WHITEPAPER: WIRELESS

Wireless Technology is a key driver in the future of industrial applications

What are the benefits of Wireless Technology in industrial applications?

Wireless technology has always had lots of benefits compared to traditional cabling. Now the technical improvements in both 5G and Wi-Fi 6 make wireless technology an even more appealing choice for industrial applications, as Oliver Hammarstig explains.

If we ignore any technical requirements for a moment, the benefits of wireless solutions over traditional cabling are numerous and significant. To start with let's imagine a smart factory offering true flexibility where Automated Guided Vehicles (AGVs) can go wherever needed all day, every day, where robotics work collaboratively to optimize production. This flexibility and automation are not possible without a wireless solution. Companies are increasingly asking for more flexibility and automation so they can create customized products at a quicker pace.

Enabling them to increase productivity and reduce the time to market so they can meet tight market windows. Wireless technology can provide the answer as wireless technology facilitates flexible and automated solutions. With wireless solutions, users can access and manage or monitor equipment remotely, which in turn offers lots of benefits, such as increased personal safety or comfort. There is no need for personnel to climb a long ladder, descend into the depths of a mine, or enter any other unpleasant or potentially dangerous environment to check on an equipment.

In this white paper, we answer the following questions:

- What are the benefits of wireless technology in industrial applications?
- Why haven't industries already moved to wireless solutions?
- What are the key differences between 5G and Wi-Fi 6 and their predecessors?
- What are the similarities and differences between 5G and Wi-Fi 6 and how will they be used in industrial applications?
- Does Anybus have any use case examples showing wireless solutions?

