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Make the IoT Work with Industrial Wireless Sensor Nodes

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The Internet of Things, (IoT) is both a large industrial opportunity and a huge industrial challenge. Applications of the IoT include everything from smart cities to cattle roaming the range, with distributed facilities like wind farms and pumping stations also part of the mix. In these and other areas, the ability to gather data from a wide array of devices opens the door up to better monitoring and optimization of performance as measured by output, return on investment or other metrics.

However, to achieve the maximum IoT benefit, there must be a dense sensing network because that is the best way to collect the required data. This leads to multiple challenges: dealing with a variety of equipment and signal types, managing complex communication, deploying expensive transmission cables, handling a harsh environment and tight installation space.

These challenges act as barriers to implementing an IoT strategy, but they can be overcome with the right technology. Of particular importance is the communication protocol and scheme, which should be wireless. It also should be capable of cost-effectively meeting the requirement of wide area, long distance coverage but low data rate communications. Such a capability can be combined with flexibility, cloud integration, standard communication protocols, and a rugged implementation to create a solution to the barriers standing in the way of IoT deployment.

This paper will explore how to make the most of the IoT, examine the barriers to its implantation, outline what a solution should look like, and offer a real-world example solution.

Making the Most of the IoT

The IoT has generated considerable interest, and it is easy to see why. On one hand, the business opportunity is significant. For instance, the number of connected devices is expected to nearly triple from 2016 to 2021, rising from 17 to 45 billion units worldwide. During that time, IoT global software revenue will more than double, climbing from just under 35 to about 80 billion US$.

As a result, there is a ripple effect that is moving through various industries. Some are reacting because they will supply the devices that form the basis for the IoT. For example, the semiconductor industry is looking to the IoT as a key driver for future growth, fueled by the demand for sensor, communication and processor chips. In other industries, the focus is on IoT applications, with 70 percent of companies responding to a survey saying they are either implementing or exploring IoT uses.

The list of possible IoT applications includes smart cities, with sensor arrays being deployed, for example, to make traffic counts. Some of these systems are for keeping track of cars, trucks and buses. In other cases, the sensors are counting bicycles. The choice of which type of vehicle to count depends upon the local traffic patterns. In some cities, a significant number of commuters use something other than automobiles and mass transit. The key, in any case, is to capture data that can then be used to make travel more efficient. A similar approach can be implemented for other urban infrastructure, such as lighting, utilities and communications.

Other IoT usage scenarios are in wind farms, pipelines, pumping stations, large factories and elsewhere. Consider, for instance, a wind farm that consists of many turbines situated over large areas of land in a remote location. Each turbine undergoes varying acceleration, temperature and vibration as wind speeds change. What's more, each turbine may have hundreds of sensors that capture this information. Collecting and analyzing this data enables real-time adjustment, such as changing the angle of the blades and altering other turbine operating parameters. That can up power production by 15 percent or more, if these changes are done in real-time using IoT-sensor data and analytics.

Efficiency improvements are also possible for pipelines, pumping stations, factories and elsewhere. Like wind farms, these applications tend to be dispersed over wide areas and may be found in remote locations. These applications, along with those in smart cities, have another characteristic in common: they benefit the most if there is a dense sensor network. In the case of traffic monitoring, for instance, every possible path should have a sensor on it before and after every intersection, along with other sensors spaced periodically along each potential route. That is the only way to see not only how traffic flows but also where vehicles are coming from and where they are going. What's more, since the traffic flow changes over time, the sensors must also capture and report the data often enough to paint a true picture of what is going on.

In addition to sensor density, there must also be a wide variety of sensors. As the wind turbine example shows, there may be many parameters that should be monitored. In the case of traffic, not only the number but type of vehicles may be critical for optimization. So, to make the most of IoT deployments, it is important to have as large a sensor array as possible as a foundation. There also must be a mix of sensors so that a complete picture of the process being monitored can be built up.

