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White Paper

Connecting field-level data to the industrial Internet of Things via RFID and OPC enabling technologies

Capturing field-level data of moving objects – feeder stocks, containers, tools, work-in-progress, and finished goods – in production and supply chains is core to further unlocking the benefits of digitalization for manufacturing and logistics industries.

ABSTRACT

Field-level data often gets lost in discussions of the Internet of Things (IoT). But, for manufacturing processes and their supply and distribution chains, such basic data is indispensable and, in fact, enables the whole idea of an industrial IoT. This paper explains the next generation of RFID as represented by the newest Siemens SIMATIC RF600 technology with built-in OPC UA interoperability that opens doors to new applications. OPC-UA can help span wider geographic areas and include cloud-based analytics for predictive capabilities via the Siemens MindSphere IoT operating system platform.

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Digitalization depends on fast, accurate field-level data capture

Worldwide, industries of all kinds are quickly digitalizing their operations more deeply and widely than ever, especially those making and shipping goods. Why? Rising customer expectations. Stiffer competition. Cost pressures. Regulatory compliance. Those are among the top business drivers behind the substantial investments companies are making in a wide variety of transformative technologies.

Properly deployed and integrated, these technologies have the potential to radically change how work gets done and possibly even disrupt markets with new products, services, and operational models. Radio frequency identification (RFID) is one such technology, enabling field-level data to be collected almost instantly and error-free – a key requirement for any effective digitalization effort.

Revitalizing production technology. Of course, digitalization isn't new. Production cells and assembly lines inside factories have been digitally automated for decades, spawning streams of electronic bytes zipping along wired and, more recently, wireless networks spanning shop floors, keeping human operators informed and automated systems synchronized. And, to gain enterprise-wide visibility and functionality, companies would invest years of effort and huge sums of money in complex manufacturing execution (MES) and enterprise resource planning (ERP) systems.

But despite all that investment, much data was isolated in operational siloes. Real-time decision support was nil, as a result. Fortunately, that's changing fast. Yesterday's limited machine-to-machine communications have given rise to the idea of an Internet of Things (IoT) continuously sharing data with each other.

Supporting the IoT are newer, faster, and more interoperable technologies backed by open communications standards and ubiquitous connectivity. What's more, emerging cloud technologies have lifted much of the capital and management burdens of procuring and deploying complex hardware and software, making technology solutions less costly, much easier, more capable, and far more scalable. Advanced analytics, for example, are being used for condition-monitoring and predicting maintenance requirements for equipment operating on offshore oil platforms far at sea but with control rooms safely onshore.

Expanding the digital fabric. These technologies have dramatically expanded the digital fabric of the world's factories, warehouses, and the logistics and transportation systems that keep feeder stocks and goods moving between them as well as to markets. Still, for all of digitalization's abstraction and virtualization of processes into software applications, essential data from the physical world would be largely missing if not for field-level data associated with actual objects, whether feeder stocks, containers, tools, work-in-progress, or finished goods in production and supply chains.

Most likely, these objects are on the move, too, which can make tracking them difficult. Fortunately, radio frequency identification (RFID) is a mature and proven enabling technology that can gather and deliver that data to those systems where it needs to go. Ultra-high frequency (UHF) RFID, in particular, offers long read ranges, fast read speeds, and large simultaneous tag-reading capacity to enable more complex applications typical of increasing levels of digitalization.

As this paper will explain, Siemens SIMATIC RF600 UHF RFID solutions have the recently added benefit of being compliant with the 2016 AutoID Companion Specification to the global OPC Unified Architecture (UA) interoperability communications standards. This vastly expands the potential for UHF RFID technology to extend its reach beyond factory floors to cover entire supply chains.

In addition, the RF600 RFID solutions can communicate with the Siemens MindSphere IoT cloud operating system. The latter provides a global platform to manage field-level data across wide geographic expanses, while also applying advanced analytics for real-time asset visibility and predictive capabilities to support more informed and faster decision making.

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Brief overview of RFID and the UHF RFID distinction

With RFID technology, companies worldwide have driven tremendous amounts of variability and errors as well as time and costs from their operating models. They've gained much greater visibility and asset utilization. They've also achieved levels of traceability that weren't possible before. All this has helped them to realize big improvements in speed, quality, and profitability.