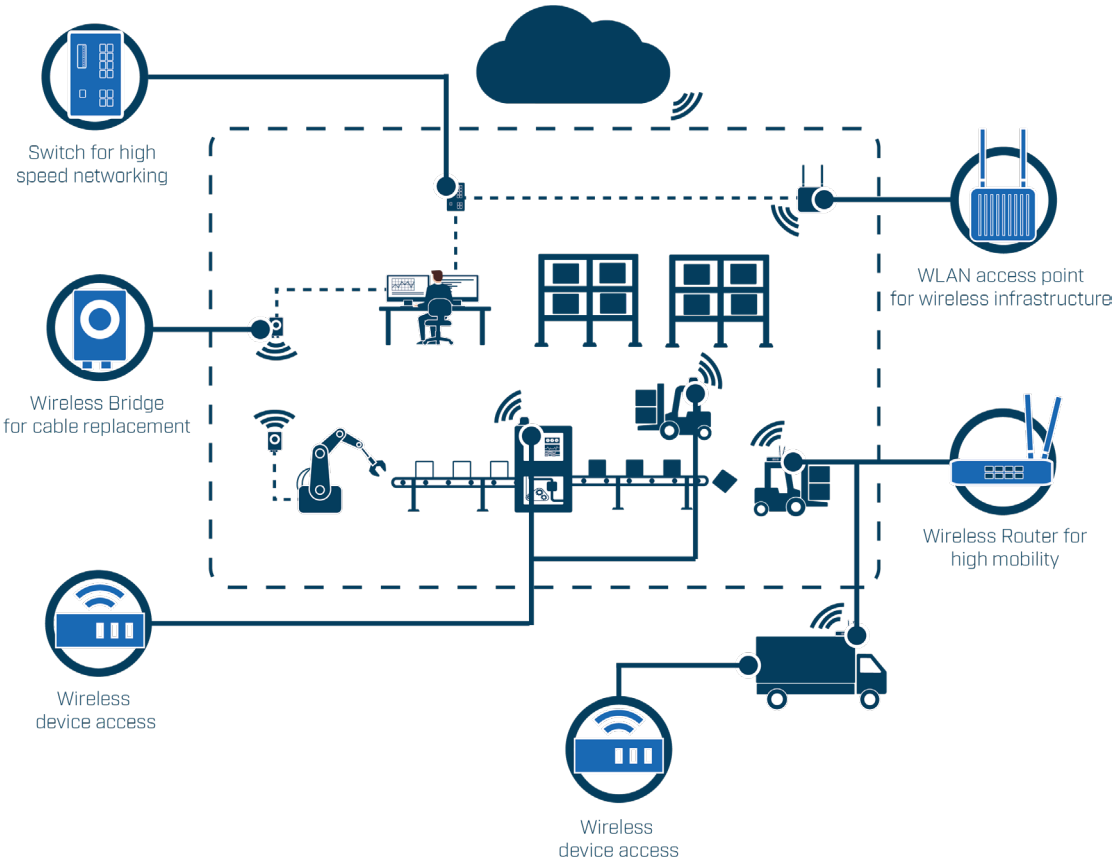

Figure 1. Using wireless technology brings many benefits such as flexibility, automation, and remote management or monitoring

It's possible to access the data remotely and in real time allowing companies to analyze the data and conduct predictive maintenance to prevent unexpected downtimes. Some factories, such as Hitachi are now using AR and creating digital twins to constantly monitor equipment and collect live data so they can quickly spot problems and take the required actions before the problems impact productivity [1]. If the equipment is connected to a WAN, then there's no need to even be near the equipment and as a result you can reduce the cost and the inconveniences of travelling.

It's also easier to use the equipment. You can Bring Your Own Device (BYOD) and access an easy-to-use Human Machine Interface (HMI) to monitor or configure the equipment rather than having to use a Command Line Interface (CLI) onsite.

The younger engineers, who grew up using smartphones, are more comfortable using an HMI rather than a CLI so this option is becoming increasingly important as the number of younger engineers in the market increases.

On top of the reduction in travel, there are also other cost benefits. Wireless solutions are cheaper to install and easier to scale or modify. Maintenance costs are also reduced. As you don't need to manually connect to the equipment, the connectors are less likely to be damaged from constant use. Replacing worn or damaged cables is no longer a concern, as you're using the electromagnetic spectrum which doesn't suffer from wear and tear as cables do.

Finally, wireless technology can be used in situations where it's hard to use traditional caballing. For example, in the oil industry or maritime logistics where installing miles and miles of underwater cables is not possible and a more practical solution is to connect devices wirelessly to a base station or satellite.

Automation	- Equipment can work all day, every day
Flexability	- Greater mobility and freedom of movement - Collaborative robotics
Remote Managment & Monitoring	- Reduce workers' exposure to unpleasant, dangerous, or busy industrial environments - Reduce travel - Better access to data enables predictive maintenance, for example via Digital twins
Ease of Use	- Use a Human-Machine Interface (HMI) rather than a CLI - BYOD to access the equipment
Reduced Costs	- Cheaper to install - Easier to scale or modify - Cheaper to maintain – no need to replace worn cables, reduce wear & tear on connectors
Long distance communication	- Enables communication over long distances which can be difficult for cables. Example use cases, maritime transport or oil industry

Figure 2. Benefits of Wireless technology compared to traditional cabling

Why haven't industries already moved to a Wireless solution?

The common reasons why companies still use wired solutions rather than wireless solutions fall into two broad categories. The first category is one of apprehension. There's a fear of change, a fear of stepping into the unknown, a concern that the transition will be complex. The second category is about the technology. There's a concern that the wireless technology is not good enough. The latency too high, bandwidth too low, or the connection is not stable or secure. Both concerns are understandable, but let's look at each in turn.

Fear of Change

The fear of change makes sense, a common mindset in the industry is “if it’s working don’t break it.” This mindset is understandable as caution is fundamental in industrial applications, we want to ensure safety and prevent downtime. But the transition from cables to wireless does not need to be complex and wireless solutions are already in use. It’s not a step into the unknown. There are companies such as Anybus with years of experience who can help with the transition.

