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Cloud Connectivity for Industrial IoT Applications

A hardware communication hub such as an RTU or a gateway is often the best tool to collect, format, and forward industrial automation system big data to the cloud.

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Industrial automation systems are increasingly using the cloud as a repository for big data storage and as a means for accessing and implementing internet of Things (IoT) applications. The cloud provides a low cost and secure way to store big data and it offers a wide range of wired and wireless access methods to this data from anywhere in the world, chief among them the internet. In an industrial setting, integrating IoT devices are over the internet creates what is called an industrial IoT (IIoT) application.

These IIoT applications are often implemented to monitor and control assets located in widespread geographical areas which are frequently subject to harsh operating conditions. Such applications are commonly found in the oil & gas, power, and water/wastewater industries.

The first step to realizing this vision is getting properly formatted data from industrial automation systems and components to the cloud. This task is complicated by the wide range of unique industrial automation protocols and networks, and by the many different ways in which data is acquired by and stored in automation components and systems.

One of the best ways to address these issues is by using a hardware communications hub to gather all of the required data from the different components and systems, to format the data as required by the cloud database, and to send the data to the cloud. Alternately, a software communications hub in the form of a PC-based HMI such as Advantech's WebAccess can also be used as discussed in this white paper titled *Cloud-based SCADA as an Industrial IoT Gateway* (Reference 1). This approach isn't covered in this white paper because this document instead focuses on applications without a local PC-based HMI.

Hardware hubs are not new, but their enhanced capabilities have greatly expanded the role of gateways. As the ARC Advisory Group observes, gateways were "Originally relegated largely to network protocol conversion", but "today's gateways target sensor-to-cloud integration in furtherance of industrial internet-based strategies designed to improve business performance. IT technology continues to extend its reach into the OT realm in pursuit of the data needed to this end. Availability of gateway devices featuring standard operating systems, such as Linux and Windows 10, are furthering the march towards edge or fog computing" (Reference 2). This white paper will explore just how cloud connectivity can be achieved in modern systems.

Hardware Communication Hubs

The two main types of hardware communication hubs are remote terminal units (RTUs) and industrial communication gateways, with the main difference between the two centering on I/O availability. RTUs feature discrete and analog hardwired I/O points, enabling them to directly interface with field devices such as sensors, valves and motors to achieve measurement and control. Gateways lack this capability, and are purely data handling devices.

Both RTUs and gateways do contain all of the required ports, protocol support and data handling features to gather data from industrial automation components and systems, and to send this data to the cloud. Table 1 lists some of the leading reasons for using a hardware communications hub in IIoT applications.

Table 1, Benefits of a Hardware Communications Hub in IIoT Applications

- Multiple wired and wireless communication options
- Can interface to almost any automation component or smart system
- Can interface to cloud

- Extensive data handling capabilities
- Designed to operate in harsh environments
- Less expensive than a PC-based SCADA system hub
- Low total cost of ownership

RTUs and gateways share many key features. Both offer multiple wired and wireless communications options, with a variety of hardware and software protocol choices. Therefore, versions of these devices can be obtained to interface with almost any automation component or smart system. Of course, not every protocol is available on every device, so sometimes the requirement to communicate via a certain protocol will dictate the hardware hub choice.

As with most contemporary electronic devices, communications hubs are quite likely to offer cloud connectivity and more comprehensive data handling capabilities than ever before. However, users will find that these features may be available to a greater or lesser extent depending on the selected device, so it is crucial to investigate the detailed specifications when considering a hardware hub. Quite commonly, Ethernet-based RTUs and gateways will come with web server functionality built in, allowing users to create internal web pages or services to facilitate remote online monitoring. This web server functionality makes RTUs and gateways exceptionally easy to monitor and configure remotely.

RTUs and gateways both must offer some type of wired or wireless uplink communication capability for integration with a supervisory system. The uplink capabilities may be fixed, but devices using the Mini-PCIe format provide a modular solution and greatly expand communication options. Options include an Ethernet link over fiber optic or a dedicated radio link to another compatible device. It is becoming much more common now for this uplink to be a cellular wireless connection (such as 4G) to the cloud via the Ethernet.

