories upgraded and the impacts of COVID-19 were evident, the end users began requiring suppliers to not only provide equipment with OPC UA interfaces and solutions, including OPC UA, but also to ensure the OPC UA products are certified by the OPC Foundation. This led more and more Chinese companies to start developing OPC UA interfaces to support their software and hardware, such as Machine Tools, Robots, and MES.

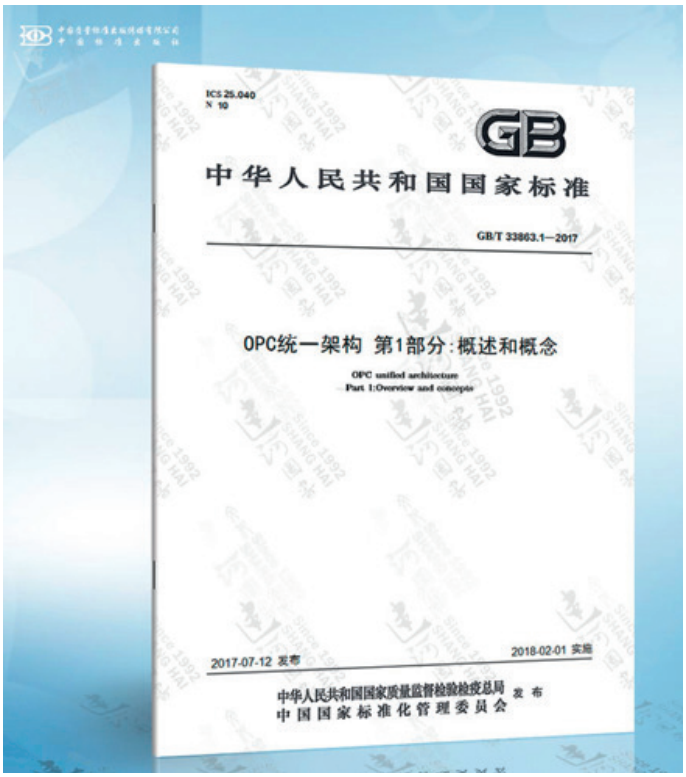
At present, OPC UA is increasingly deployed in many advanced factories and demo projects, such as "The World Factory" by Foxconn, production lines of Geely (Automobile Manufacturing) and CSSC (Shipbuilding), "Intelligent Building project"by Wanda (Property Developer) , Alibaba Cainiao (Logistics) etc. Many excellent cases have also emerged in the fields of Food & Beverage processing and Machining processing. By using OPC UA, they have realized small batch and diversified flexible manufacturing. The application of OPC UA information models, enables them to quickly adapt to changes in market demand under the premise of time and cost savings in engineering and operations. There are also subway projects, such as the recently completed Kunming Line 4, and the upcoming Zhuzhou Metro and the Shaoxing Line 1, all of which use OPC UA. Through the integration of their own OPC UA interface along with off-the-shelf 3rd party OPC UA products, the Beijing Urban Construction Group (BUCG) has realized the management, control, monitoring, operation, and maintenance of communication and power systems, while reserving expansion space for upgrading the centralized cloud deployment in the future. Based on what we know today, OPC UA will be used in at least 13 subway projects in the future.

OPC UA and Chinese National Standard

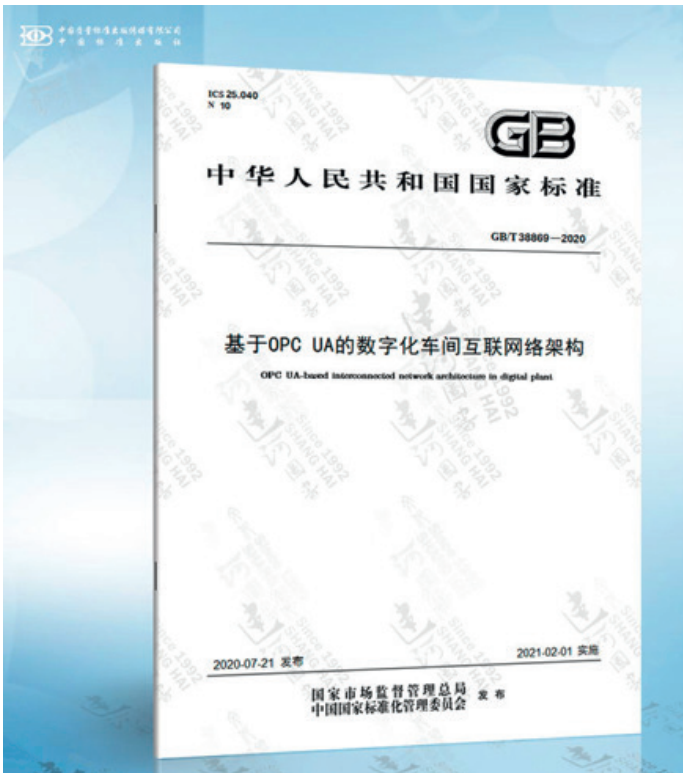
In 2016, OPC UA officially became the Chinese national standard GB/T 33863 (OPC Unified Architecture). Since then, many national projects led by the Chinese government began to require the use of OPC UA. For example, ITEI's national demonstration project in Beijing Economic-Technological Development Area, the "Intelligent Manufacturing Comprehensive Test Platform", uses OPC UA to connect and interoperate controllers, equipment and software in three production lines from several different manufacturers, thus realizing the integration of factory management & control.

Intelligent Manufacturing Comprehensive Test Platform

In 2020, the Chinese national standard GB / T 38869 (OPC UA based interconnected network architecture in digital plant) was released.



GB/T 33863.1-2017



GB/T 38869-2020

This year (2021), two industry information model standards based on OPC UA have been released - GB/T 40209 (General Modelling Principle for Integration Based on Information Model about Manufacturing Equipment) and GB/T 39483 (Rubber and Plastics Injection Moulding Machine-Interface). GB/T 40209 is a basic standard and applicable to the modeling of manufacturing equipment integration information model by manufacturers, integrators and other users. The information models of equipment / units / systems like CNC machine tools, industrial robots, injection molding equipment, instruments and meters, logistics storage, production units or lines, and digital workshops can be modeled uniformly according to the rules specified in this standard. GB/T 39483 is highly consistent with OPC 40083. China's injection moulding machine industry led by Haitian Plastics Machinery developing Plastic & Rubber Machinery with OPC UA information model is starting to begin.

In addition, the new Chinese national standards related to OPC UA, such as Machine Tools, Robots, and Machine Vision are on-going. The OPC UA information model is very important to many industries. We are looking forward to more and more Chinese national standards for the OPC UA information model in the future. Our job is to ensure they are consistent with OPC standards, such as address space, data dictionary, etc., so that devices from different countries can quickly work together and plug and play in the future.

OPC UA and China Industrial Internet / Made in China 2025

"Made in China 2025" was designed and approved by Premier Li Keqiang and officially proposed in 2015 the plan for the first decade of China's manufacturing power strategy. Later, it was gradually modified and refined and became „Internet +" and „Strong Foundation Project". Currently the goal is to realize China's Industrial Internet. Under the guidance of the Ministry of Industry and Information Technology (MIIT), two affiliated institutes - China Academy of Information and Communications Technology (CAICT) and China Academy of Industrial Internet (CAII+) – are responsible for implementation methods and related standards. The two institutes agreed that information modeling is the top priority of the Industrial Internet. The OPC UA information model will play a vital role in the implementation of China's Industrial Internet. Therefore, they have initiated cooperation with the OPC Foundation. Among them, the „3IM Partnership" program initiated by CAICT and AII (Alliance of Industrial Internet) has invited the OPC Foundation and its members to participate, and also include China Mobile, China Telecom, Aerospace Intelligence, Hollysys, Haier and many other major Chinese listed companies.

Whether we are talking about "Made in China 2025" or China Industrial Internet, their development will be closely related and based on the OPC UA information model. Therefore, the main task of OPC China is to help more Chinese companies realize the value of the OPC UA information model and participate in the OPC UA information model standard working group to jointly develop a neutral information model standard that meets not only the demands from China, but globally.

The strong emphasis on OPC UA from leading industrial companies in China

The rapid development of OPC UA is inseparable from the support of many companies and partners, and this is also true in China. The interoperability, modeling, and security of OPC UA have been recognized and supported by many advanced Chinese companies. For example, Huawei has deeply participated in the FLC initiative of the OPC Foundation and has contributed funds, knowledge and experts to the future integration of OPC UA over TSN and 5G. Another well-known Chinese technology company, Inovance, a comprehensive product and solution provider focusing on industrial automation and new energy, will fully support OPC UA in a large number of products covering more than a dozen industries. Both Huawei and Inovance are Class A Members of the OPC Foundation. In addition, many industry leaders also expressed a high level of interest and recognition for the development of OPC UA, such as China Mobile, one of the global top 500 companies, CATL, which has the world's largest power battery usage, and Delta, a well-known Taiwan company.

ABOUT THE INTERVIEW PARTNER – ALBERT ZHANG:

Albert worked in the Chinese government for 6 years and was responsible for the design and establishment of industrial parks. In 2015 to become the general manager of OPC Foundation China. Industrial Development Consultant of CODESYS China, and Technical Consultant of WellSell Group, ZGC Advanced Manufacturing Industry Alliance & China Industrial Interconnection Standard Technology Alliance Deputy Secretary.

ABOUT THE OPC CHINA TEAM

The OPC China team consists of part-time volunteers who make up the OPC China Steering Committee (CSC), which provides guidance and support to the full-time workers, Albert Zhang and Holly Lou, who are responsible for marketing, promotions, operations, and membership services in China. In the 20 years since the establishment of OPC China, the team has helped more and more companies understand the value and embrace the use OPC UA in China. Thanks to the attention and support of the OPC Foundation and OPC President Stefan Hoppe, as well as the CSC which is composed of experts from Siemens, NI, and other well-known companies, Chinese companies, the Chinese government, and end users are embracing OPC UA and we look forward to many OPC success stories coming out of China.

OPC EXPERTS INTERVIEWS: EQUINOR OPC UA USE CASE

STEFFAN SØRENES,
Leading Advisor Plant IT Architecture & Integration
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IN THIS SECTION: This interview is with Steffan Sørenes of Equinor. He is the leading advisor for Plant IT Architecture and Integration. He will share Equinor's OPC UA use case, explain how they implemented and scaled-up OPC UA, the benefits Equinor is achieving, the open-source information model library they've shared with the world, and Equinor's roadmap going forward.