Concern that wireless and cellular standards don’t meet the requirements

This concern is getting less valid with every wireless advancement. The key thing is to establish your requirements and then look at the options, including the wireless and cellular standards. If stability is key, the amount of data is low, and no internet connection is required, then Bluetooth is a good choice. If you need an internet connection but with low bandwidth, low cost, and low power then a cellular connection using Low-Power Wide-Area Network (LPWAN) standards is an excellent choice. If you want low latency, high bandwidth, and high security then the newer wireless solutions may meet your needs, and this is where wireless solutions will be a key driver over the next few years. The advancements of 5G compared to 4G and Wi-Fi 6 compared to Wi-Fi 4 and 5 enable more industrial applications to cut the cables and install a wireless solution as the wireless technology can meet more technical requirements. This means that more industrial applications can take advantage of the benefits of wireless solutions which we outlined above such as automation, flexibility, and remote management.

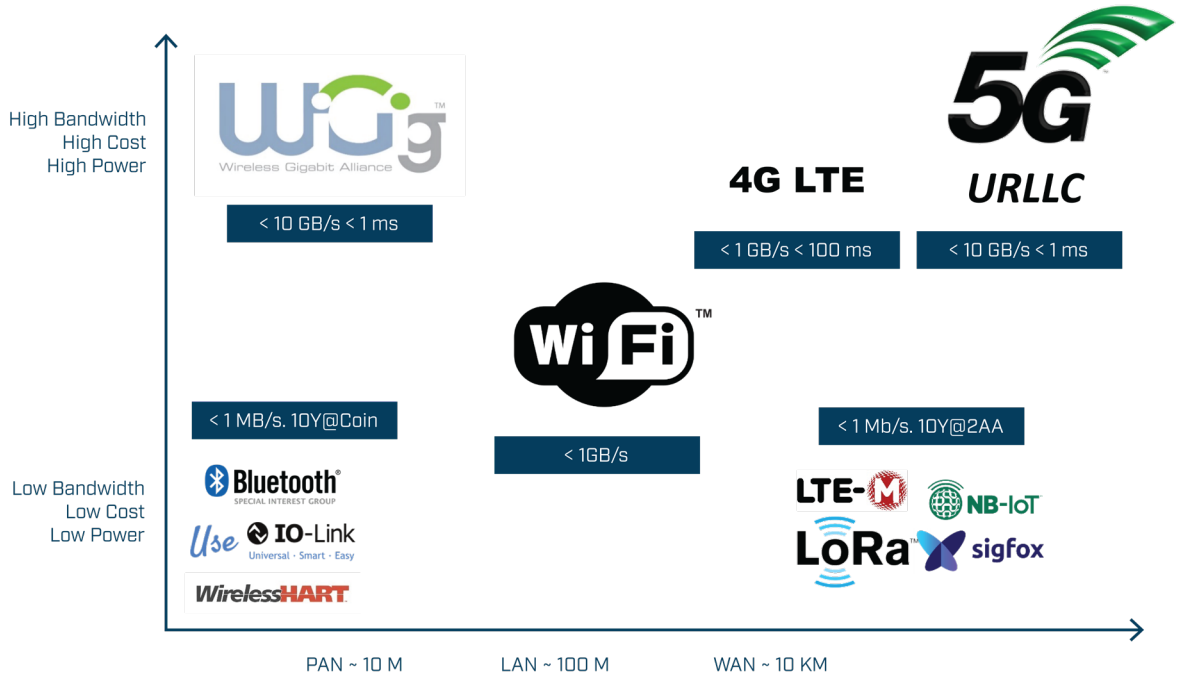

Figure 3. Wireless and Cellular standards

What are the key differences between 5G and Wi-Fi 6 and their predecessors?

Comparing 5G with 4G

Let's start with 5G. 5G is not just an incremental improvement over 4G LTE, it's the next major evolution providing significant improvements such as fifty times more speed, ten times less latency, and thousand times more capacity.