Barriers to implementing IoT

A sensing network of sufficient density and scope is, therefore, a first step and vital to maximizing IoT benefits. However, deploying a proper sensing network is difficult due to

- Complicated hardware and integration issues
- Varying equipment and diverse signal types
- Transmission and power supply cable challenges
- Harsh environments with small spaces for equipment
- Communication standards that are complex and hard to integrate
- The need to cover wide areas cost effectively

Consider the first two of these items: **complicated hardware and integration issues along with diverse equipment and signals**. They are related, in that a wide variety of sensors are likely needed. It may be necessary, for instance, to measure stress, strain, temperature, wind speed and other parameters in an application. By necessity, collecting this data will typically mean that different sensors will be deployed, despite a desire and efforts to avoid doing so. A wide variety of sensors often means that information will be carried on different signal types, with varying values and meanings for what is a full-scale reading and what is a minimum reading.

All of this leads to a complicated assortment of hardware and associated integration issues. This can be particularly difficult when many different sensor networks are being deployed, such as is likely to be the case for smart cities and large factories. A smart city, for instance, could have sensors on every utility pole, water line, traffic light and more. In the case of a manufacturing plant, which may have machines and tools from many different vendors, each machine or tool could be equipped with its own sensor array. So, the requirement of getting enough data runs into some real-world challenges.

That also is the case for the next two items on the list, **putting in cabling in harsh environments and small spaces**. Data generated by every sensor must be sent to some location for analytics and storage. If not done wirelessly, this means that there must be a transmission cable. There often may be a need to run a power cable as well, if the sensor is not battery operated or does not employ a photovoltaic or other local source of power. Laying cable can be both difficult and expensive. The cost of putting down fiber optic cabling in urban areas can run in the tens of thousands of dollars per mile in the United States, for instance.

In the case of IoT sensing devices arrays, any cabling must also often go into harsh environments, where wide swings in temperature and humidity may take place along with exposure to dust, vibration and chemicals. A large food and beverage processing factory, for example, may be subject to periodic cleaning by soaps, chemicals and water. In such industrial settings and other locations where an IoT sensing network is deployed, the available space for the sensors may also be severely constrained, making installation of the sensor and any cabling a challenge.

The final set of barriers include **communication standards and the need to cover a wide area**. The communication standards issue arises because there will be a wide variety of sensors and, consequently, many different communication protocols. As is the case with hardware, this complexity in communication standards makes it difficult to integrate everything into a total and complete solution.

As for the wide area and long-distance coverage requirement, this must be combined with distributed data transmission at a reasonable cost. Consequently, some frequently used wireless solutions, Wi-Fi and cellular

3G, are not suitable. Any of these options would be able to support the needed data rates, which for IoT sensing devices may only be relatively low total number of bits per minute. However, existing Wi-Fi only works for short distances of a few tens of meters (less than 100 feet). Cellular connections typically have high data transmission fees, which rules them out.

An ideal IoT solution

What would an ideal solution to these barriers look like? It should be

- Highly flexible
- Provide wireless transmission over both wireless Ethernet and LPWAN (low-power wide-area network)
- Integrate with the cloud
- Support standard communication protocols
- Be rugged, with, for example, IP65 grade protection against water and dust

Flexibility is important because, as noted above, any solution that helps make deployment of an IoT sensing network easier must accommodate a wide variety of devices and types of sensors. This can only be accomplished when a solution can be configured to accept and work with as many different sensors as possible. An IoT sensing network solution must work with many different devices on the input end of the sensor array. An ideal solution would also need to interface with as wide a variety of devices and schemes on the output end as well.

It is critical that an ideal solution have the right wireless transmission capabilities, which is where wireless Ethernet and LPWAN come in. The first has limited range, offers high data rates, real-time transmission and is standard in offices and some industrial settings. Despite its limited reach, wireless Ethernet may be the best choice for an IoT sensing network in the right circumstances. However, LPWAN has been designed for long range communications at low bits rates and at a low power consumption, which could be the case when deploying a network of battery-operated IoT sensing devices.