CLARK: Thank you, Steffan, for sharing your time and expertise with our readers. Please introduce yourself and describe your role at Equinor.

SØRENES: Today, we are called Equinor but in the past our name was Statoil. We are a 50-year-old Norwegian company, originally focused on oil and gas, but these days, we are transforming into becoming a broader energy company. We are moving into offshore wind, operating several wind-power plants and we are also expanding into carbon capture and storage, hydrogen, value chains, solar, et cetera.

We are not only doing business in Norway anymore; we are doing business in over 30 countries, with around 21,000 employees.

I have been with the company for 10 years now and my current role is as a leading advisor on Industrial IT. So, I spend most of my time in the avenues built between Operations Technology and Information Technology integration, where the plant-floor meets the IT world. I have been working on these types of interfaces directly and indirectly over these ten years, through various roles and projects, and this is where OPC comes into the picture. OPC is something that we have actually been using for decades and now we are scaling up more and more with OPC UA.

CLARK: So where does OPC UA come into the picture, and why?

SØRENES: We see that OPC UA is very applicable – almost all over the place – ranging from field sensors to the cloud; but, from my perspective, OPC UA is a key enabler and a key framework to connect and better integrate data coming from the industrial automation and control system. We utilize this within the enterprise systems, business processes, and various applications and analytics from the domain of the IT platform.

When I tell people about this, I normally use an analogy related to the headlights that we have in all our cars: our cars have headlights with two modes to help us light the road in front of us when it's dark outside. These modes are low-beam and high-beam.

The low-beam mode provides enough light, so to speak, to help us see only what's right in front of us, while high-beam mode helps us see even further down the road – you can be more forward looking.

This is a good explanation of the OT and IT architecture because the industrial automation and control systems more closely emulate the low-beam mode – the real-time domain. Personnel who use these systems need to control and operate the facility in a safe and efficient manner; they need to make important and critical decisions, here and now; they can't sit and spend time in training or using machine learning models to predict what might happen four months from now.

The control-room operators cannot have that focus. Instead, subject matter experts who reside in the back office or at our onshore operations centers, they are the ones that can help our facilities with this. They are the high-beam mode. They use the data from the facility and really, really help operations become more forward looking by using the collected data.

So, OPC UA, from my perspective, is a framework that basically connects this low-beam and high-beam world in a better way. This ensures that the engineers and subject matter experts, in the back office or at our onshore operations center, not only get access to data but that they are also given access to the context – the description of the data – so they cannot only read data but also understand the data and to act upon it. This is where OPC UA really comes into the picture.

CLARK: You've been using OPC UA for some years now in major oil and gas fields. Where and when did this journey start?
SØRENES: Yes, as I mentioned, when it comes to OPC, we have been a member of the OPC Foundation for 11 years now. We have been using OPC UA for over 10 years, although we have used OPC Classic for decades.
Prior to 2014, our approach to OPC UA was that we "preferred" OPC UA. So, in our company requirements, we said that we preferred suppliers to deliver data via OPC UA; but we also said that it's completely fine to deliver data some other way.
We began a new oil and gas project around 2013 called Johan Sverdrup, one of the largest oil and gas field developments in Norway, which started production in 2019.
At the commencement of this project, we decided that, OK, now it's time to really get serious with OPC UA and start to really understand OPC; to understand the potential that is there and to see what we can do to properly use it.
So, on this project, we went from saying that "OPC UA is preferred" to saying that "OPC UA is what we shall use" … period!
This was quite a big project back then, now a big operating facility, today. It's a field consisting of a drilling platform, a riser platform, and one process platform. We are building yet another process platform and living quarters. The whole field is getting its power from a station onshore and, at its peak production, this field alone will produce 30% of Norway's total production. This was the project where the OPC UA journey within Equinor really took off.
So, on this project, we asked that we only acquire from suppliers who could deliver software that would deliver real-time data over OPC UA. We also utilized the information modeling features and capabilities within OPC UA to model and describe the facilities, the equipment, and operational data so that the IT world – the high-beam world – would not only get access to raw data, but that they could have access to the context of the data in order to understand and use it.
So, today, we make around 200,000 OPC UA variables available to the IT platform in near-real-time.
[Editor's Note: The number of OPC UA variables collected from the Johan Sverdrup facility has increased to over 1 million since the time of this original interview]

CLARK: So, with the help of these 200,000 variables, in a structured way, in an OPC UA information model, you kind of make a digital twin of your plant such that, at whatever level I'm viewing within the OPC UA tree structure, I can get an understanding of what exactly that variable is and its meaning?
SØRENES: Yes, it's basically a model of the facility where you can start by viewing the top node in the OPC UA address space but then you can drill down to a single piece of equipment, expand that equipment, and easily subscribe to live data – operational data – originating from the plant floor. This is something you can do now in the IT world by using OPC UA. We are not providing only raw sensor data without any context, but we have provided the sensor data in context so that the operational people can understand and use it by utilizing the capabilities of modeling within OPC UA.

ABOUT THE INTERVIEW PARTNER – STEFFAN SØRENES:

Steffan is passionate about making industrial plant data from the physical world available and transform it into usable information through data capture, contextualization and distribution with the purpose to support analytics, business processes and decision-makers with long-term plant optimization.
Steffan holds a Bachelor's Degree in Computer Science and a Master's in Risk Management, specializing in offshore safety. He has been providing Equinor with IT analysis and architecture and integration advice for over ten years.

CLARK: What can other companies learn from you when it comes to implementing and scaling up the usage of OPC UA?

SØRENES: What I think other companies can learn from us is that, first of all, the decision to utilize OPC UA on this project was actually not a big companywide, top-down strategy; this was driven, I would say, from the bottom up – driven by personal engagement champions and advanced learners. My experience is that you often need such champions to lead the way before it becomes operational throughout the entire company.

One of the first learnings we did was to get expert help because, back in 2014, the fact was that we didn't know anything about OPC UA. It was very new to us, so we quickly saw that we needed to get help and we needed to educate ourselves – we needed to invest in learning. We partnered up with some of the most knowledgeable and experienced people and companies in Norway on OPC UA. We worked together with them, spending one year studying and diving deep, deep, deep into OPC UA in order to understand it. We saw the overall concepts but especially learned how the information modeling concept can actually solve some significant challenges we had when it came to lack of context and a lack of interoperability between systems, and so forth.

Another lesson we discovered was that we cannot do this alone. So, back in 2014, yes, this was new to Equinor but it was also new to all the suppliers and we are 100% dependent on the suppliers and the markets to understand this technology as well as deliver good products that we can utilize. So, that is a main lesson that one company cannot do this alone; we need to work on this together, we need to help each other, we need to collaborate.

Yet another lesson that I learned, and you may have heard this phrase, that when it comes to digitalization, "Think big; Start small; Scale fast." But in this Johan Sverdrup project, we were actually thinking big but we also started big… and scaled fast.

We started big in terms of actually implementing OPC UA in one of the biggest oil and gas field developments of all time in Norway. We made a bet on OPC UA – on a flagship project – not only in the Norwegian industry, but the entire global oil and gas industry. We made this bet on OPC UA and it paid off!

We proved that OPC UA works on such a major project. Today, it's operational – we are using OPC right here and now. When we operate this field, and when we do so on such a big project, we remove any doubts within Equinor, and across the industry, as to whether OPC will work or not.

When you succeed with OPC UA in such a flagship project, that quickly becomes the blueprint for the next projects and this inspires people. So, what started out with one to three champions and advanced learners leading the way, quickly became 30 champions and advanced learners leading the way.

CLARK: Along the way, did you meet any bumps in the road? What surprised you the most?

SØRENES: Yeah, we met bumps on the road – there will always be some bumps on the road.

When we started to talk about OPC UA, what I heard from a lot of people around us, especially since OPC UA was not new at that time – I think the first version of OPC UA specification was released in 2006 or something like that – what I heard people say is, "Oh, OPC UA, we have heard about it for many years but we have not seen anything yet."

I felt that it was a kind of a chicken and egg situation. Since Equinor is an end user, when we talked to suppliers out there, we felt that we should kind of wait on the market and all the suppliers and companies will come up with OPC UA products on their own; but when we talked to some suppliers, they, instead, were waiting for a push from us as an operator, as an end user. So, we kind of inadvertently waited on each other.

The take away for me is that sometimes we, as an operator and an end user, need to set the direction and take the lead by saying, "now, we're doing this!" and then things start to happen.

Another bump along the way is that, when you do projects like this, the whole project development and construction has an investment cost; then when you put the facility into operation, it becomes an operational cost. But, when we are going to do something new, such as using OPC UA, but not all suppliers support it at that time, then they have to develop OPC UA. We, and our suppliers, need to do some investment, which means that the investment cost is increasing.

If you only look at things from the investment cost perspective, it means higher cost, which is not good; but the perspective we need to observe is the total cost of ownership. Since we did so when implementing OPC UA, we believe that, in the long term, the cost will be reduced due to more flexibility, more interoperability, and system standardization.

The third challenge, I would say, is that OPC UA is very, very flexible, it's powerful, and it's comprehensive. You have many features and options that can be utilized. We experienced this when we said to suppliers that, "you shall deliver data over OPC UA." That's a very generic requirement and, as luck would have it, you can deliver data over OPC UA in many, many different ways using different functionality but, also, on the modeling side of things. So, each supplier can basically structure the address space and the information model in vastly different ways and, yet, still deliver on the requirement that, yes, they have used OPC UA.

We have learned that, as an industry, we need to agree on which models and which OPC UA features we need for which use cases; because it's not realistic that every company, in every OPC server, is required to support every part and every feature in OPC UA. That is not realistic.

CLARK: You suggested that, within your industry, you would need to agree on features and use cases and on specific models. That has been happening in many industrial sectors like, let's say robotics, as an example, and many types of machine equipment manufacturers. Has that kind of industry talk happened within your industry; perhaps taking the model, which you developed, as a kind of a de facto industry standard?

SØRENES: Now, when it comes to standardization of information models within OPC UA, I think that many positive things have happened over the last few years, especially when it comes to development and all the initiatives that are happening around the world. We are following closely what the VDMA is doing; we are following closely what NAMUR is doing with their NAMUR Open Architecture. Equinor is a member of NAMUR and we are also a member of the Open Process Automation Forum, which also relies heavily on OPC UA.

So, yes, many things are happening and it's a huge untapped potential; but I also know that it takes time to go from agreeing on a model and a specification before we see it in a product we can buy. Hopefully more and more products will come with these models, standardized, out of the box. That is what we hope and believe will happen.