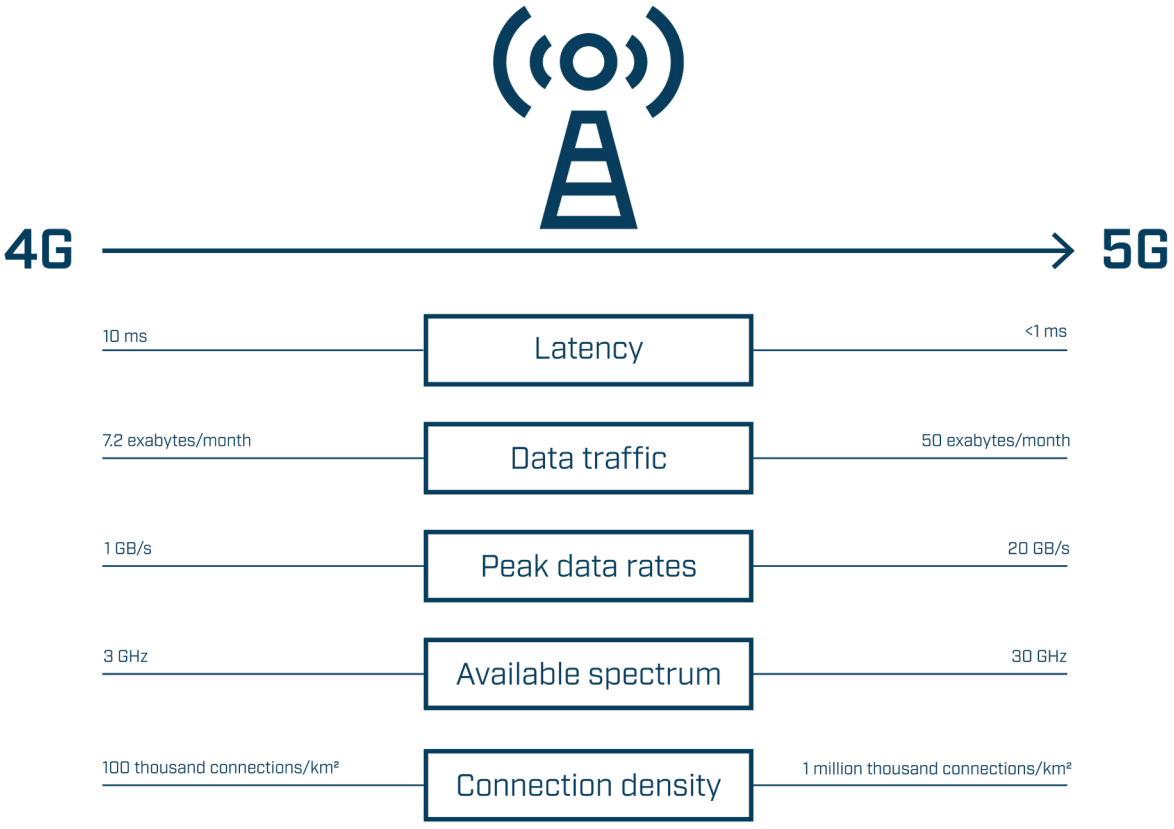

Figure 4. A comparison of key 4G and 5G parameters

In industrial applications this opens lots of possibilities. Anybus have already published a whitepaper explaining how the improved technology will benefit factories [2] and now we are starting to see those benefits in action. Volkswagen, for example, have created their own 5G network where the increased speed and capacity, and reduced latency enable robots to complete complex tasks which would have been impossible on a 4G network [3].

But it's important to note that 5G does not mean that there is no place for 4G LTE in the industrial applications. LPWAN standards such as LTE-M, and NB-IoT can provide the wireless connections required for Massive IoT applications where low cost, low energy, and small amounts of data need to be sent over massive distances. Whereas 5G can be used in Critical IoT applications where reliability, low latency and high availability are required.