In addition to these compelling benefits, three key characteristics of RFID technology have helped to drive its widespread adoption:

- RFID readers can query tags and extract information from them without the line-of-sight requirements of bar codes, an optical technology. Most tags can be written to, as well, updating status for historical and traceability purposes.
- Tags can provide much more information than bar codes, up to 4KB with UHF tags, which contain a small antenna and microchip with a unique 96-bit or 240-bit EPC identifier.
- Continuing advances in RFID's technology, especially those lowering its costs and expanding its capabilities, which make the business case for RFID much more compelling.

Short history. Although its RF technology roots go back decades, modern RFID started in the 1970s with low frequency (LF) 120-150 KHz applications designed for automatic toll systems, vehicle identification, and many other uses, such as livestock ear tags.

In 2003, RFID adoption accelerated when a set of open global RFID standards debuted that defined unique, universally accepted identifiers – Electronic Product Codes (EPCs) – to be used by high frequency (HF) 13.56 MHz RFID systems around the world. A year later, the EPCglobal Class 1 Gen 2 standard was introduced for RFID using the UHF radio spectrum, 901-928 MHz in North America and 865-868 MHz in Europe. Table 1 below compares the two technologies.

	High Frequency (HF) RFID	Ultra High Frequency (UHF) RFID
Radio Spectrum	13.56 MHz	902-928 MHz (North America) 865-868 MHz (Europe)
Read Distance	4 in. (10 cm) – 3.3 ft. (1 m)	Up to 26 ft. (8 m)
Data Speed	Low to moderate	Moderate to high
Tag memory	Up to 64 KB	Up to 8 KB
Number of tags read simultaneously	Approximately 100	Approximately 1,000

Table 1. Comparison of HR and UHF RFID capabilities

Note that UHF is not a "better" RFID technology than HF, or even LF; it just provides more options and capabilities to extend the already broad range of RFID applications for manufacturing and logistics for even greater operational visibility and control.

Today, EPCs have found their way into a wide range of industrial RFID applications that put them in small transponders known as tags or labels with small radio antennas and data-carrying microchips inlaid in them. The labels can be put in or on goods themselves, on cases of goods, or on pallets holding cases of goods – the three levels of RFID deployment most typically cited.

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Now, an important emerging UHF RFID application tags material containers, too, whether those are massive buckets carrying ore to a smelter or a brewery's barrels carrying beer to a local tavern. This Siemens SIMATIC RF600 RFID application takes advantage of the OPC UA standards and, via the Siemens MindSphere cloud platform, opens doors to RFID's benefits beyond assembly lines to entire supply chains. Among those are:

- Greater transparency in production and logistics
- Enhanced production control and efficiency
- Better inventory management and control
- Increased asset utilization and availability
- Improved tracking and tracing
- Easier regulatory compliance

UHF RFID and OPC-UA – a powerful pair of technologies

By enhancing RFID's enabling capabilities to pull data from physical objects, the release of the OPC UA AutoID Companion Specification for RFID is a technical watershed for RFID applications and, by extension, the IoT as a whole. The OPC Foundation, which developed OPC UA, has active collaborations with many industries, including pharmaceutical, oil and gas, building automation, industrial robotics, security, manufacturing and process control.

For background, the OPC UA standards define a machine-to-machine communications protocol that focuses on linking industrial equipment and systems for data collection and control. Sanctioned as IEC 62541, it builds upon the time-tested mechanics of the OLE for Process Control (OPC) specification. Its advantages include:

- **Open and freely available** for unrestricted use without fees;
- **Cross-platform**, to span programming languages and operating systems, including Linux, Windows, OS X, Android, and iOS platforms;
- **Service-oriented architecture** (SOA), enabling users to model RFID data into an OPC UA namespace;
- **Robust security,** as defined by IEC/TR 62541-2, to provide for authentication, data integrity, and audit ability and guard against such threats as eavesdropping, message spoofing and flooding, and others.

In these ways, OPC UA incorporates all features of OPC classic specifications like OPC Data Access (DA), Alarms and Events (A&E), and Historical Data Access (HDA). It also defines platform independent and secure communication mechanisms. This includes an extensible, object- oriented framework at the field-device level which abstracts the communications layer. As such, OPC UA is directly integrated into the communication interfaces of automation equipment for configuration, diagnostics, maintenance, and of course, online data exchange.

Using the AutoID RFID Companion Specification, Siemens incorporated OPC UA interoperability in the firmware intelligence behind its SIMATIC RF600 line of readers, antennas, and transponder tags and labels. This important feature offers both Siemens and third-party solution designers a common, feature-rich RFID programming interface to take advantage of OPC UA, so the SIMATIC RF600 applications can interact with all kinds of IoT infrastructure, including legacy applications to safeguard prior investments in them.