CLARK: I'm sure it's going to happen and, you know, with your huge initiative, others are likely to join your effort. What are the benefits to Equinor, as an end user and operator, when using OPC UA?

SØRENES: To illustrate the benefits, I'll use an example from the Johan Sverdrup project.

When it comes to the model that we developed, we actually created the OPC UA modeling – the types – in a software tool from vendor A. Then we instantiated the models – created the instances – in a tool from vendor B. And, finally, we broached the model and read the data and subscribed to live data from OPC UA Clients from vendors C, D, and E. So, we used different products from different vendors to create this plug-and-play environment – no hassles, no integration, and no manual translation or conversion. This is the future that we are seeking; this plug-and-play flexibility is one of the biggest benefits that we see in the overall architecture… easier to plug-and-play a wider array of products, easier to replace.

We also become more competitive because, without standardized interfaces, we'll never be competitive if we're stuck with vendor lock-in. Instead, we need to compete on business value; that is a benefit for everybody in the industry, I think.

Another benefit that I'm starting to see today, but that I also expect to see improve in the future, is lower costs. The oil and gas industry is not so special because many of the machines and equipment we have on an oil and gas platform are similar to other industries using pumps, heat exchangers, valves, control systems, turbines, compressors, and so on. The good thing about that is that OPC UA is industry-independent by design; it is not locked to oil and gas or locked to manufacturing or anything like that. So that means that the same supplier can deliver the same OPC UA server, the same type of model, across industries, and I believe that we can lower the cost over the long term.

Overall, the main benefit for us is, of course, interoperability. That is the key word here; to get an architecture and a flow where similar types of data are described, defined, and represented in a standardized manner, independent of the system or system supplier. That means that we can achieve more plug-and-play and spend less human engineering time doing manual translations, mappings, transformations of the data, et cetera, et cetera.

CLARK: So, you mentioned the benefits of an open standard, an open architecture. I saw your presentation during the ARC Industry Forum in 2021 where you mentioned that you have an open source OPC UA information model library. Can you elaborate more on what that is and why you opened it up for the world?

SØRENES: What we offered as open-source software is the information model library that we built for the Johan Sverdrup project.

The library is actually an extension of the ISA S95 Companion Specification with OPC UA. So, it's basically a library of equipment that you typically find in an oil and gas facility, including the operational data model. The library is actually based on ten years of experience of making data available to our operations group, to plant integrity people, and so on. So, over the last ten years, we have built on our experience, knowing what types of data these people and teams need. And, as such, we have modeled this experience into the OPC UA library, which today, I think consists of around 50 different object types – types of equipment – and almost 1000 attributes.

This library is something we have made openly available for the entire world and, within Equinor, "Open" and "Collaborative" are two out of our four company values. We truly believe that having openness is the key to achieving adoption across the industry. In order to make a real impact, we need open standards, open ecosystems, open-source code, and we need to make it simple for people and companies to get started. Lower the investment risk, lower the investment cost; make it as simple as possible; and OPC UA is open, which is the key to ensuring, even driving, adoption.

Now, if OPC UA was a closed standard, we would be very skeptical of OPC UA. So, the fact that OPC UA is open, it is a key benefit and a key enabler for adoption. Within Equinor, we are committed to a very firm open-source strategy; we have a requirement that, when we develop software, that software shall be open-sourced. Some might argue that we shouldn't make our code open to the world. However, if people want to look at our strategy and our repositories, they can! All you have to do is go to opensource.equinor.com to view our commitment and our strategy – even look up the Equinor organization on github.com.

So why did we open source this OPC UA information model? Well, for me, OPC UA is not only a connectivity framework but I look at OPC UA or the OPC Foundation as a community consisting of people and companies that share, in my opinion, the same beliefs, the same passion for standardization, for plug-and-play, interoperability, exchange of information, all in a seamless manner. That is the kind of passion that people share together by using OPC UA. We, as an end user, receive benefits from this community; therefore, we would like to share something in return, which, I believe, is a win-win for everybody.

CLARK: You've put a lot of energy into this effort, clearly, with great results. What is your road map going forward with regards to using OPC UA at Equinor?

SØRENES: We are focusing on a standardized OPC information model. It's great to see all these companion specifications that companies and people are now working on across all industries. There's a huge untapped potential there; broader usage, scaling up of these models; that's an important part of the way forward.

Additionally, we are focusing on making sure that we get closer integration between the plant floor and the applications and services in the cloud, especially when it comes to OPC UA information models. For example, if you have an OPC UA server at the plant floor, it's quite easy to stream real-time time-series data, the telemetry data, to the cloud. But, in many cases, you also leave the model or the context behind. So, when we stream this live, time-series data, we also need to find a way to make the information model – the context – also available to the cloud, not just the simple time-series data.

To be fair, we acknowledge that OPC UA isn't the answer for everything; but there are other exchange formats that exist for different use cases. I sense that there is huge potential in closing the loop between engineering and operations by combining OPC UA and the Automation Markup Language (AML).

We are also following Platform Industrie 4.0 in Germany, quite closely, and have a dialogue with many people and companies there. So, to be clear, this is the Asset Administration Shell, which is maturing in Germany. We see huge potential and many benefits in this concept, which is based on OPC UA, AutomationML, and REST APIs in order to make the semantics available to different mechanisms.

CLARK: Thank you, Steffan, for a fantastic interview. Do you have any more key takeaways or final messages to share with our readers?

SØRENES: Yes. So, to summarize our experience and our learning, I would say that one of the most important things is to find a spark, a passion for interoperability, for standardization, for plug-and-play, for collaboration across companies, but also across industries. That is simply what OPC UA is all about; if you have that passion, and if you truly believe in it, then you will find a lot of joy in OPC UA.

The second takeaway is to invest in learning. So, let the champions and advanced learners within your company lead the way, ask for help, reach out to other companies and people to learn from them and share experiences. I would encourage readers to share your story and your experiences, both good and bad experiences when using OPC UA; because, if we share, then we can improve and do things even better while working together.

And the last thing that I believe we all need is to have stamina because, through adoption and through semantic interoperability, using standardized OPC UA models will take time. It's not a quick win; we need stamina; we need to approach this with a long-term perspective and a long-term mindset but also, at the same time, do things step by step. We can do things here and now; it's already providing value.

So, personally, I'm looking forward to continuing utilizing and getting business-value out of OPC UA.

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OPC EXPERTS INTERVIEWS: OPC UA FX SPECIFICATION EXTENSIONS

IN THIS SECTION: This interview is with Clark Case of Rockwell Automation and Georg Biehler from Siemens. In this article, they will share the current status and future roadmap of the OPC UA FX Specification, an initiative of the OPC UA Field Level Communications (FLC) initiative. They will cover the achievements, the creative process, parties involved, the background and features of the OPC UA FX Standard.

CLARK: Thanks for taking part in this interview, gentlemen. Let's start from the beginning. Can you both introduce yourselves to our readers and provide a little background as to how you're contributing to the initiative?

CASE: My name is Clark Case and I'm with Rockwell Automation. I've worked with Rockwell in various roles over the past 20 years or so and in recent years, have been focusing on various topics related to communication between devices and between devices and software.

So, when the opportunity came up to be involved in the OPC UA FX effort or, as it previously was known, the OPC UA FLC effort, I thought it was a very exciting opportunity and was happy to take part in it.

BIEHLER: My name is Georg Biehler and I've been with Siemens for about 35 years now. I've been participating in standardization in the area of industrial communication for about 20 years and, similar to Clark, when I heard about the OPC UA FLC initiative and the OPC UA FX specification, I was glad to be part of the team. It's a really interesting opportunity.

CLARK: We already mentioned that we are talking about the OPC UA FX specification, can one of you explain it in more detail and highlight the latest achievements you've made as an initiative?

CASE: I'll give an overview and then Georg can talk a little bit more about the specifics.

So, the first version of the OPC UA FX specification focuses on controller-to-controller communication for real-time control communications. As such, we're trying to enable a controller from Siemens and a controller from Rockwell and a controller from Phoenix Contact and a controller from B&R to all communicate with each other in real-time for the purposes of synchronizing operation, for doing command and control activities – the kinds of use cases that are commonly encountered when a manufacturing facility is trying to integrate machines from different machine builders or from other different providers. We're trying to make that challenge much more easily achievable than it has been in the past.

BIEHLER: So, to achieve this, we wrote the OPC UA FX Specification. FX stands for Field eXchange, which is the title of our specification series. FLC stands for Field Level Communications initiative, so it's the name for the working group, while FX is the name of our specification.

In our first release, the core context of our specification has concentrated on controller-to-controller communication. Part of the specification is concentrating on the information model of an automation component. This is used to harmonize the information models that we today, typically find in different companion specifications. So, if you have a controller where you are looking for information for assets or functions, the specification has this now in a specific place, with a navigation path to the harmonized information. It's exactly the same regardless if you have a Rockwell controller, an ABB controller, a B&R controller, a Siemens controller, or from some other automation company.

And secondly, also expanding on what Clark said, regarding controller-to-controller communication, "communication" means "data exchange". We have specified real-time data exchange, including TSN, or Time Sensitive Networking, and easy management of these connections between different automation components.

Last, but not least, we have specified offline descriptors, so we are able to engineer these machines in either offline or online modes in a very nice and easy way.

CASE: Let me expand on that, just a little bit. There's a couple of reasons why this work that Georg just described is very important. One aspect is the common way of discovering what one controller knows about the data it is capable of publishing as well as the data it expects to be able to consume. Without the OPC UA FX specification in place, that process is different for each and every vendor's controller, and it becomes a nightmare for the system integrator or for the end user to figure out exactly what data a given controller is expecting and what data it is able to provide.

The second critical aspect is the manner in which the data is actually exchanged. Instead of having a different vendor-specific protocol for each and every vendor's controller, it becomes the same protocol. Without the OPCA UA FX specification in place to enable different vendor's controllers to communicate with each other, it would be necessary to put in place a number of different gateways, bridges, or translation devices – all of which require time and money to purchase and configure and, furthermore, slowdown communications when such intermediate hardware or software is implemented. So, OPC UA FX is going to make a huge difference in the deployment of integrated machines between different vendors.

CLARK: How was the FX idea created and what is on the horizon for OPC UA FX?