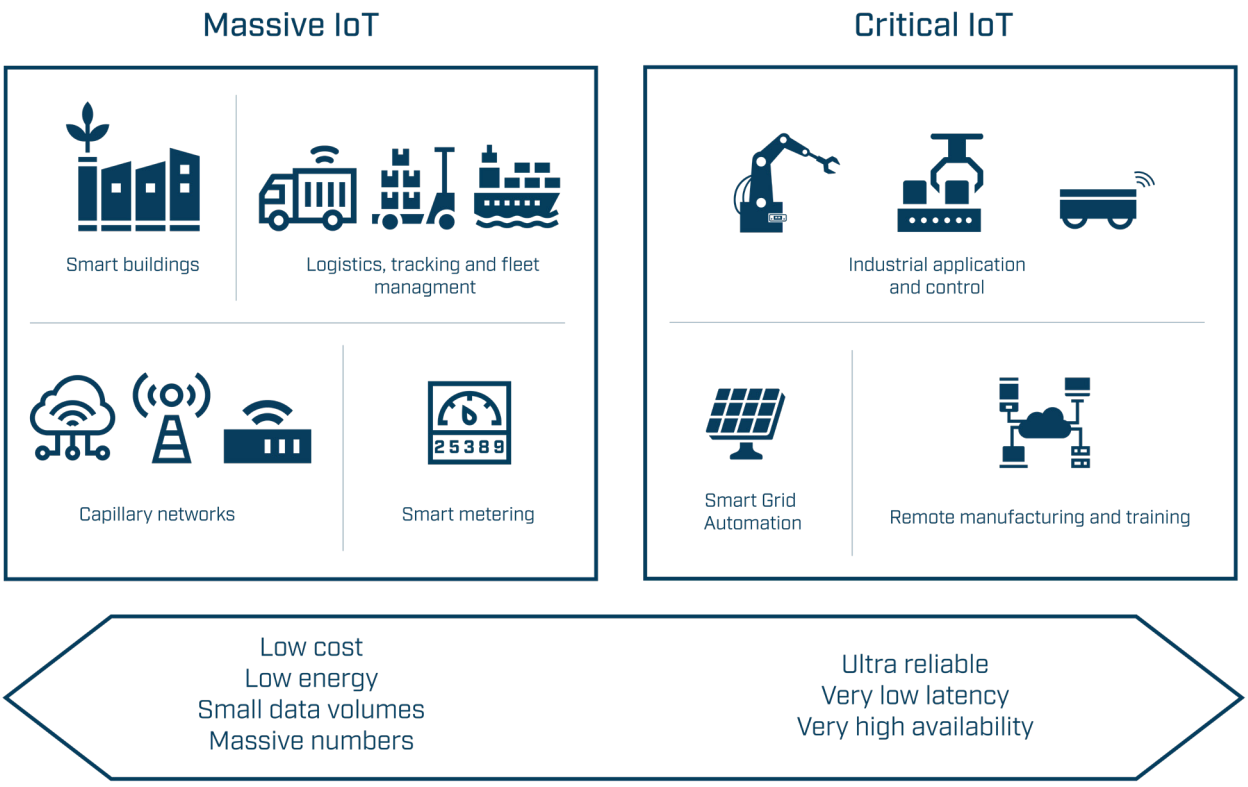

Figure 5. Massive IoT and Critical IoT applications

Comparing Wi-Fi 6 with Wi-Fi 5 and Wi-Fi 4

Wi-Fi technology is improving with each generation offering higher speeds, larger capacity, better efficiency, wider coverage, lower power consumption, smarter management, and the ability to serve more devices simultaneously.

Feature	Wi-Fi 4	Wi-Fi 5	Wi-Fi 6
Channel bandwidth (MHz)	20, 40	20, 40, 80, 80 + 80, 160	10, 40, 80, 80 + 80, 160
Frequency bands	2.4 and 5 GHz	5 GHz	2.4, 5 and 6* GHz
Maximum data rate	150 Mbps	3.5 Gbps**	9.6 Gbps**
Highest subcarrier modulation	64-QAM	256-QAM	1024-QAM
Spatial streams	1	4	8
Underlying technology	IEEE 802.11n	IEEE 802.11ac	IEEE 802.11ax