A feature differentiating RTUs and gateways from commercial communication hubs is the degree of robustness they provide. RTUs and gateways are flexible, but mission-specific in terms of their ability to be powered in remote locations and installed in harsh environments. Allowable operating temperatures are usually in the -40 to +70 degree C range. By contrast, commercial communication hubs are much less robust, and thus prone to failure when installed in industrial environments.

A PC-based supervisory control and data acquisition (SCADA) system can offer superior connectivity and processing capabilities, but at a much higher cost than an RTU or gateway due to the required hardware, installation footprint and mounting considerations—along with PC-based software. In contrast, RTU and gateway solutions are much more cost-effective since users are buying exactly the capabilities they need in the form of a device with a defined purpose, as opposed to general purpose hardware such as a PC.

Now that we've looked at some similarities between RTUs and gateways, let's examine the RTU option in more detail, and show just how it can be implemented in IIoT applications.

Reasons to Use an RTU

Any time an IIoT application requires monitoring and control of devices via hardwired discrete or analog signals, then an RTU solution should be considered first. RTUs are often distinguished by the large number of terminal blocks and I/O offered for interface to field devices (Figure 1).

Figure 1 - Advantech's ADAM-3600 Wireless Intelligent RTU

RTUs with a fixed quantity of I/O are simpler and more economical, while those with expandable I/O capabilities are able to scale to the application size and better connect to a variety of signals. While modularity usually adds cost and complexity, it also allows users to consistently use one product line to meet a wide range of needs.

An uplink may be a critical feature for users and a key reason why they implement an RTU, but is not always required by the RTU. In fact, many RTUs are in local control service with little or no connection to the outside world. Even those connected to a supervisory system are still typically configured to continue operating in a standalone fashion if the uplink is disrupted.

Automation complexity is generally low for RTUs, as they are called into service for mostly straightforward functions. However, they are often located where there is a notable amount of process instrumentation for pressures, flows and analytical values. In this case, the RTU is ideally positioned as a hub to gather this information and transmit it up to the supervisory system.

It is quite common for RTUs to offer a few communications ports, whether serial or Ethernet, to support a growing number of smart devices which may be located at a remote location. In addition to port availability, it is equally important for the RTU to support appropriate protocols. Modbus is probably the most common industrial communication protocol, while DNP3 is especially suitable for the robust needs of the utility and oil & gas industries.

Due to RTU control programming requirements, users must consider the operating system and programming languages available. Implementations supporting IEC 61131-3 programming languages are a plus. This IEC standard’s defines several industrial programming languages, to

promote consistency and reusability between various platforms. This makes it easier for users to implement and reuse code.

RTUs represent an excellent fit for remote locations with direct control needs. On the other hand, for locations where no I/O is required, a gateway would likely prove to be the ideal hub device.

Industrial Communication Gateway Advantages
While industrial communication gateways do not feature any I/O, they compensate with a larger range of communication ports (Figure 2).

Figure 2 - Advantech's ECU-1152 Industrial Communication Gateway

They commonly come with several serial and/or Ethernet ports which can be configured to meet application needs. Although industry is largely moving toward Ethernet, there is still a huge quantity of serial-based devices in the field, making this legacy interface technology very relevant today. Also, serial electrical characteristics offer some advantages over Ethernet with regards to the maximum distance for cable runs in certain situations.

Due to their data handling role, gateways will typically come with more on-board memory than an RTU, which gives engineers flexibility to perform a level of data manipulation and pre-processing at the gateway level. Also, one or more SD cards can provide additional storage options. The extended storage might be used by users to perform data logging or other similarly advanced functions.

Although gateways might feature processing power comparable to what is found in RTUs, they don’t perform the same kind of active control role as RTUs, so real-time response is not as critical. Users may find that gateways have lower power consumption requirements, making them an especially good fit for remote solar-powered locations.

Gateways may not require a specialized command-and-control programming environment, but they still need a fundamental operating system. Many gateway solutions rely on the proven Linux operating system for this purpose. This provides an ideal open platform for users to develop their own Linux C and other programs for gathering and forwarding data.

In addition, certain manufacturers may offer specialized applications to facilitate the configuration of gateways and provide enhanced data manipulation features. These applications can empower users to develop data acquisition systems with greater ease.

Data Handling Applications
One example of data handling through a specialized application is Taglink, an embedded technology available on RTUs and industrial gateways offered by computing and automation manufacturer Advantech. These new hardware communication hubs enable users to establish cloud connectivity quickly and easily with Taglink (Figure 3).