CASE: Well before the standards effort got underway in January of 2019, there were a lot of discussions among representatives from all of the different major automation vendors; discussing the different vendors goals and how they would want to interact. That, of course, took some time but all the different vendors seemed to understand the value of this effort and that it would provide benefit to all the vendors and, ultimately, all of the different end users. Once that agreement was in place, and they had agreed that they wanted to work within the framework of the OPC Foundation in order to develop these specifications, we put into place an OPC UA Working Group and began our work.

We've organized our overall group into a number of different subteams focused on different, specific areas. We have a team focused on the overall architecture of the system. We have a team focused on information modeling. We have a team that is focused on the mechanisms for establishing, monitoring, and managing communications between devices. We also have a team focused on the specification around the offline engineering deliverables. And we have teams focused on specification for networking aspects, for safety, for profiling the features defined in the specification, and for prototyping and test specification.

BIEHLER: Actually, at the moment, and this is just a rough count, we have 320 members from 65 companies.

CASE: And it's quite an impressive roster of companies. Basically, all of the automation companies with perhaps one or two notable exceptions; but we also have representatives from Intel and Microsoft I believe, and some other companies that aren't directly involved in industrial automation but who are interested in perhaps providing enabling products or services for this space.

CLARK: Let's talk about the technologies behind OPC UA FX because there's a lot of OPC UA technologies used in the specification. How are they being utilized and how does everything work together?

CASE: There are a number of technologies underlying the OPC UA FX specifications. We are utilizing the functionality provided by OPC UA as much as possible. If there is a capability offered by OPC UA, we're going to utilize that capability, instead of inventing something new. So, we are using OPC UA Client/Server communication capability. We are using OPC UA pub-sub communication capability. We are utilizing OPC UA security model; however, there are some areas that OPC UA doesn't cover, so we're also having discussions around how we apply TSN technologies to the OPC UA FX specifications, which Georg mentioned a bit ago.

BIEHLER: We haven't yet mentioned offline descriptors, so allow me to speak to that topic. We're using the Open Process Container specification, but that's not OPC, even though it uses the same letters, it also uses AutomationML for the contents of the offline descriptor.

For TSN, we actually do not want to build our own TSN on the side, but we are enjoying contact with an IEC/IEEE 60802 working group, who is driving the TSN profile for industrial automation to ensure interoperability between several protocols utilizing TSN in an automation network.

Regarding Client/Server and Pub-Sub, we're using the base security servers, which are provided by OPC UA, so we are actually extending OPC UA and we are an integral part of the OPC UA base specification. We are not considered to be something on the side, doing our own stuff but instead, we are built on top of OPC UA and extending our standards.

CLARK: I think it's important to emphasize that the OPC UA FLC initiative isn't doing something on their own but is, instead, building on top of OPC UA and trying to help the industry in this way.
I think you've already mentioned harmonization but can you explain in more detail what harmonization means and how the information model and automation component are being harmonized.

BIEHLER: If you, today, look at some components of an OPC UA Server, what you have on hand is a Client/Server protocol where you can access information, which is structured in objects, which are put into a navigation tree so you can follow references. As you navigate through such a tree, the problem that we see today is that, as you look at the elements throughout the tree, you don't really know what they are intended for. To figure this out, you have to read some specification. Unfortunately, you can structure your components in whatever way you want.

OPC UA FX is fixing this by actually making a standard navigation tree. So, on top, you see something called FX Root and below that you have an automation component, which has several functional entities, which model the functional world of an automation component. It also has a tree of assets, which models the physical world, which also includes software licenses and so on.

By having such a standard navigation tree, you always know where to find your input data – that data to which a controller subscribes – or the output data is always found at the same location. So, you don't have to know a lot about your automation component; you can just use it because the information is always structured in the same way for anybody using that component. That is the harmonization of the information model.

CLARK: Let's clarify again how the architecture is designed. Can it be used for both factory and process automation?

CASE: Absolutely!

Our goal is to be able to address process automation, factory automation, as well as hybrid situations. As Georg mentioned, the OPC UA FX specification is addressing how automation components, in those systems, exchange data. It does not specify anything about how devices are internally programmed. This frees-up the machine builder, the device vendor, or the system integrator to implement automation logic for whatever they have in their automation component, in the best way that they can. If they conform to the standard for exchanging data with other automation components, they'll then be OPC UA FX conformant and they'll be able to exchange data with other automation components, independent of the specific application type.

CLARK: Perhaps our readers might benefit from an explanation of the terms, "functional entities" and "assets".

BIEHLER: A "functional entity" models the automation function of an automation component or a part of the automation function of an automation component. For example, if you have a temperature sensor, a functional entity could be providing the value from a temperature sensor. So, a functional entity, generally, receives input data from somewhere else and, as an internal function, produces output data, which can then be exchanged. Input data could be given by someone to a functional entity, whereas output data could be provided by a functional entity to someone else.

In addition, you have configuration data, where you could, for example, adjust your measurement value. Examples could include, speed, in miles per hour, in kilometers per hour, in rotations per second, or whatever.

The "asset" is actually the thing the automation component is built off. For example, when considering a modular IO device, we are speaking about its modules, its connectors to the outside world, its clamps, and all that stuff; but in addition, its licenses, certificates, firmware.

CLARK: Let's discuss connections and how they help to exchange data.

BIEHLER: The first methodology is OPC UA Pub-Sub. We build on top of publish-subscribe the notion of a connection. We can use that connection to transport data in a few ways. First of all, we can move data in only one direction; next, we could have an arrangement to get a heartbeat; and lastly, we can have bidirectional data flowing on a connection.

Pub-Sub can also be used across four different transports. The first transport is pure Layer-2 Ethernet based, the second is UDP, and then cloud protocols like MQTT and AMQP are supported.

Pub-Sub can also be used with different quality of service applications, which allows you to utilize deadline or latency, supported by time sensitive networking, or TSN.

CLARK: So, how are those connections established?

BIEHLER: There is the notion of an entity holding configuration data for connections, which is called the connection manager. The connection manager could be integrated into one of the automation components, but it could also be located on some external server like a shop floor manager, for example, connecting two machines or perhaps on a plant server or something like that. The connection manager gets in contact with the two automation components that are to be connected.

CLARK: Can you shortly summarize how data is being exchanged?

BIEHLER: Actually, data can be exchanged with a lot of different quality of services. One example is the isochronous mode, which means that the end stations, the network, and the applications are synchronized to each other. Then you have a very precise operation between two automation components.

CASE: And not every application is going to require the use of this technology.

So, we are working to make sure that we can support applications that both require the TSN technology and those that don't.

CLARK: I'm sure that creating the specification required a lot of prototyping and testing. Can you give us a little insight on that?

BIEHLER: Actually, we formed a prototyping group inside one of the working groups that Clark mentioned before. Companies who are interested in the prototyping work are joining together, bringing prototypes to exchange with each other, sharing progress and even fragments of code with the goal to have several independently built prototypes based on our specification.

By sharing outcomes with each other, we prove that the specification is correct – because writing a specification is a bit different than implementing it – so, by implementing prototypes, you may be able to detect flaws in the specification.

The outcome is to prove that our specification is implementable and that several different implementations are able to interact or be interoperable with each other.

CLARK: What are the next goals for the initiative and for the specification?

CASE: Well, currently we are wrapping up work on Release Candidate 1, which contains the basics for establishing connections between controllers and exchanging data.

Next up will be Release Candidate 2, which will add in TSN capabilities, security capabilities, and support for exchanging data with SIL 3 Safety. That will complete the scope for our controller-to-controller release.

Release Candidate 2 should form the basis for what will be released as version one. Once we have completed release 1, covering controller-to-controller communications, we will then turn our attention to controller-to-device communications, defining how controllers communicate with devices such as drives, temperature transmitters, pressure transmitters, IO devices – pretty much any field-level device.

That will be a very interesting activity because, then, we'll actually be able to deploy systems that are fully based on OPC UA FX communications.

ABOUT ABOUT THE INTERVIEW PARTNER – CLARK CASE:

Clark is the former chairperson of the Architecture (Core) Working Group of the FLC Technical Working Group. Clark is a Platform Leader for communications at Rockwell Automation, where he has worked for over 20 years. In his time at Rockwell, he has worked in roles ranging field engineer and software developer to requirements analyst and technology manager.

ABOUT ABOUT THE INTERVIEW PARTNER – GEORG BIEHLER:

Georg is the editor of the OPC UA FX specification. Georg is a Senior Key Expert for industrial communication at Siemens, where he has worked for almost 35 years. In his time at Siemens, he has worked as software developer, team leader and system architect. Since 25 years he is involved in standardization for industrial communication, amongst others he was editor of IEC 61158-5-10 (PROFINET IO services).

PETER LUTZ,
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OPC UA SUPPORTING FIELD EXCHANGE (FX) INCLUDING TSN AND APL – AN INTERMEDIATE GOAL HAS BEEN ACHIEVED!

Two years after the launch in November 2018, the Field Level Communications (FLC) Initiative of the OPC Foundation has completed the initial Release Candidate for OPC UA-based Field Exchange (UAFX) for the use case "controller-to-controller". This marked an important milestone in establishing OPC UA as a standardized industrial interoperability solution at the field level, taking advantage of key technologies, such as Ethernet Time-Sensitive Networking (TSN) and the Ethernet Advanced Physical Layer (APL).
The FLC Initiative has also published a 40-page technical paper in which the technical approach and the basic concepts for expanding OPC UA to the field level for the various requirements and use cases in factory and process automation are explained.