** Wi-Fi 6E only*
*** Depending upon number of spatial streams and channel used*

Figure 6. Wi-Fi 6, Wi-Fi 5, and Wi-Fi 6 comparison

The areas with the quickest uptake of Wi-Fi 6 technology are likely to be public Wi-Fi and the home market as with Wi-Fi 6 it's now possible to connect more devices simultaneously and still have a stable and fast connection. In fact, sports stadiums have already successfully used Wi-Fi 6 [4]. Industrial applications will of course also benefit from the technological advances. Applications using virtual or augmented reality such as digital twins for remote monitoring will appreciate the higher throughput and lower latencies on offer. Smart management techniques such as the Target Wake Time (TWT) feature will reduce energy consumption as the devices will only be active when they need to send or receive data, this will be a key benefit to anything battery powered. While the number of devices and density of devices in industrial applications won't match the numbers in sports stadiums, the numbers will still increase. When that happens the industry will benefit from Orthogonal Frequency-Division Multiple Access (OFDMA), Multi-user, multiple-input, multiple-output (MU-MIMO), Basic Service Set (BSS) coloring, and spatial reuse techniques which allow a high number of simultaneous connections while avoiding interference.

Companies that want to maximize the potential of the new techniques should consider Wi-Fi 6E. Wi-Fi 6E has access to a previously unused frequency band, 6 GHz, in addition to the 2.4 and 5 GHz frequency bands. As a result, Wi-Fi 6E devices can use seven additional 160MHz channels which means that Wi-Fi 6E devices are less likely to suffer from interference and will enjoy a more stable connection at higher speeds.

One thing to note is that Wi-Fi 6E is not backward compatible, it will only support the 802.11ax standard. But this lack of backward compatibility is a good thing in terms of performance. Trying to support old generations has often prevented devices from taking advantage of new techniques. By removing these constraints Wi-Fi 6E will be able to utilize OFDMA and similar improvements to offer users a better connection.

What are the similarities and differences between 5G and Wi-Fi 6 and how will they be used in industrial applications?

As we've seen both 5G and Wi-Fi 6 are significant improvements on their predecessors and as a result, both offer opportunities for industrial applications. Whether you should choose 5G or Wi-Fi 6 depends on the use case.

Generally, Wi-Fi 6 provides an internet connection either indoors or in defined high-density outside areas such as stadiums. Whereas 5G provides an internet connection to all other outdoor areas, including vehicles or people on the move. On that basis, a typical industrial use case for 5G would be to remotely track vehicles on the move. While a typical Wi-Fi 6 industrial example would be to provide internet connectivity to capillary networks or any other indoor application falling under the Massive IoT umbrella.

But as always, before deciding on the best solution it's important to go into more detail and check your requirements. Wi-Fi 6 is cheaper to install and scale so if your intended application is indoors or in a high density outside area and Wi-Fi 6 meets the requirements, choose Wi-Fi 6. But if your requirements are more demanding and fall into the critical IoT category then cellular is a better choice even if your installation is indoors. For example, low latency is essential to critical IoT applications, and although latency has improved in both Wi-Fi 6 and 5G, the supported levels are lower in 5G. Wi-Fi 6 supports latency down to twenty ms, but 5G supports latency down to ten ms meaning that 5G is now a viable option for all but the most demanding critical IoT applications.

Cellular networks also offer other advantages compared to Wi-Fi. Cellular networks are more secure and easier for operators to control. Cellular networks use licensed spectrum bands which allow operators to exclusively manage their network enabling them to fulfil critical capacity requirements. With cellular networks it's easier to limit unauthorized access, possible to use network slicing, and possible to separate uplink and downlink data.