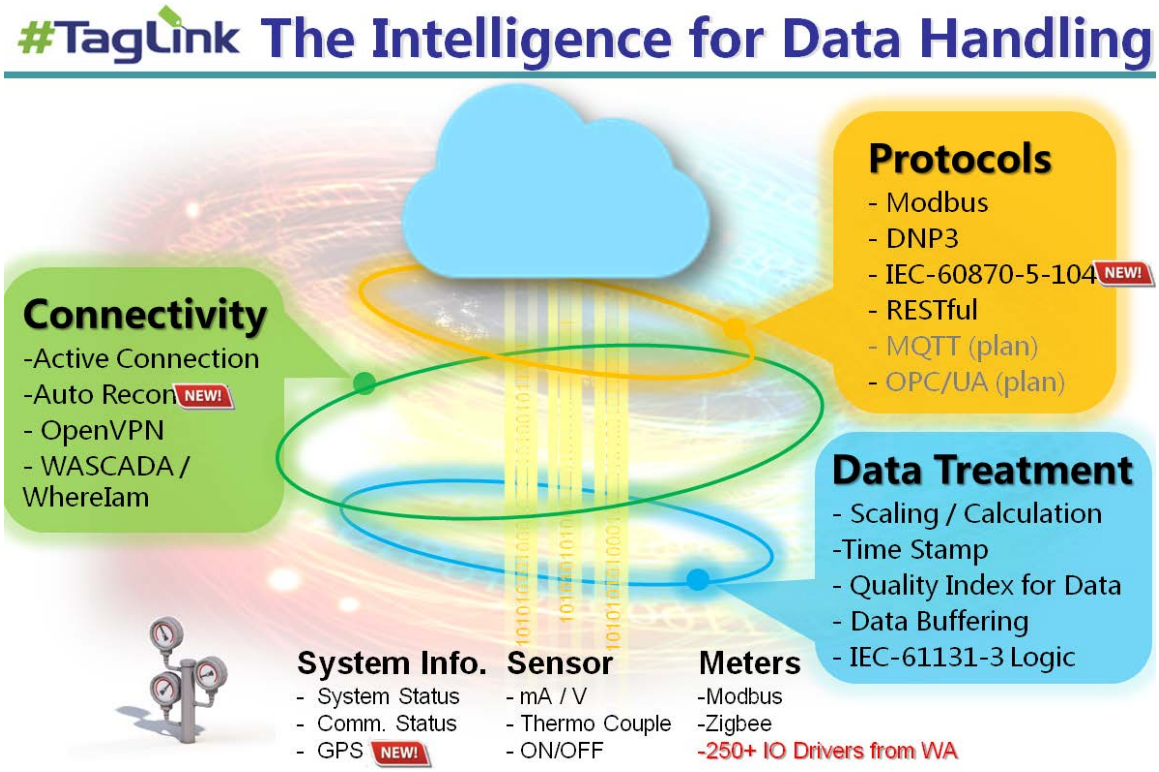

Figure 3

Instead of having to manually process raw data, Taglink enables engineers to assign real meaning to the data obtained by RTUs and gateways, and to make this content available via a unified interface regardless of the source protocol. This technology makes IIoT data easy to maintain, and convenient to access via the cloud. Table 2 points out the detailed benefits of embedding this data handling functionality into hardware communication hubs.

Table 2, Benefits of Embedding Data Handling Functionality in Hardware Communications Hubs

- Assigns meaning to data

- Makes it easier to maintain data
- Provides an open interface
- Prevents conflicts among different data sources
- Includes provisions for maintaining cloud connections
- Compatible with cloud data storage systems
- Less expensive than software-based solutions
- More rugged than software-based solutions
- Acts to bridge industrial capability with IT friendliness

Traditional RTU architectures require rigorous data addressing and mapping tables at every RTU, and at the corresponding supervisory system. Even if a large block of data points is obtained from a field device, users must carefully query items of interest via their raw address.

Polling commonly follows the Modbus model and is established when the system is first configured. Polling remains inflexible, with any I/O changes demanding reprogramming. Furthermore, the data itself is often a “raw” value throughout the entire communications transport chain until a scaling calculation is performed at the SCADA system to make the information comprehensible.

