What to Expect in Industrial Communication with OPC UA and 5G?

- Published in IEN Magazine, Europe

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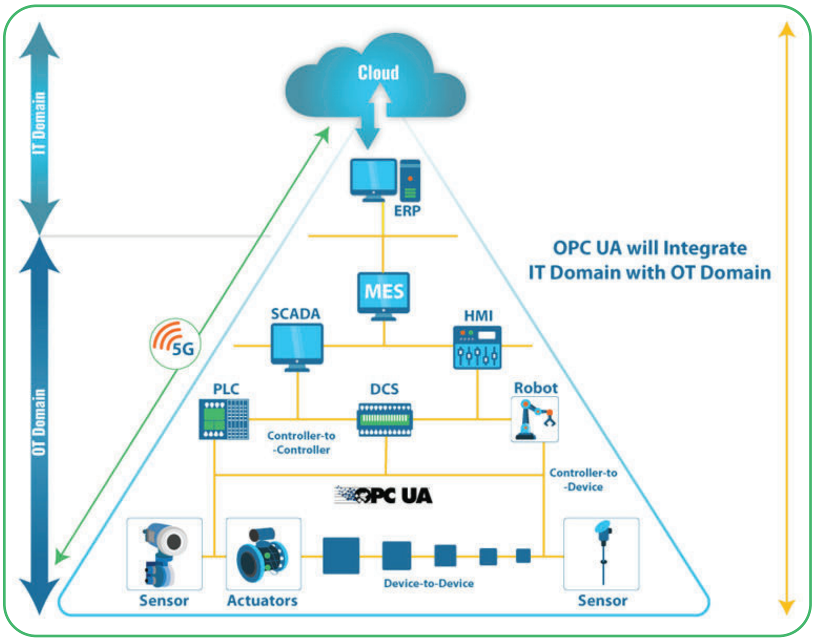
Introduction

Digitalization is a benchmark that every industry is after to achieve greater flexibility, improved responsiveness, and enhanced performance. Industrial communication technologies act as the facilitators to achieve this goal. The recent efforts towards improving communication have been leaning towards integrating IT technologies with the products, systems, solutions, and services across the automation value chain. The goal is to enable secure, reliable, and seamless access to information at every level.

Industrial IoT comprises of a wide range of devices that cannot be connected over IP-based networks. While Ethernet is widely used in industrial architecture, a standardized and integrated way of communication is still missing.

- **M2M Communication (Horizontal Communication):** Machine-to-machine communication is an important part of Industrial IoT. IIoT requires transcending from the IT to the OT domain as well enabling communication between sensors and actuators. Plant floor equipment/machines and field-devices are expected to process data collected from other peer devices.
- **Device-to-Cloud Communication (Vertical Communication):** Vertical communication implies communication across all layers. In a network architecture, the controllers communicate to the SCADA/HMI systems, which then communicate with MES/ERP systems. This calls for a seamless exchange of information among heterogeneous systems across multiple layers of the automation pyramid.

Smart manufacturing revolves around the networking of dissimilar systems within and outside the factory and process boundary. Modern industrial communities and consortiums have made and are making immense efforts towards addressing the horizontal and vertical communication requirements by proposing '***Single communication technology/standard, i.e., OPC UA***' to enable integration and interoperability between devices across IT and OT domains.



The following paragraphs will further elaborate the prevailing communication scenarios in industrial automation.

OPC UA for M2M Communication: Horizontal Integration

To be precise, the scope of field-level communication in not limited to only the elementary field-level devices, but also extends to control-level devices and Manufacturing Execution System (MES) that together form the '**OT Network**'.

At present, more than 90% of the field network is dominated by wired technologies. Profibus, Profinet, Ethernet/IP, Modbus, etc., have been ruling the field-level communications in industrial automation for a long time.

Despite being connected, a pressing challenge that has kept OT networks from realizing the seamless integration in industry 4.0, is "**Lack of complete interoperability**". While Ethernet is surely used predominantly to reach multiple devices, there is no standardized way for the devices to communicate.

In order to address multiple such compatibility and interoperability issues in the OT layer, OPC Foundation launched the **Field Level Communication Initiative** in November 2018. Aimed at solving the prevailing connectivity challenges at the field-level, OPC UA, as part of this initiative, seeks to extend OPC UA to the bottom layer of the automation pyramid to provide a secure, unified, and standardized communication platform for factory and process automation industries.