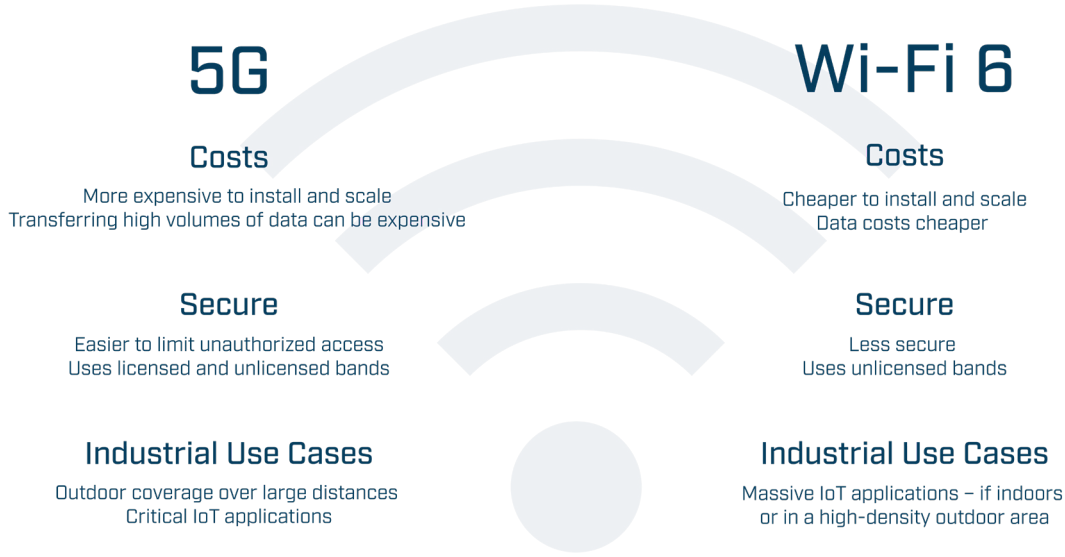

Figure 7. Comparing 5G and Wi-Fi 6

Does Anybus have any use case examples showing wireless solutions?

Yes, we have lots of different use cases where customers have benefited from implementing wireless solutions. Here are some use cases showing a Bluetooth, Cellular, or Wi-Fi wireless solution.

Bluetooth use case

We attached an Anybus Wireless Bolt to about 40 AGVs in a modern automotive factory in Germany to enable the automated transportation of automotive parts from the loading dock to the assembly line. The Anybus Wireless Bolt communicates via Bluetooth to an Anybus Wireless Bridge in the ceiling of the factory on a LAN. Data exchange includes position, cargo, energy levels etc., which enable the control system to ensure that the AGVs are in the needed location and don't crash. In this use case, Bluetooth technology supplied a low power consumption, low cost, and low interference solution enabling the customer to enjoy the benefits of automation, including increased productivity.

Figure 8. The Anybus Wireless Bolt is attached to an AGV and uses Bluetooth technology to safely move around the factory

Cellular uses cases

Low Bandwidth, Low Cost, Low Power

The Anybus Wireless Bolt IoT provides an internet connection with a low bandwidth, low cost, low power consumption solution. A typical use case is for devices and machines that are not connected to the electric grid, such as battery powered traffic signs.

Figure 9. Battery powered traffic sign with an internet connection

High Bandwidth, High Cost, High Power

Lundin Mining AB wanted a wireless solution in a tough environment which was connected to the internet to enable remote monitoring of the water level and temperature in a deep underground mine. They were also keen to use a little cabling as possible. The Anybus Wireless Bolt LTE solved all those requirements and by using PoE technology the customer used only one cable for data and power.

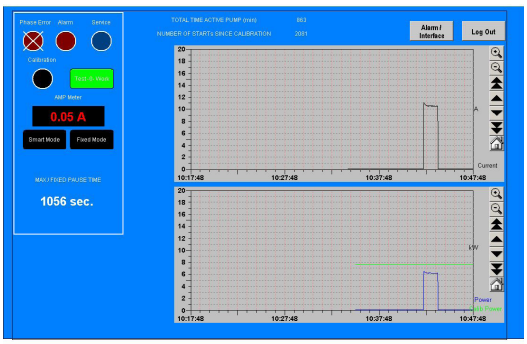

Figure 10. The Anybus Wireless Bolt LTE attached to the control unit

Figure 11. Dashboard used to remotely monitor water levels and temperature

The Anybus Wireless Bolt LTE has also been successfully used by DVi Innovation Inc to remotely analyze rocket engine emissions. They chose the Anyway Wireless Bolt as it can be used for both low bandwidth communication, such as MQTT, as well as connections which require more bandwidth such as firmware updates or video transmissions.