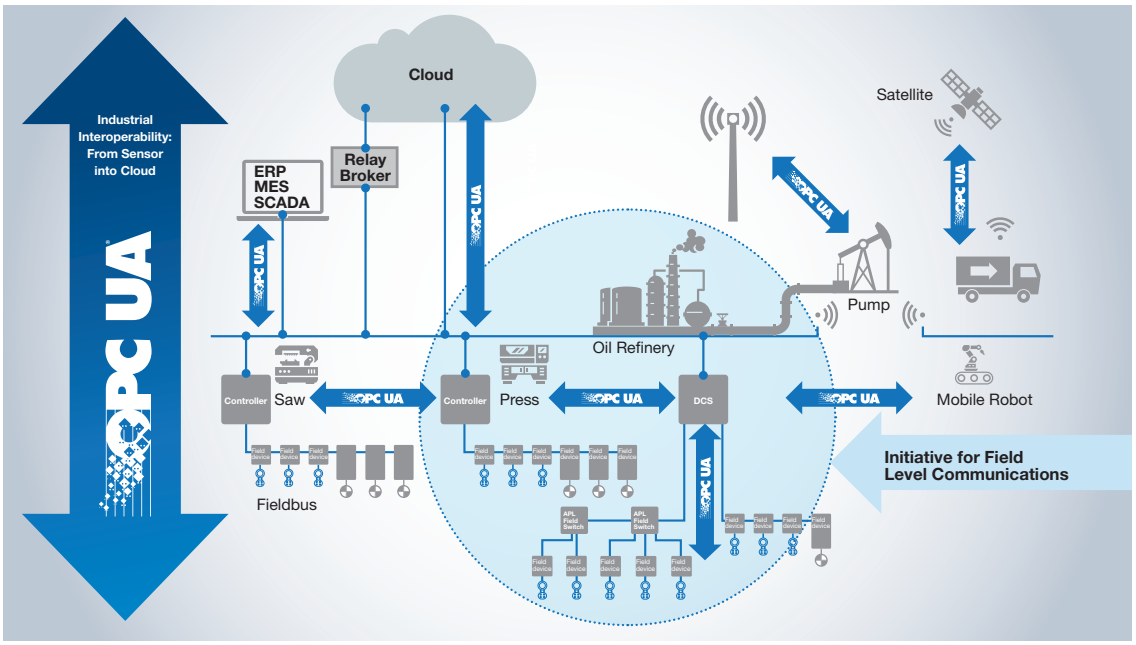
The member companies of the Steering Committee of the OPC Foundation's Field Level Communications (FLC) initiative

At SPS 2018, in Nuremberg, Germany the FLC initiative was founded under the umbrella of the OPC Foundation. A total of 27 companies, including the largest automation manufacturers in the world, have joined the initiative's Steering Committee, supporting it financially as well as with man-power and technical know-how (Fig. 1). The common goal is to expand the scope of OPC UA down to the field level and to establish OPC UA as a uniform and consistent communication standard in factory and process automation (Fig. 2). In the technical working groups, which are open to all members of the OPC Foundation, a total of over 300 experts from more than 60 companies are currently working to develop appropriate concepts and specifications.

Work on the first version of the specification has made good progress in the past year - despite Covid-19 and the associated restrictions. The basic concepts for the use case controller-to-controller (C2C) have largely been developed and have been incorporated into the first draft specifications. A first Release Candidate was completed in November of 2020. On this basis, prototypes have now been implemented in order to validate the draft specifications. At the same time, a Working Group is developing test specifications which are then converted into corresponding test cases for the OPC UA Compliance Test Tool (UACTT).

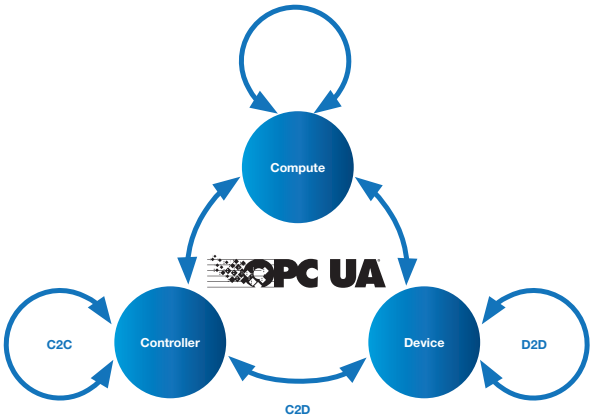
ABOUT THE INTERVIEW PARTNER – PETER LUTZ:

Peter Lutz is director field level communications of the OPC Foundation. He has more than 25 years of experience in open control systems, industrial automation, and real-time communications. He has been engaged in several national and international standardization committees, including IEC SC65C (digital communication), IEC SC22G (adjustable speed electric drive systems), and IEC/IEEE 60802 WG (TSN Profile for industrial automation). Since April 2019, he has been managing the OPC Foundation's FLC initiative with the goal of establishing OPC UA as a globally accepted standard for field level communications in the factory and process industries.



OPC UA as an integrated communication solution down to the field level

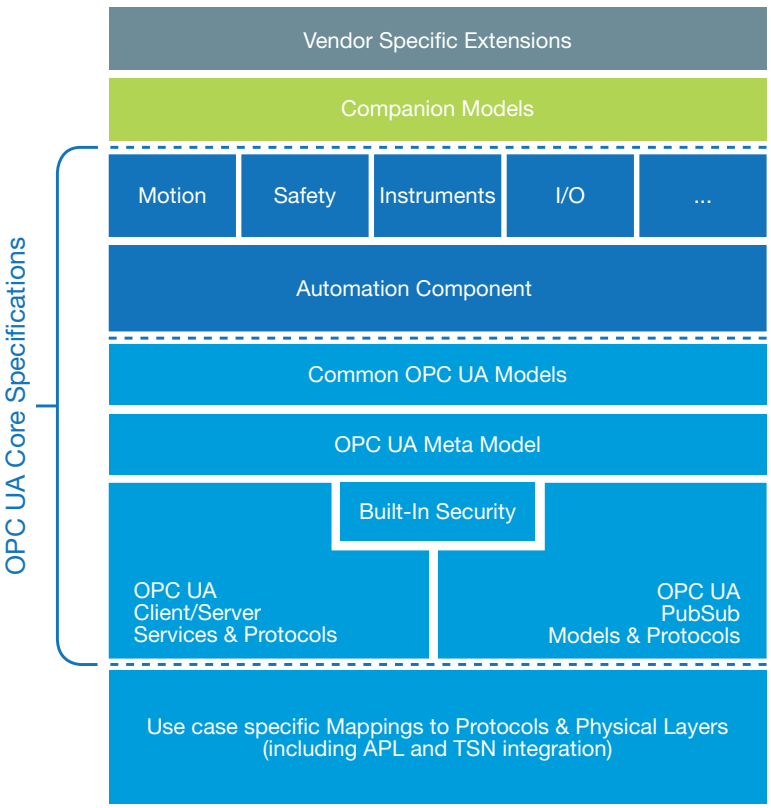
In a second version of the specification, the already developed concepts are extended for the use cases controller-to-device (C2D) and device-to-device (D2D), with which OPC UA can then be used as a uniform and consistent communication solution across all automation levels (Figure 3). This opens up completely new possibilities, especially with regard to the different Industry 4.0 application scenarios and IT/OT convergence.



Use cases for OPC UA with the extensions for the field level (controller-to-controller C2C, controller-to-device C2D and device-to-device D2D).

OPC UA at the field level – the system architecture

The extensions specified by the FLC Initiative are based on the OPC UA Framework (IEC 62541), which enables a secure and reliable, manufacturer and platform-independent information exchange (Figure 4). Controllers and field devices support both, the connection-oriented client/server communication model and the publish/subscribe extensions, which are indispensable for communication at the field level due to the corresponding requirements for flexibility, efficiency and determinism. The security mechanisms specified in OPC UA are also used, which, among other things, support authentication, signing and encryption of the data to be transported and can be used for both client/server and publish/subscribe communication relationships.



OPC UA based system architecture with extensions for the field level.

The initial release candidate of the FLC Initiative, completed in November 2020, consists of four specification parts (OPC UA Parts 80-83) and focuses on C2C communication (controller-to-controller) for the exchange of process and configuration data by means of peer-to peer-connections and a basic diagnosis:

- **Part 80 (OPC 10000-80) includes an introduction and provides an overview of the basic concepts for expanding OPC UA for communication with and at the field level.**
- **Part 81 (OPC 10000-81) specifies the basic information model for controllers and field devices (automation components) and the communication concepts to meet the various use cases and requirements of factory and process automation.**
- **Part 82 (OPC 10000-82) describes network services such as topology detection and time synchronization.**
- **Part 83 (OPC 10000-83) describes the data structures for the exchange of information required for offline engineering using descriptors and descriptor packages.**

Work on the safety solution for OPC UA (OPC UA Safety) is also very advanced. A first OPC UA Safety specification, which is based on client/server mechanisms which arose from a Joint Working Group with Profibus & Profinet International (PI), was already adopted in November 2019 (Part 15, OPC 10000-15). Revisions to the OPC UA Safety specification describe extensions for OPC UA publish/subscribe and the parameterization of safety participants. The special thing about the safety concept for OPC UA is, among other things, that safe participants can be dynamically integrated into the communication, with a unique identification, even while a machine or system is in operation.

Progress can also be reported with regard to motion. A working group has been developing an OPC UA-based motion solution since mid-2020. OPC UA Motion comprises the specification of motion control functions for various types of motion devices such as controllers, standard drives, frequency converters and servo drives. The FLC Steering Committee has agreed to base the work on the CIP Motion and Sercos specifications and to adapt them to the OPC UA information modeling and system architecture, taking into account the relevant Industry 4.0 use cases. The fact that, as with safety, existing concepts and specifications are being used, the specification work can be significantly accelerated.

The combination with TSN, APL and 5G

The OPC UA Framework is fundamentally transport-agnostic and can therefore be flexibly used with various underlying communication protocols and transmission physics. Ethernet Time-Sensitive Networking (Ethernet TSN) and the Ethernet Advanced Physical Layer (Ethernet APL) are considered by the OPC Foundation as important elements of the strategy to expand OPC UA to all use cases and requirements in factory and process automation and the vision to create a completely scalable, industrial interoperability solution.

The combination with TSN

By using Ethernet TSN, deterministic data transmission via OPC UA is facilitated, which is particularly indispensable for demanding automation applications. In addition, TSN allows different applications and protocols to be operated using standard sized hardware and a common network infrastructure. This enables convergent industrial automation networks to be implemented in which various IT and OT protocols can coexist. A Working Group of the FLC Initiative is currently working out which TSN sub-standards shall be mandatory for OPC UA-based end devices and infrastructure components in order to meet the specified requirements for performance, flexibility and ease-of-use. The OPC Foundation has given a clear commitment to the TSN-IA (Industrial Automation) profile, which is being developed by the IEC/IEEE 60802 working group. For this reason, the OPC Foundation has entered into liaison agreements with the standardization bodies IEC SC65C and IEEE 802.1.

The combination with APL

Ethernet APL describes a physical layer for Ethernet that was specially developed for the requirements of the process industry. Ethernet APL enables data transmission at high speeds over long distances, the supply of energy and data via a common, twisted 2-wire cable, and protective measures for safe use in hazardous areas. This makes Ethernet APL the enabling technology for the use of OPC UA and other Ethernet-based protocols in the process industry. Due to the special importance of this technology, the OPC Foundation joined the Advanced Physical Layer (APL) project group in June 2020 to develop and promote APL together with other non-profit organizations and various industrial partners.