Ease of use. With its onboard commissioning and diagnostic tools, the SIMATIC RF600 doesn't need PC software to be installed and periodically updated, as that's done automatically. For example, to install and tune a SIMATIC RF600 system, users simply open its user interface via a web browser or the Siemens TIA Portal and simple tuning tools facilitate aligning antennas and calculate the response performance of tags.

Users can initialize tags and edit data content, with access to error logs and diagnostic views, even during production is in operation. If a SIMATIC RF600 device is damaged, it's easily and quickly replaced, because stored parameters are compared automatically. The result is reduced downtime and increased plant availability. Everything is available when it is needed. And data reading results are preprocessed in the reader, cutting the time needed for its integration in higher-level systems.

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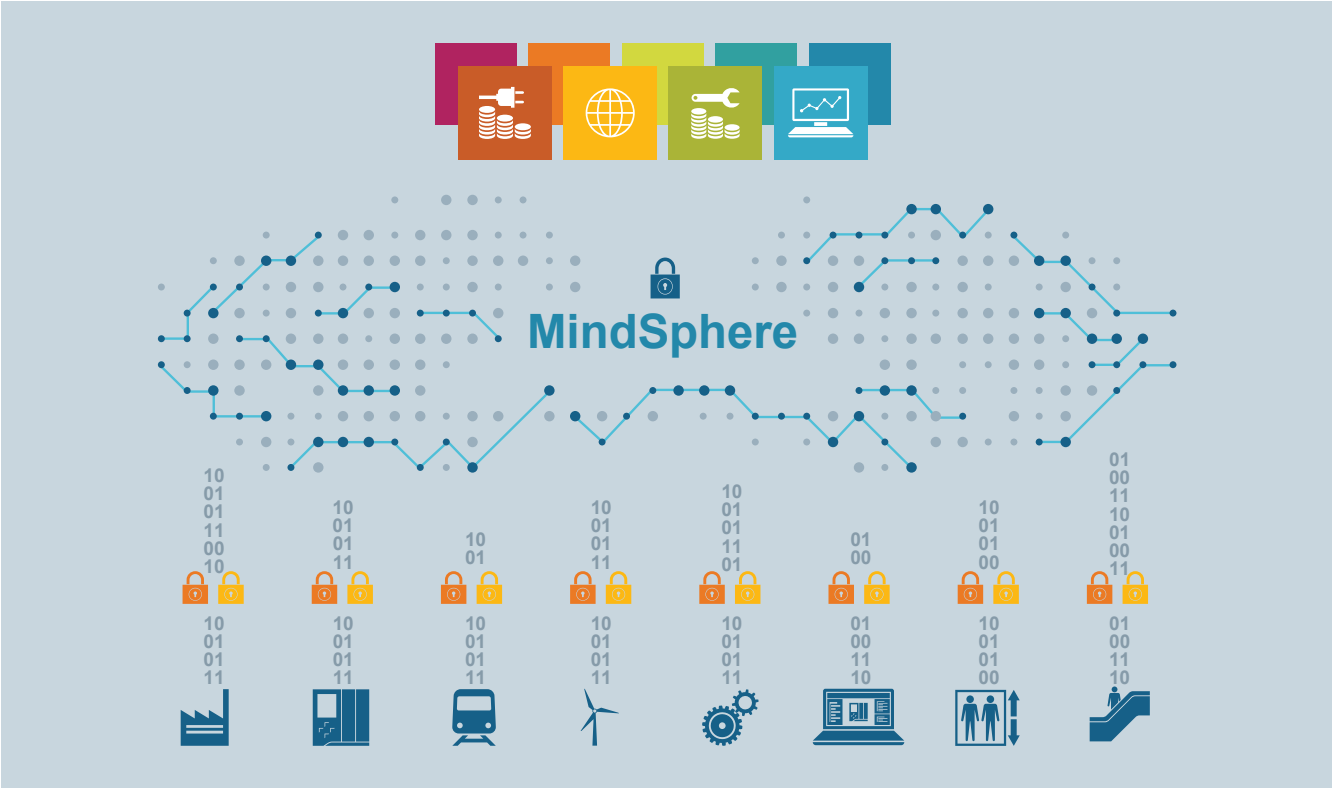

MindSphere – The cloud-based, open IoT operating system from Siemens

Siemens MindSphere takes RFID to IoT via the cloud

Another advantage of incorporating OPC UA into SIMATIC RF600 UHF RFID solutions is this: Field-level data from tools, products, cartons, pallets, and containers can be transmitted to Siemens MindSphere, the highly secure, cloud-based IoT operating system, for real-time analysis and archiving. Analytics, in turn, can support much faster and better-informed decision-making.