Figure 12. The dashboard showing the level emissions

Figure 13. The Anybus Wireless Bolt LTE attached to the control unit

Wi-Fi use case

The Bluetooth use case we mentioned from the automotive factory was also a Wi-Fi use case as the Anybus Wireless Bolts connected to a LAN. That use case showed how wireless technology can be used with AGVs to help companies implement an automated solution. Another Wi-Fi use case is to mount an Anybus Wireless Bolt to a machine to give the machine access to a LAN in a brownfield application. This provides three main benefits. Firstly, it's a retrofit, so the solution provides network access to legacy equipment without replacing the legacy equipment. Secondly, it saves money as the legacy equipment can be re-used and cabling is not required. Cabling is expensive to maintain as the cables become worn over time and need to be replaced. Thirdly, it provides network access to a machine that is in a difficult-to-reach area. For example, there's no need to open a cabinet to connect to the machine, as it can be accessed remotely.

While the Bluetooth use case showed how wireless technology can be used to implement an automated solution. This brownfield use case shows how wireless technology can be used to connect to machines without any physical access, useful when the machines are in hard-to-reach areas or unpleasant environments, and to reduce costs in buying new machines or maintaining expensive cables.

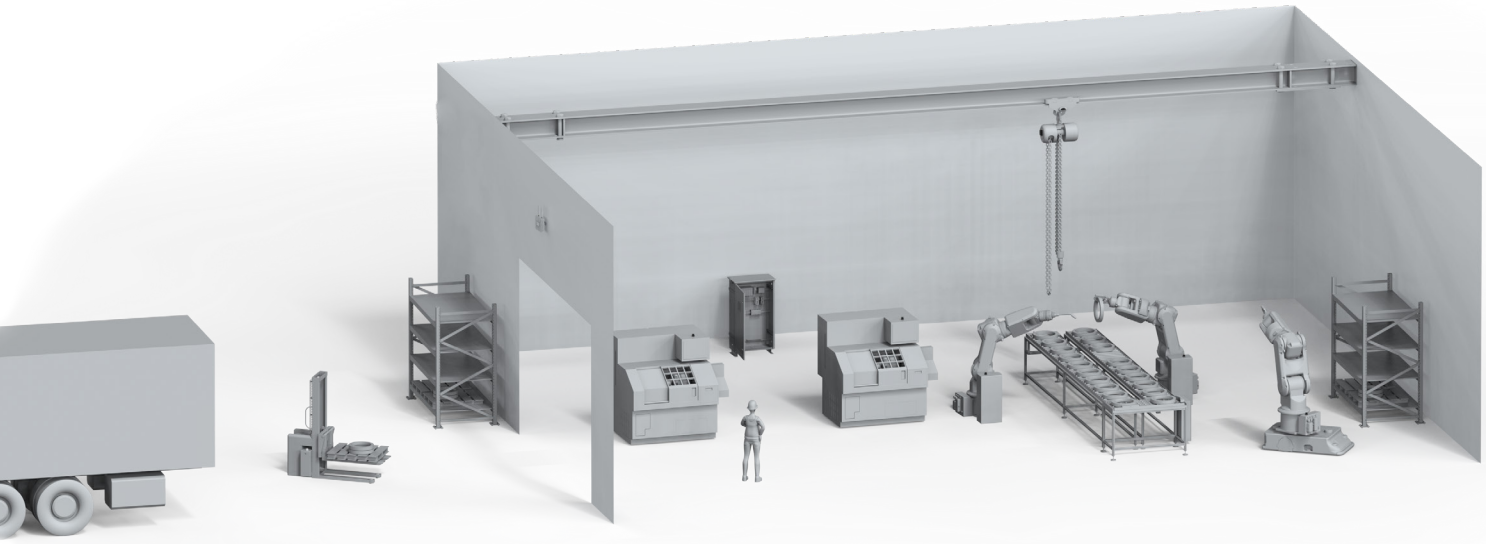

Figure 14. The Anybus Bolt can give LAN access to legacy devices in a brownfield application

About the author

Oliver Hammarstig is the Product Line Director for Wireless technology at HMS Networks Business Unit Anybus in Halmstad, Sweden. He has been working with various wireless technologies for over 16 years and has experience in a variety of industries, each focusing on different technologies, ranging from military communications to commercial telecommunications. Now he is working with wireless communication in industrial environments

www.hms-networks.com

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