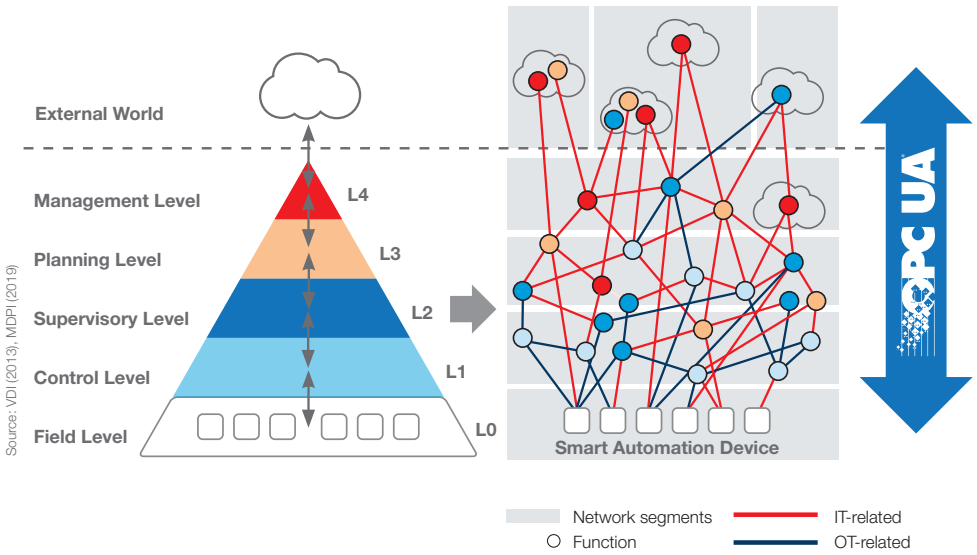
The combination with 5G

Data exchange via OPC UA is not limited to wired or wireless Ethernet communication. Support for the 5G mobile communications standard is also on the OPC Foundation‘s development horizon. The mapping to 5G will be seamlessly integrated into the existing OPC UA architecture, so that all protocol and profile extensions of the FLC initiative can be used, not only via Ethernet and Ethernet TSN, but also via 5G in the future.

Summary

The OPC UA (IEC 62541) framework, with extensions for the field level, specified by the FLC Initiative, in combination with underlying communication standards such as APL, TSN, and, in the future, 5G, offers a complete, open, standardized and interoperable solution. It not only fulfills the requirements of industrial communication, but, at the same time, enables consistency and semantic interoperability from the field level to the cloud and vice versa (Fig. 5). With this approach - in combination with the various companion specifications - information is made available with a standardized semantics directly at the data source.

Use cases to consider: A flow meter offers directly standardized „OPC UA flow measuring data“ the moment the APL cable is plugged in. And analogously, servo drives directly process standardized „OPC UA drive setpoints” and provide standardized “OPC UA actual drive values” as soon as they are integrated into a machine network with Ethernet TSN.



Semantic interoperability with OPC UA from the sensor to the cloud

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MAX WALTER,
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OPC EXPERTS INTERVIEWS: FUNCTIONAL SAFETY

IN THIS SECTION: Learn from an interview with Max Walter from Siemens, in his role as the chairperson of the OPC UA Safety working group. Max will give us a quick introduction into functional safety, how OPC UA deals with safety, discuss example use cases, talk about key features, prerequisites, certification, and how OPC UA Safety will become the one and only safety protocol.

CLARK: Max, please introduce yourself to our readers and tell us about your involvement with OPC technology and the OPC Foundation.

WALTER: I'm located in Nuremberg, Germany working for Siemens as an expert in functional safety, specifically in the area of functional safety for communication, including PROFIsafe and OPC UA Safety. I'm involved in standards development, working for IEC, where we define the prerequisites of functional safety communication. I'm also the chairman of the OPC UA Safety Working Group and the PROFIsafe Technical Working Group.

Siemens is a founding member of the OPC Foundation and is very active in advancing OPC UA technology. We actively contribute by providing experts and managers, in fact, the Vice President of the OPC Foundation is from Siemens.

Siemens supports OPC UA because we see it as a very important technology today, and into the future. It's very important that controllers can collaborate and communicate with each other using OPC UA technology.

CLARK: Max, today we are discussing functional safety. For those readers that are not familiar with this topic, please give us a quick introduction. What is the difference between safety communication and non-safety communication? And what is the difference between safety and security?

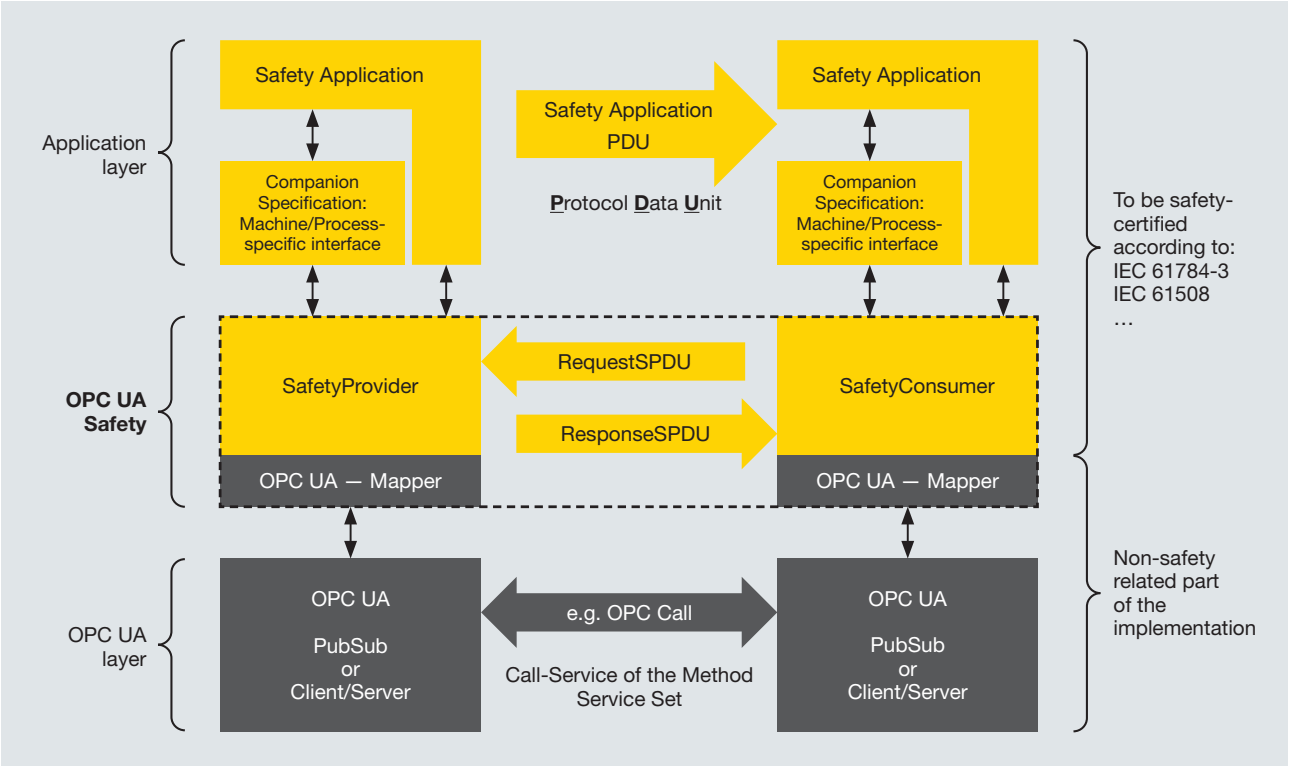
WALTER: Functional safety comes into play if there is a risk that people could be injured or, perhaps, other accidents could happen, like a potentially dangerous impact to the environment. In many industrial plants, it's common to find components which are specifically implemented as part of a safety function. Functional safety specifically addresses risks stemming from incorrectly functioning equipment.

For example, if there's a risk that a motor might start while a person is in close proximity to a machine, this is deemed to be an issue of functional safety. For such risks, plants will install light curtains, emergency stop buttons, or other protective measures. These components must communicate with each other and it's critically important that the communication either works correctly or that the components are able to detect that a communication error has occurred. If a communication fault is detected, the components are configured to transition into a safe state. This is the typical way of handling problems in a safety function; there is always a safe state into which components can switch.

The difference between functional safety and security is that, in functional safety, we deal with hardware or software errors but not with human adversaries. We do not take into account that somebody is attacking a system, trying to provoke an accident. Something like this would be considered part of security and, in practice, safety always needs a secure environment. You cannot operate a safety-critical system if it is in an insecure environment. To that end, I would say security is a prerequisite for safety, but security alone is not sufficient. This is why it is necessary to have safety communication throughout a plant.

CLARK: How does OPC UA deal with Safety?