MindSphere offers what's called a platform-as-a-service (PaaS), hosted in the global public clouds of Amazon and soon Microsoft Azure, with open interfaces to a growing number of the world's top third-party application developers. Its pay-as-you go subscription model relieves customers of having to incur the capital expense, operating costs, and management efforts of procuring, deploying, and administering complex infrastructure, as previously mentioned.

Iron-clad data security. Customers always own their data, too. Whether encrypted in motion or at rest, data is always protected by the same rigorous cybersecurity standards used by governments and banks worldwide. These safeguards complement the IEC/TR 62541-2 protections of OPC UA, which are coded into the firmware of SIMATIC RF600 components.

Once data reaches MindSphere — via the Siemens industrial Once data reaches Mindsphere – via the Siemens industrial gateway IoT gateway RUGGEDCOM RX1400 with a MindConnect interface or the Siemens MindConnect Nano PC – it can be compared to key performance indicators (KPIs). Application software can flag and, if problematic, then investigated and acted upon right away. What's more, MindSphere is a global platform, so it offers manufacturers and their suppliers, including OEMs, a way to track and trace products much further along their supply chains, if not the entire length from shipping to receiving and while in transit.

Actionable intelligence and real-time decision support

In times past, not knowing about and acting on issues as they occur could be costly. Years ago, a major telephone maker shipped but never could invoice tens of thousands of newly introduced executive desk phones costing hundreds of dollars each because a SKU (stock keeping unit) number was never assigned. As a result, the firm couldn't track down where the individual phones went, resulting in a loss amounting to tens of millions of dollars. Today, this loss could have been avoided with RFID tracking and tracing, and possibly flagged for action much sooner before the first phone shipped.

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By combining OPC UA-capable SIMATIC RF600 technology with the MindSphere IoT operating system, RFID users and OEM solution developers can create greater transparency and visibility into plant availability, asset utilization, and energy-saving potential. The combination also can offer operations planners the means to better optimize production processes and supply chains with a view to improving efficiency, quality, and costs in production, logistics, asset management, and other areas. Tracking and traceability can be enhanced, too.

Another advantage of integrating cloud-based analytics is that multi-site operators can also compare field-level data according to KPI categories of parameters or tools, products, pallets, and containers across plants. That way, they can identify trends and improvement opportunities.

Issues discovered at one facility can alert others to preempt occurrences at other plants. They can also remotely monitor the conditions of feeder stocks, work-in-progress finished goods, plus the tools making them and the containers carrying them, using new predictive analytics about their current and future status.

Ultimately, RFID enhanced with OPC UA interoperability and secure cloud capabilities, such as advanced analytics of field-level data and the actionable intelligence from it, can enable the industrial IoT to deliver on its potential not only for things talking to things, but also things making things. The results will be greater flexibility to respond to customer expectations and market opportunities, a sharper competitive edge, and increased shareholder value.

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Intelligent Container Management with RFID

Like pallets, containers are used extensively in industry, whether carrying ore to a smelter or beer to a local tavern. The first example illustrates container use inside a plant, while the second shows use outside a plant. Tracking the former can be a matter of affixing a read/write RFID tag to it, then monitoring its contents, status, and location as it moves through the facility. But the latter can be more problematic because of their number and diverse destinations.

This asset class – returnable transport items (RTIs) – can also apply to reusable crates used to deliver dairy or bakery goods to supermarkets, or even shopping carts outside in the parking lot. Businesses can have millions of dollars tied up in RTIs and not be clear on their location or status. Some 2 million shopping carts costing $75–100 each go missing every year, according to one industry source.)

With OPC UA-enabled RFID supported by the cloud, such as Siemens SIMATIC RF600 solutions with Siemens MindSphere, RTIs can be much better accounted for using a tag reader at the receiving end that uploads its data to the cloud. Proof of delivery can be certified, reducing errors and helping prevent theft. If a shipment is short its contents, the RFID reader can signal the plant to send the missing items. RTIs can even serve as a fee-based revenue stream through customer chargebacks when they lose the assets or hold on to them longer than agreed. At the very least, the application can help track RTI assets much better and optimize their utilization.

Inside a plant, tagged containers can provide transparency, flexibility, and cost savings. In addition to identity, their RFID tags can contain such data as contents filling date/time, filling status, temperature, quantity, and so on. In food and beverage plants, for example, expensive perishable feeder stocks can be better managed this way, reducing waste and even reducing costly cleaning-in-place requirements.

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