OPC UA FX (Field eXchange)

With OPC Foundation's FLC initiative in motion, a complete network with end-to-end interoperability between the field devices is going to revolutionize the communication model in the OT network. Some of the modifications in the OPC UA stack to support field-level communication are:

- Standardization of OPC UA information models to support field devices offline and online
- Synchronizing various application profiles
- Defining the system behavior to support common functionalities
- Integrating the OPC UA companion models
- Defining the certificate procedures
- Mapping the application profiles to support real-time communication

Some of the field communication extensions to OPC UA stack are:

- **Part 80 (OPC UA FX 10000-80):** Lays the basic conceptual foundation for OPC UA field communication
- **Part 81 (OPC UA FX 10000-81):** specifies the base information model and the communication concepts to meet the various use cases and requirements of Factory and Process Automation
- **Part 82 (OPC UA FX 10000-82):** Discusses the networking services, time synchronization, and topology discovery, etc
- **Part 83 (OPC UA FX 10000-83):** Describes the data structure for information sharing

OPC UA for Device-to-Cloud Communication: Vertical Integration

Vertical integration essentially focuses on communication across layers, i.e., from the field layer to the enterpriser layer. However, as the image above depicts, the entire automation pyramid is separated into two different domains (IT and OT) with different operations, devices, message frequencies, data size, and above all, protocol types.

The OT domain networking consists of tightly-coupled systems, while the IT domain consists of loosely-coupled systems. The OT systems have more strictly defined communication models, data models, and data types. On the other hand, the IT systems are more platform-independent and flexible. Hence, if you use the same interface to connect the IT domain that you would use for OT domain, it would be inflexible, impractical, costly, and non-scalable.

Therefore, it becomes challenging to integrate these two different domains in one single thread.

IT/OT Integration through OPC UA

The prime factor that allows OPC UA to be broadly used across layers is its ability to be independent of the transport. Transport can be understood as the way a message is transferred between two nodes. Conventionally, the nodes that wished to communicate with each other needed to communicate in the transport method that was supported by that node manufacturer. In contrast, OPC UA supports multiple transports, even custom, and proprietary transports. This allows all types of devices to support OPC UA ranging from shop floor sensors/actuators to controllers, HMIs, databases, etc.

Implementing IIoT calls for rich data exchange among the devices. OPC UA enables communication between devices irrespective of the programming languages in which a software is coded. Also, it is independent of the vendors and proprietary technologies, which makes it an open and suitable standard for deployment across the automation pyramid.

OPC UA Pub-Sub (OPC Publish-Subscriber Model)

By far, the communication model supported by OPC was the client-server architecture. In this architecture, the clients are directly connected to the server nodes. For example, to fetch the data from PLCs, the SCADA would have to contact each and every PLC (via OPC Server) directly.

However, this configuration poses several challenges as the number of devices increase, the network throughput starts declining due to an increased number of data requests. Also, the servers require a larger memory footprint and processing power to accommodate the rising number of clients. This turns out to be a roadblock in scaling the architecture.

OPC UA Pub-Sub solves this issue by introducing a middleware that is responsible for connecting, sending, and receiving messages between applications. Here, the publisher(s) (OPC UA Servers) send messages to the middleware without knowing about the subscriber(s) (OPC UA Clients) and the subscribers receive the message without knowing the publisher details.
This not only allows balancing the load on both the client and server ends but also enables secure and reliable scaling. **OPC UA Part 14** defines the specification for Pub-Sub model.

Though the industrial networks are primarily wired, which is convenient and fail-proof in most cases, it also adds to the maintenance cost. The devices are bound to structural limits and hence the entire architecture becomes less flexible. This is where wireless networks can prove to be beneficial in terms of speed, performance, and flexibility, especially if it is 5G.

5G in Industrial Automation

Speed is also an important parameter to judge the quality of a network. While wireless networks are being looked at as an alternative for lot of industrial communications, 5G is the new buzzword industrial enterprises are looking forward to.

3GPP (3rd Generation Partnership Project) is a standard that creates specifications for mobile networks. 5G is the 5th generation cellular network that is up to 100 times faster than the 4th generation 4G network. This new technology promises to deliver a unified connectivity fabric that will take industrial automation to a whole new level. The 5G specifications defined by 3GPP includes the following elements that make it the next big thing for smart factories:

- **QoS(Quality of Service):** 3GPP has defined 4 parameters for 5G based on the types of traffic, i.e.,
  - **Periodic Deterministic** Traffic: Stringent requirements are defined.
  - **Aperiodic Deterministic Traffic:** No pre-set sending time, but stringent requirements in terms of timeliness and availability are defined.
  - **Non-Deterministic Traffic:** Lesser stringent requirements are mentioned.
  - **Mixed Traffic:** Lesser stringent requirements are mentioned.
- **End-to-End Latency:** As less as 0.5 ms that goes up to 500 ms.
- **Data Rate:** Up to Gbits/second
- **Communication Service Availability:** 99.9 % to 99.999999 %
- Seamless integration with wired technologies on the same machines