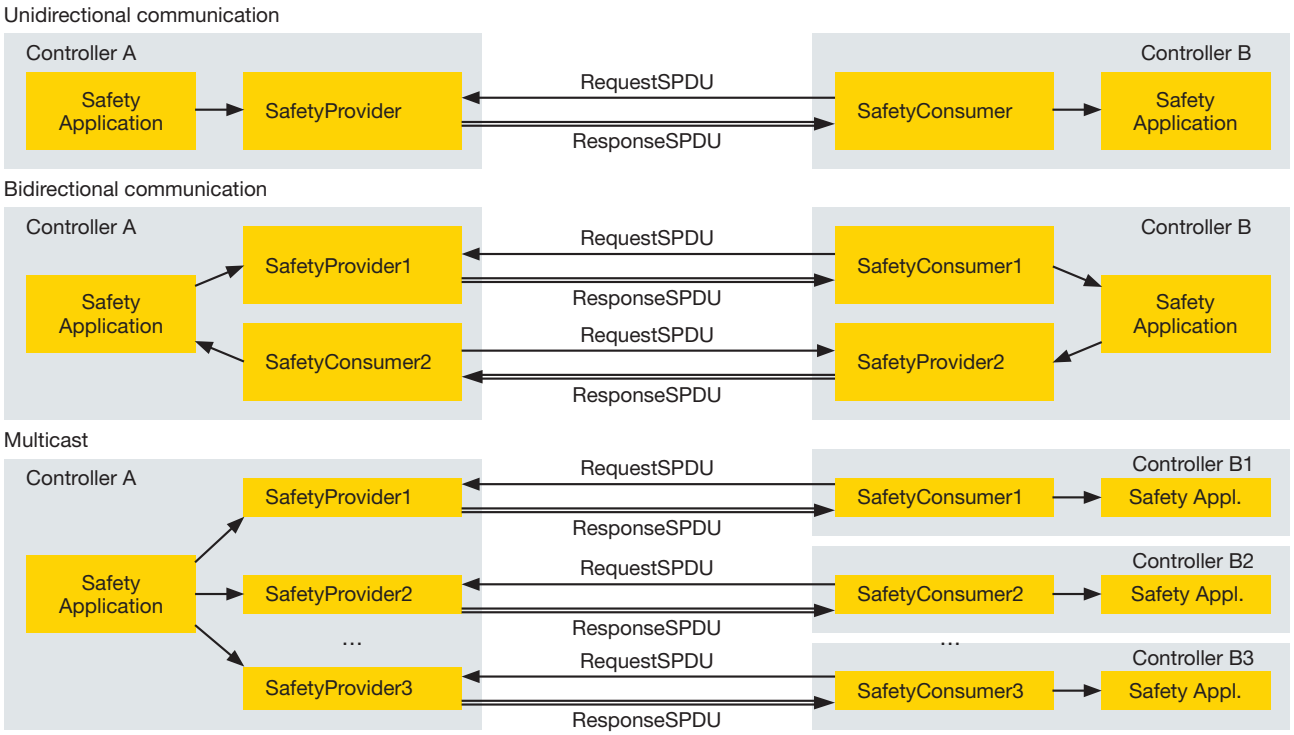
WALTER: In the OPC UA Standard, there is a reserved Part (or Specification) number "15" which deals with functional safety. It's a specification which was jointly created by PROFIbus, PROFInet International, and the OPC Foundation. It's based on well-established PROFIsafe technology. The goal is to have a specification, which contains a protocol, describing how controllers can communicate with each other in a vendor neutral and functionally safe way. For example, users can connect different vendor's PLC's and exchange safety critical data; like the state of an emergency stop button or the state of a light curtain. This is how we facilitate machine-to-machine communication in a safety-critical way.



OPC UA Part 15: Safety is re-using standard OPC-technology to provide functional safe communication. All possible communication errors such as loss, data corruption, incorrect addressing, and unacceptable delay are detected. Only error-free data is delivered to the safety application program.

CLARK: Which kinds of components can communicate via OPC UA Safety?

WALTER: For machine-to-machine communication, a machine is typically represented by a controller – a PLC, a DCS, or an industrial PC – and it is important that these components are safety components. There's sometimes the misconception that if you implement a safety protocol on a standard component it becomes a safety component. Unfortunately, that is not true. The component, itself, must be implemented in a safety-critical way. The mandate of our specification centered around controller-to-controller communication, and just recently, the Field Level Communication (FLC) initiative decided to use OPC UA Safety as part of their work. This means that we are now extending the specification to field-level devices such as safe IO modules, laser scanners, electric drives with safety functions, and so on.



The basic building blocks of OPC Safety are the SafetyProvider and the SafetyConsumer. Together, they establish a unidirectional communication link. By instantiating multiple pairs of SafetyProviders and SafetyConsumers, bi-directional communication, multicast, and even more complex communication topologies (line, ring, star, tree, …) can be realized.

CLARK: Can you please give us some use-case examples in which safe controller-to-controller communication is needed?

WALTER: A typical example, which I've already mentioned, is an emergency stop button. If you have two machines next to each other, there's a general rule that everything that is in view, from the proximity of the button, should stop. In other words, in the event that something bad is happening, you don't want to be searching for the correct button; you simply press the emergency stop button that is close by and things should stop.

In another example, if you have a modular machine comprised of different modules plugged together, if you press an emergency stop button at one module, all of the other modules should also stop.

One more example – if you open a safety door or a safety latch and the machine is then supposed to run at a reduced speed, if multiple machines are connected to this one, then of course, all the associated machines should run at a similarly reduced speed.

Looking a bit more into the future, I think it will become very important that automated guided vehicles and autonomous mobile robots are able to connect to machines and work together in one safety function for many obvious reasons.

CLARK: Was OPC UA Safety built from scratch, or was it derived from existing fieldbus safety protocols?

WALTER: Yes, of course, we wisely used what was already established. OPC UA Safety is built on the existing PROFIsafe protocol. We already have some well-established mechanisms – cyclic redundancy checks, monitoring number, SIL monitor – which we re-used in OPC UA safety. Of course, there are also some novel features, one being the dynamic behavior that I just mentioned. So, it's not a word-for-word clone of the PROFIsafe specification, but rather, it's an advanced version of it.

CLARK: What are the key features of OPC UA Safety?

WALTER: OPC UA Safety uses the standard OPC UA communication as a, so called, "black channel". This sits on top of standard communications. It can either use OPC UA client/server or OPC UA pub/sub, making it suitable for both real-time and non-real-time applications.

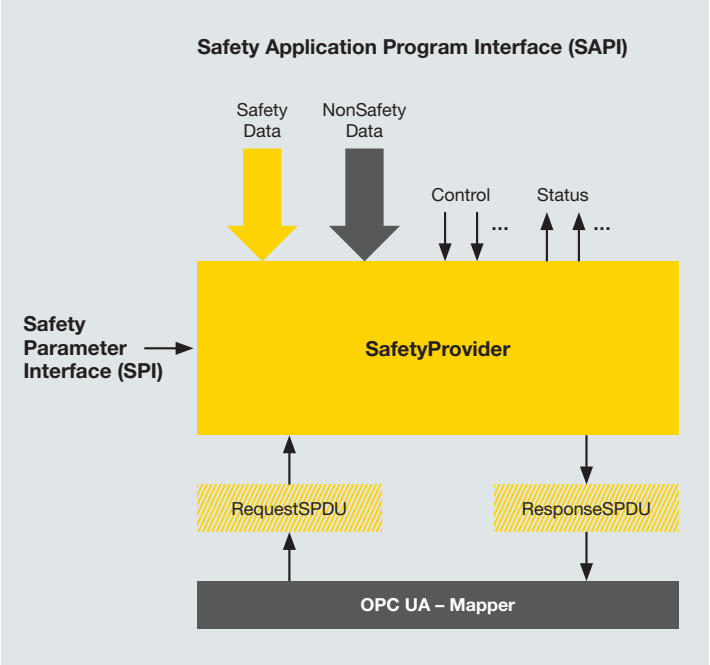
The basic building block of OPC UA Safety is a unidirectional communication link, but if choosing to instantiate multiple links, you can communicate bidirectionally or even create multicast connections. If the architecture is comprised of more than two controllers, we can build arbitrary bus, tree, or star network topologies.

The communication payload allows up to 1500 bytes of data per telegram. These packets can be arbitrarily structured to include whatever basic data types you choose as part of an OPC UA information model.

CLARK: Does OPC UA Safety have any existing prerequisites like error rate, transmission rate, or limits on the number of network components?

WALTER: What is important is that the communication endpoints must be safety devices developed according to safety standards like the IEC 61508. What is in between is the, so called, “black channel” principle, where there are no requirements from a safety point of view; the transmission rates are not limited, the number of network elements such as routers or switches are not limited. It works over any arbitrary local or even wide area networks including wireless. Yes, it’s possible to build a safety function over a wireless connection.

If you use a channel which is too unreliable, then the safety function will detect this and go into a safe state. From an availability point of view, it’s important to ensure that the communication channel has high reliability and that it fulfills the real-time requirements of the application.



The SafetyProvider accepts application data via the safety application interface (SAPI). Upon receiving a RequestSPDU from the OPC UA Mapper, it returns a ResponseSPDU containing the application data protected by an error detecting code.

CLARK: Does OPC UA Safety have certification?

WALTER: Yes. This is a very important aspect. OPC UA Safety will be tested by a certification authority. We are working closely with TUV, up to Safety Integrity Level (SIL) 3 and the accompanying test specification will be TUV-Certified. Therefore, when implementing an OPC UA Safety device, the certification process will be described in the test specification.

The OPC Foundation and PROFIbus/PROFInet International are working together to establish a certification process for OPC UA Safety products. We are doing everything we can to make the implementation of OPC UA Safety devices as simple as possible; this includes developer training.

Finally, there will be a test tool provided, and the OPC Foundation will provide a communication stack implementation, which can be integrated into the device development process. If you choose to use the stack and the test tool, then you have already done many of the steps required for safety certification of your product.

CLARK: What is the timeline for OPC UA Safety?

WALTER: The first release has already been published and the working group has begun work on the next release, which will include pub/sub (since the first release only included client/server). The test specification and the test tools are currently under development. They are targeted to be included with the second release.

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

WALTER: If anyone wishes to cooperate in the area of OPC UA Safety, they are most welcome. To anyone who may be interested in reviewing and providing remarks on subsequent releases, we appreciate your comments. Lastly, there is an open invitation for anyone wishing to join the working group; we would be happy to hear from your readers.

ALEXANDER ALLMENDINGER,
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GETTING OPC UA PRODUCTS CERTIFIED

IN THIS SECTION: Learn from an nterview with Alexander Allmendinger from the OPC Foundation, where he outlines the process of getting OPC UA products certified. He'll explain the certification process, the preparation, how to reach compliance, the testing itself, what is being tested, how to get started, and the tools available to support developers and end usesr.

CLARK: Alexander, please introduce yourself to our readers and tell us about your role at the OPC Foundation.
ALLMENDINGER: I'm located in the South of Germany, close to Stuttgart, to be more precise, and my first contact with OPC UA was actually before the initial specification had been released. I had the opportunity to do some testing of the initial versions of the OPC UA stacks. So, I've been doing testing of OPC UA right from the beginning. In the OPC Foundation, I am involved in a lot of different activities. For example, I participate in the UA Working Group, the Security Working Group, as well as the Harmonization Working Group all with the aim to ensure that the certification labs are handling the latest updates, so that we can assure that we use the latest versions for certification.

CLARK: So, you have been "Mr. OPC Tester" right from the beginning.
ALLMENDINGER: Well, kind of. It hasn't been an official role. Back then, the work I was doing was more internal to our company and less on the broader OPC scope.

CLARK: But now you have the official hat on; so, please describe what you do these days.
ALLMENDINGER: I'm working on the Compliance Test Tool, or CTT development, though, most of all, I'm organizing all the different development steps. I've personally performed quite a lot of development on the CTT framework, including binary code and scripting for the test scripts, but I'm also heading the European certification test lab, which is kind of the headquarters for the certification program. As such, I'm also educating the other test labs on the certification tools, the certification program, and all the implemented changes that are being made to the technology and certification.