This combination of transmission capabilities thus can cover situations inside many factories and those cases where sensors are located across a wide area and at a long distance. Data rates will be higher in the former and lower in the latter. Importantly, this approach avoids the need to lay down cabling, an expensive and time-consuming affair, while still enabling the extensive coverage required in many IoT usage scenarios.

Cloud capabilities and standard communication protocols are necessary because they make integration of a solution easier. Cloud support means that any solution can be more easily incorporated into existing IT schemes, which will often already include cloud-based tools, such as the ability to spin up, visualize data and deploy an analytics package as needed. Having the right cloud capabilities will mean that incoming IoT data can be treated as any other big data problem.

Support for standard communication protocols ensures that data generated by a sensing network can be gathered and disseminated as needed. The use of standard communication protocols also means that the movement of the data, which is critical, can be handled with a minimum of effort.

More than that, a solution must support lightweight communication protocols designed for IoT use. MQTT (Message Queuing Telemetry Transport) and REST (Representational State Transfer) are two examples of these protocols. Because such protocols provide the required information with minimal resources, they simplify data transmission and ensure that vital information from sensors is readily accessible.

As for being rugged, any IoT solution will, as noted earlier, be going into areas where conditions of high heat, humidity, dust, vibration and cleaning by water wash-down are all possible. Thus, a solution would need to be able to survive in such an environment. An IP65 rating would mean that a device's enclosure would protect it against dust and low-pressure water jets from any direction. Offering such environmental ruggedness is why an ideal IoT solution should have such an option for such a rating.

An example solution – Advantech's WISE-4000 series of products

An example of such a solution can be seen in Advantech's WISE-4000 series of IoT wireless sensor node products. They offer connectivity via wireless Ethernet, cellular networks, standard LPWAN, LoRa, NB-IoT and eMTC, and a proprietary spread spectrum radio modulation technology used for LPWAN applications. The LPWAN implementation enables wide coverage, thus providing connectivity for wide areas over long distances. The choice of which connection option to deploy depends upon the application.

If environmental monitoring of a computer room is the usage scenario, for example, then a wireless Ethernet-based approach may be best. If, on the other hand, remote management of a water treatment plant is the application, then a LPWAN-scheme is likely the optimum choice. WISE-4000 products can run on external power or on a solar rechargeable battery, an important capability that eliminates the need to run power cables. They also support public and private cloud connectivity, as well as lightweight communication protocols MQTT and REST. This array of communication capabilities allows for easy and rapid cloud service integration.

Because WISE-4000 wireless IoT sensing devices also provide acquisition and communication services, they make it possible to complete an IoT deployment faster than would otherwise be possible. They also offer other industry standard automation communication protocols, such as Modbus.

WISE-4000 product enclosures can be IP65 rated and UV resistant, making them suitable for use in harsh environments as well as outdoors or other areas exposed to the Sun. The ability to withstand environmental challenges is also important in machine shops and food and beverage processing applications, both of which involve exposure to oil and dust along with regular cleanings via chemicals or water wash-downs.

There are I/O interfaces for sensor modules, allowing data to be plugged directly into the WISE-4000 products. There can be, for instance, a built-in sensor for temperature and humidity, two of the parameters that are most frequently monitored. This plug-in capability reduces the need for wiring, and with the built-in antennas makes it easier to fit the WISE-4000 devices in a limited space. Other plug-in options on the WISE-4000 products are for combinations of sensor channels with digital and analog inputs, allowing for fast customization of different I/O combinations.

Conclusion

The Internet of Things offers significant benefits and payback on what can be a substantial investment. However, maximizing these benefits and return on investment requires that a dense sensor network be deployed. In turn, this means that the sensor node solution should be wireless, flexible, rugged and capable of providing the low-power, wide-area network required by many IoT applications. Fortunately, the technology needed to achieve this exists, as illustrated by Advantech's WISE-4000 product family.