

ABB ABILITY

Leading the way to wireless automation

Can wireless standards meet the performance requirements of fieldbuses, and thereby deliver the wireless automation future? An ABB research team set out to find the answer.

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Factories around the world have been wired for automated controls since the 1970s (digital communication was introduced in 2000s), enabled in large part by standardized communication protocols, called “fieldbuses”, that allow for access to large scale production systems. Somehow, the promises of fieldbuses, such as easy and reliable deployment, use, maintenance, and issue diagnoses have not paid off, as still many installations run on analog 4..20 mA technology, even with smart sensors and actors.

Since wireless devices are around us everywhere, why not use radio communication technology to bypass shortcomings resulting of any wired installations, such as the effort of planning and installing cables, shielding and grounding issues to prevent EMC problems, the lack of flexibility in layout, and complexity in engineering?

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01 The Iggesund Mill
(Image courtesy of
Holmen, photo by Rolf
Andersson, Bildbolaget)

Transitioning to that future will be a challenge, mostly because of the use of competing standards for wireless field devices that were introduced in the late 2000s (mainly for monitoring appli-

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cations), and the simple fact that also a wireless fieldbus must operate reliably within explicit performance boundaries. For instance, the lag consumers are accustomed to tolerating in updating a smartphone screen could cost a manufacturer time, money, and even customers.

The wired vs. wireless challenge

The ABB team tasked with the research project knew that the current wireless standards presented many performance characteristics that needed to be challenged when addressing control applications:

Timeliness. Controlling large-scale industrial processes poses new requirements on the current wireless standards, which need to provide determinism and reliability on par with current fieldbus standards (for example, qualify for use in sub-second closed loop control of safety-critical equipment). Timeliness also means that any extension of wired fieldbuses need to be commissioned, deployed, maintained and diagnosed in a simple and efficient manner.

Visibility. Since there are some installations where parts of a plant are controlled based on instrument readings using current wireless standards, it's vital that control engineers know how data have been gathered and delivered. This is especially true when control algorithms have been modified to compensate for the additional uncertainties and delays commensurate with existing wireless tools. Deployment of some kind of data identification is required in the control system in order to prevent using the wrong algorithm(s).



THE DIVERSITY OF TODAY'S INDUSTRIAL WIRELESS PROTOCOLS

Industrial wireless sensor networks have been around for a number of years. Three standards dominate the automation market: Wireless HART, ISA 100.11a and WIA-PA. The Wireless HART standard, released in 2008, currently has the largest installed base, and all three are based on the same underlying 802.15.4 technology. The main applications for these standards are for process monitoring, but they can also be used to deliver sensor measurements for slow and non-critical process control.

There are many similarities among the three standards, but also some key differences. All three standards rely on the underlying physical layer of IEEE 802.15.4 that provides 250 kbit/s on 15 globally allowed channels in the ISM band, for instance.

One area of differentiation is in the standards for TDMA slot lengths (variable or fixed). Another is frequency hopping, as WirelessHART uses a fixed channel hopping table, but ISA 100.11a and WIA-PA have multiple channel hopping tables including the one used by WirelessHART.

From a topology perspective, they all use mesh networks, but WIA-PA uses distributed cluster heads that differentiate from the other two standards. When it comes to routing of packets, WirelessHART and ISA 100.11a use graph routing and source routing. WIA-PA uses a slightly different strategy due to the use of cluster heads, namely a mesh start routing approach since the field devices are organized in clusters. The real differences emerge in node addressing. ISA 100.11a uses IP addressing, and the others use their own proprietary solutions.

Responsiveness. Some of the most obvious limitations of the current standards are the lack of support for actuators and use of fail-safe states. For instance, having a TDMA layer instead of a CSMA doesn't guarantee predictable and consistent error detection on system level. In the same

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way, the self-healing properties of today's mesh networks are neither proactively nor reactively able to recover from link or network failures within the required deadlines for critical control applications. Any wireless network should self-heal without dropping packets, as the current redundant fieldbuses do.

Delineation. Another important characteristic that is missing in the current wireless standards is the ability to distinguish between real-time data and best-effort data. Device configuration data has to be end-to-end acknowledged before real-time communication can be used for control; otherwise, dangerous situations can occur since there are no guarantees that the information transmitted can be trusted or is properly scaled. On the other hand, real-time data for control loops may be outdated when queued together with best effort data. None of the current wireless standards provides real-time functionality as the fieldbuses do.

Based on the analysis of the current wireless fieldbus standards, ABB implemented improved stack layers on top of IEEE 802.15.4 in order to overcome the shortcomings. Tests in the lab showed such promising results that the idea was born to verify the approach in a running process plant. Iggesund Paperboard shared the innovative spirit and agreed to support such a field trial.

From modeling to reality

Iggesund Paperboard makes two of the world's leading paperboard brands, Invercote and Incada. Its Iggesund Mill →1, located approximately 300 km north of Stockholm, Sweden, began operations in 1916, and is now one of the most advanced, fully integrated pulp and paper mills in the world.

The field trial phase was designed to be very short; it lasted little more than six weeks. ABB collaborated with its partner to design test criteria that helped ensure the accuracy of the results while minimizing interference with the plant's operation; for instance, operators were not noti-

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fied when data were being transmitted wirelessly, so the data from the historian server provided an objective comparison between wired/wireless performance, instead of relying on the gut reactions of humans to the novel technology in their plant.

Specific technical details tracked in the test illustrate any trade-offs between TDMA slot length, transmission rate, and level of redundancy, along with an overall expression of availability (e.g. the number of communications failures) and end-to-end latency.

The setup involved three wireless control loops (temperature, flow, and pressure) utilizing three wireless instruments and actuators, connected to System 800xA via a Profinet IO-enabled gateway. The control loops are executed in ABB's AC800M Controller at a 250 ms period. The production system operated in batch/sequence mode, feeding information to ABB's system for full integration (thereby keeping the operator environment unchanged).

The findings

Pressure control. The performance of the pressure control loop quickly responded to process disturbances introduced by the sequence control in the batch process, and was stable in a fully wireless control loop.

Flow control. The flow controller was also stable but was subject to fewer process disturbances compared to the pressure controller. Only during the cleaning sequence at the end of a batch larger disturbances had to be controlled.

Temperature control. From a safety perspective, the most challenging control loop is the temperature controller since it injects high pressure steam into the boiler. From a control perspective it is the least challenging control loop.

Latencies. The average latencies for real-time and non real-time traffic showed that, when similar transmission and retransmission strategies as the wired fieldbuses were used, the latencies of the delivered real-time packets were small and had minimal variations.

Packet loss. During the measurements, only single occasional packet losses occurred, and the failsafe mechanisms were not triggered by three consecutive packet losses. Only three real-time packets were lost during an eight hour measurement period, which is comparable to current fieldbuses.

One final assessment from the feasibility study was to ask the operators if they could see any difference either in the control performance or the final quality of the material from the batch process. After carefully studying the data from the historian, they concluded that they couldn't.

The transition to wireless

The ABB feasibility study indicated that, with a carefully designed wireless protocol stack, it is possible to use a standard IEEE 802.15.4 radio transceiver, a real-time operating system and a stack designed for control applications to control a small part of a production plant. Perhaps more important is the finding that it is possible to achieve performance levels up to par with PROFIBUS or other modern fieldbuses.

ABB's research revealed important areas for future exploration, as it continues its work leading the way to wireless automation. ●