CLARK: In a previous interview I had with Paul Hunkar, we learned that the highest objective of OPC certification is to enhance the quality of the product. To achieve this, I assume you are testing compliance to the specification, but what else is being tested to achieve this goal?
ALLMENDINGER: So, in general, we are testing five different categories, the most obvious being the compliance test; however, we are not only testing all of the mandated features but also any optional features that are being included in a product. Furthermore, we're not just doing test cases to pass, but also tests to fail.
For example, we will send chunk messages to a Server, or inject similar behavior into responses to Clients to ensure that they are behaving compliant in all cases.
The second aspect is interoperability, and that is obviously the most important thing for an open standard like OPC UA. What we are doing here is testing the communication with products of other vendors from certain markets. And while we are doing that, we ensure that we are not just using a different vendor product but also different SDK's [software development kits] – different programming languages.

More precisely, we ensure the interoperability for the UA services for data types, security policies, user tokens, mimicking things that you would see in a production environment.

The third category is robustness. Now we are really digging into testing for communication breakdowns.

For example, assuring that a problem remains self-contained. Let's say you have an external sensor and we deliberately create intermittent communications to that external sensor; we would expect the product to still respond to UA requests. We also test to confirm that correct status codes are being supplied to a Client so that the Client – or the end user –is aware of what is happening.

These are the three core categories that we look at in order to help enhance the quality of each product; however, we do have some more extensive tests.

For example, we look at product's efficiency, wherein we put the product under real load, then retest using the same three aspects that we just covered – combining compliance testing with interoperability and robustness.

We do this by connecting the device under test with a minimum of five other products. We begin by ensuring that communication is stable and works fine; then we inject intermittent communication to not only the OPC UA peers but also to underlying data sources. While doing this over a span of 72 hours, we measure the CPU usage, RAM threads, and handles. By doing this, we ensure that the products are really capable of doing long term runs in production environments.

And then, last but not least, we evaluate product usability, which is basically all about having a positive end user experience. So, we take a look at product documentation, help files, and how intuitive it is to use the product – the idea being that we hope to ensure that a certified product is very easy for end users to operate.

To illustrate, if we notice that certificate handling – a very complex task – is not described well in the product documentation, we will point that out to the vendor and suggest enhancement tips and ideas so that product documentation can be improved.

So, like I said, in total, we concentrate on five areas: compliance, interoperability, robustness, efficiency, and usability in order to ensure very high-quality products.

CLARK: So, where and how do interested parties get started; what is the first thing I, as an interested party, would need to do to get a product certified?

ALLMENDINGER: Well, the very first thing you need to do is to identify all the features that are being supported by your product. An important thing to remember here is that a product does not automatically include all the features that are being supported by the particular SDK the vendor chooses for their development. Even though an SDK can do a lot for you, it cannot do everything. Some features do require manual integration and, therefore, the very first thing is to identify the real features that your product supports.

We provide the vendor with a profile reporting tool, which basically lists all the different features that are described in OPC UA, in order to help the vendor identify each of the included features within their product.

CLARK: So, you said that not all of the features supported by the SDK are automatically included within the product; that means that the test cases you are choosing for that specific product will be related to only the features the vendor chooses to identify, correct?

ALLMENDINGER: Exactly!

So, basically, with the feature set in mind that your product supports, you go to the profile reporting tool or you provide a list of profiles or facets to us, which we then associate with corresponding conformance units. With those conformance units, your product is assigned all the test cases that are valid for your stated profile.

CLARK: So now that I have a list of everything my product supports and the associated test cases, depending on my product, this could be a very long list of test cases. Is there a tool available that helps me execute those tests?

ALLMENDINGER: Luckily, yes.

As I already mentioned, I'm one of the developers for that tool; it is the CTT or Compliance Test Tool. To be more precise, it's actually called the UACTT, but the UA is often omitted.

The Compliance Test Tool is like the certification program itself; it's not only available to paying members of the OPC Foundation, but also to non-paying members. The Compliance Test Tool can do a lot of automated testing for OPC UA Servers, but it also helps with Client certification preparation because Client testing is not that easy. The UA specification requires Clients to support certain application-logic.

For example, it isn't possible to automate a test to see if a bad status code, received from the communication partner, is being indicated to the end user; therefore, we need to take manual steps here. So, the CTT, when in client-mode, helps you to inject bad status codes in order to force some bad things to happen, resulting in valid Client behavior.

CLARK: So, does the CTT cover OPC UA security features?

ALLMENDINGER: Of course.

The security aspects in OPC UA are quite important and, as such, they are an important part of certification and testing. The CTT takes care of all the different aspects of the security features, like certificate validation steps, which are an important thing when it comes to complex CA [Certificate Authority] structures that are being used in production environments; but also, when it comes to user token handling, having secure connections, handshakes, and everything associated with them.

The compliance test tool is continuously enhanced to have all the new security mechanisms integrated fairly fast; however, having said that, especially when it comes to security, sometimes there are manual test cases. Once again, it depends on whether application-logic is required and especially when it comes to the fact that you want to enable and disable security policies that are the baseline for secure communication in OPC UA. This may become necessary if a particular algorithm has been cracked. You may then have a use case for manual steps, therefore, there are always manual test cases when performing security compliance testing.

CLARK: So, this tool can validate product compliance, but how about interoperability – is that being tested as well?

ALLMENDINGER: Well, the nature of that kind of testing is to check the interoperability between different applications. The CTT is only one application; therefore, it is quite obvious that it cannot perform interoperability testing with only one active application. Thankfully, this need was identified by the OPC Foundation a long time ago. As a solution, they host an event called Interoperability Workshop or IOP Workshop, which invites interested vendors to gather in one room to test and validate the interoperability between their applications. I highly recommend that each provider attend these IOP workshops to ensure the interoperability of a product.

CLARK: Assuming I've done everything you've mentioned so far, what is the next step? How do I get the actual process of certification testing started?

ALLMENDINGER: So, on the OPC Foundation website, the whole process is documented. There, you will find a certification section and that is where you can always look for more information on the next steps.

Now, in order to get the process started, there is something called the application request form, which is located in the "How to Certify" section. The request form covers a lot of questions about your product; which features are being supported, which SDK did you use for your development, which version we are talking about, what operating system, and so on. By providing all this information to the lab that will execute the testing for you, they can come up with an official estimate as to how long it will take to certify your product. So, after we take a look at the completed form, we may say that it will require seven days of testing to get the product to a certifiable state; however, if the product is well prepared, we don't find any issues, and it is very intuitive to use, perhaps we may only need four days of testing. In that case, it is only four days of testing which the company needs to pay – it's not always necessary to pay the whole lump sum.

CLARK: To get my product certified, does someone need to be at the lab in person?

ALLMENDINGER: Actually, we can do a fully virtual certification; that is absolutely possible, in fact, it is the most common case. We provide you with an access point, which most likely will be a virtual machine in a designated network where you can verify your application as well as access all the reference products that we're going to use for testing. With this arrangement, we basically virtualize everything, so we don't need to have an in person visit.

CLARK: What happens during the actual testing – how is the testing executed?

ALLMENDINGER: We like to do our testing as efficiently as possible, so we try to prepare the whole environment before testing commences; we do the installation; we perform test tool commissioning; we prepare the environment; all of this is taken care of prior to the actual testing date.

We typically start the testing on either a Monday or a Tuesday, and what we do on the first day is product commissioning. We ask the vendor to guide us through the product; to guide us through how to use the application; to teach us how to find everything we need to test. This is usually not that difficult for us, especially if we've already seen four comparable applications from different vendors, the fifth is likely very similar – it just uses different icons.

Now, having said that, what is most important for us is that, throughout the entire test period, we have a developer or an expert from the vendor available. The reason for this is that, if we have questions or find issues, we have an expert with whom we can discuss how to perform a particular setup or a certain scenario in order to get it working. This helps us work as efficiently as possible.

CLARK: What happens if an issue is discovered during testing?

ALLMENDINGER: So, if an issue is found, we are prepared for such events. Actually, it isn't that uncommon but what we do in such cases is that we report any issues at either the end of a testing category or, more typically, at the end of a testing day. We provide detailed feedback – not simply that you failed test case number 24 in a certain conformance unit but, rather, we explain what went wrong and what may or may not be the issue here. Then we start an iterative approach, because we can continue the testing with the other unaffected areas.

So, let's say you have an issue in a write-call; that doesn't prohibit us from testing the read-call or data change notifications or security aspects. We will still continue testing other aspects until you have a fix for the earlier issue that we reported. Once you've provided us with the update, we will apply it to the product; we will verify that you didn't just tweak something but that you actually fixed the issue; then we will do some spot checks on potentially affected features.

Once we get to the point where there are zero failed test cases, we have a certified product.

CLARK: Good. This then means that they get an official document which will contain the name of the product tested, the date it was tested, and then that gives them the right to use the Certified OPC UA product logo, is that right?

ALLMENDINGER: Absolutely!

In fact, at the end of testing they get a few documents. The first one is a testing summary – this is the document that I highly recommend every end user request when evaluating certified products. This summary provides all the details of what has been tested and under what environment.

The second document is a detailed test record – we're talking about a few hundred pages, which I agree is not necessarily the thing that you want to take a look at as an end user.

Next, they get a report pertaining to the efficiency test, including some graphs. And last, but not least, they receive the Certified for Compliance logo and the Compliance Certificate.

CLARK: OK, final question; are there any final thoughts that you would like to share with our readers?

ALLMENDINGER: There is a big push coming from each of the different joint working groups with respect to their companion specifications. A lot of companion specifications are aiming for a way to ensure that products, those built to the standards of the companion specifications, can be tested so that not only the vendor themselves can verify whether they have done everything right, but also provide an opportunity to end users allowing them to test a product once they've commissioned it.

We have already integrated testing scripts into the CTT for multiple companion groups, including MDIS, which is from the oil and gas industry; PLC-Open representing PLCs; and a first draft for PA-DIM testing. We have further developments under way for automated testing capabilities for IO-Link and machine tools as well as other groups from VDMA.

ABOUT THE INTERVIEW PARTNER – ALEXANDER ALLMENDINGER:

Alexander Allmendinger is heading the OPC Foundation European Certification Test Lab since 2016. In this role he actively participates in shaping the certification program of the OPC Foundation. He also works in the training and auditing team for certification test labs as well as being a member of the Compliance Steering Committee. To complete the scope of testing the OPC Foundation also appointed him to coordinate the Interoperability (IOP) Workshops of the OPC Foundation as IOP Workshop Coordinator.

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