The TagLink solution improves on this situation in several ways (Figure 4). Users identify points of interest with meaningful tag names, and can configure scaling and calculation to be performed locally at the RTU so that the value is natively available in useful engineering units. The overall structure is one of a real-time database, with an offline configuration file saved in XML format for easy development, deployment and future maintenance.

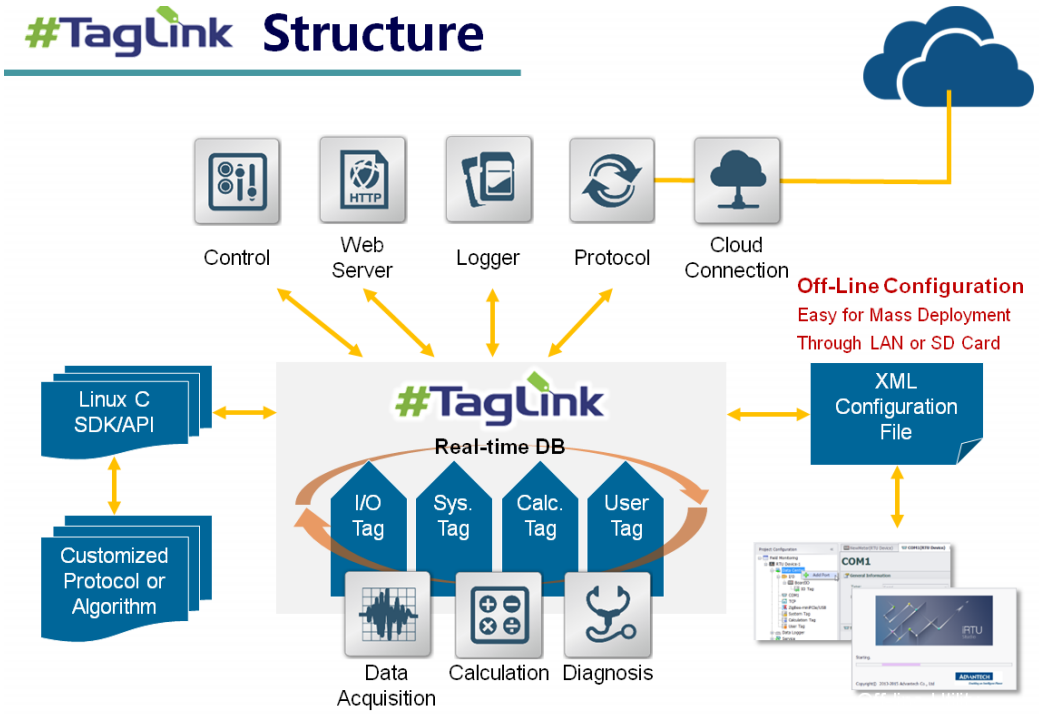

Figure 4

As a truly open interface, TagLink supports hundreds of I/O drivers and MS SQL Server ODBC queries, and provides a serial mode command/query frame editor for extracting data from non-standard devices. User tags can enable supervisory systems to transfer parameters and set points out to the RTUs.

Within a distributed data acquisition system, there is always the possibility of one device improperly overwriting another. TagLink helps prevent this by supporting a data interlock to prevent conflicting access among different applications.

Hardware communication hubs featuring TagLink establish a highway to the cloud for IIoT data. Reporting by exception minimizes the amount of data transfer and optimizes bandwidth usage, particularly important for cellular connections. In addition, provisions for monitoring data traffic and triggering ping signals as a “heartbeat” after a certain idle time ensure the communication service stays online, or is restored as soon as possible.

TagLink works natively with another Advantech platform called WebAccess, which is a cross-platform HTML5-based web product. Using these two technologies, users can easily define and capture data from RTUs anywhere in the world, connect them up to the cloud, and then publish them in customizable dashboard-type displays. This provides a consistent user experience across any computing and handheld platform.

Other advanced capabilities are built right in. Time synchronization ensures time-stamped data can be coordinated among multiple sites, and makes sequence-of-event recording possible. Data uploads can be scheduled and regulated to meet application requirements, while encryption and authorization systems ensure system integrity. As established in another Advantech white paper, “cloud technologies are a mature and secure way to handle consumer and banking data, and are more than up to the challenge of securely handling manufacturing data” (Reference 1).