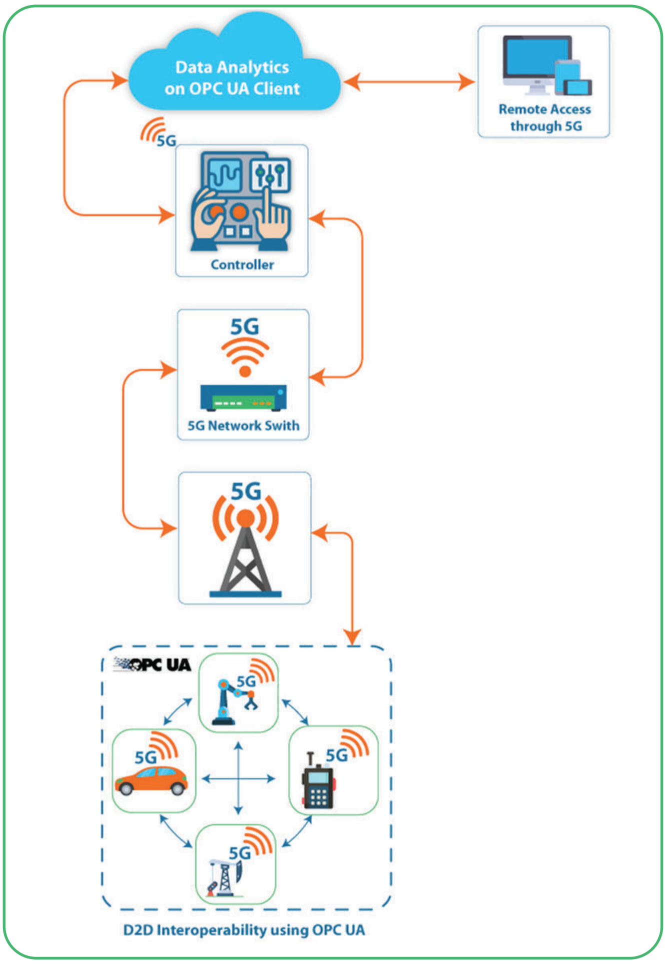
Faster speed, ultra-low latency, and increased bandwidth are some of the highlighting features of 5G. What makes 5G stand out is its capability of network slicing. Being capable of slicing the network, 5G allocates different speed segments to different network slices thereby defining different dedicated bandwidth and network modes. This allows 5G to achieve highly improved performance - something which previous cellular network generations could not achieve.

For an instance, imagine an Automated Guided Vehicle (AGV) is being operated remotely in a factory to move objects from one place to another. With no driver, the vehicle would require a data exchange speed in milliseconds that would enable the AGV to detect an obstacle and respond accordingly. With a latency of 1 millisecond, 5G is recognized as faster than human responses.

OPC UA with 5G

The preference for wireless networks over wired networks is growing at a tremendous speed at a growth rate of 32%. With a vision to create networking more flexible, cost-efficient, and mobile, wireless networking is grabbing a strong foothold in industrial communication systems. With wireless becoming the new trend, automation industries can channelize the power of fast 5G networks with its extended version called "**5G Ultra-Reliable Low Latency Communications (URLLC)**" mode.

With an ability to connect multiple low-power IIoT devices to the cellular network and a high-reliability rate of more than 99.9999%, 5G URLLC is capable of enabling mission-critical industrial use cases. URLLC has a response time of 1 millisecond that allows it to be a lightning-fast technology to be deployed in field-level communication.



OPC UA has data profiles like Nano Profile, which allow the smallest embedded devices to get easily ported. OPC UA can work without TCP/IP Stack. With 5G Infrastructure, various connected devices can establish very high-speed connectivity with the edge gateways or even field-level sensors using the flexibility and interoperability of OPC-UA. Therefore, the combination of unprecedented speed and Industrial protocol will drive Industry 4.0 with real-time communication and speed allowing smarter technologies like AI/DL to be proliferated.

Following are two real-life applications of 5G in industrial automation:

Robotic Motion Control

Controlling of machine tools, assembly robots, precision AGVs, etc., are some of the most demanding use cases of 5G communication system in industrial automation. These operations require highly reliable network with high availability and low latency. However, with moving equipment on the plant floor, the latency requirements make retransmission impractical. 5G URLLC can be used in this scenario to support the dual requirement for high availability and low latency by deploying architectures using a robotic arm or AGV.

Intelligent Transport

With an unprecedented speed 5G URLLC allow routing, spacing, and controlling operations of the trains in real-time. Preventing the trains from taking the colliding routes, optimizing track usage, maintaining safe distance, etc., can be reliably carried-out with minimal signal latency allowing to optimize the transport flow more efficiently.

Conclusion

Technology is advancing as we speak, and so are the industrial demands to meet the end-user expectations. With OPC UA as the standard for communication in the industrial space, a sea of changes is expected to be witnessed in coming years. It will be interesting to see how OPC UA and 5G will change the automation game in exceptional ways. The writing is on the way, OPC UA for standardized and seamless data exchange and 5G for break neck speed. It may not be farfetched to say that in not a too far future, we could see a plant operate completely from the cloud. Worried/Excited? The OPC/5G narrative will unravel very fast, keep watching.

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