Combining hardware communication hubs with standard applications tailored to data handling is far more cost effective than custom configuration of PCs and development programs to establish cloud-based data connectivity. Not only that, but RTUs and gateways are ruggedly built to operate reliably in harsh environments. This marriage of hardware and embedded firmware effectively merges industrial capabilities with IT friendliness.

Application Examples

Water pumping stations are the most important node in a water network, the pumping station can influence the public water supply. It’s important to have a proper network of RTUs, gateways, and cloud connectivity. See Figure 5 for a typical arrangement.

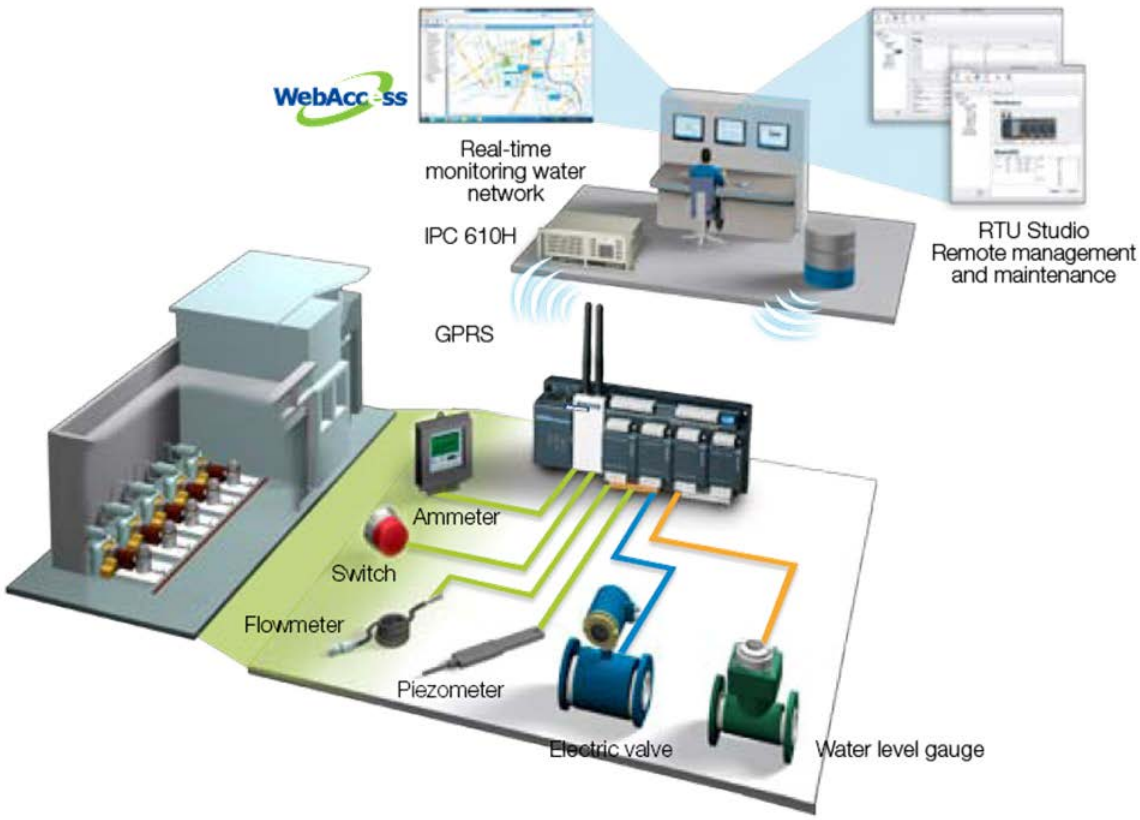

Figure 5

Commonly, a number of pumping sites are located in a particular geographical area. Each site needs to be able to function in a standalone manner, while all sites are monitored and operated in an overall coordinated fashion by a supervisory system. Using traditional wired networking, or even dedicated wireless systems, would require extensive effort to interconnect all the sites, but there's a better way.

Choosing a modern RTU for each site provides a comprehensive control platform. Each site is configured to use any combination of connections. Native local I/O is the most typical method of establishing standalone control strategies, and this could be combined with Wi-Fi Ethernet remote I/O at the site to help minimize expensive field wiring needs. Even more specialized field devices and subsystems, which might use ZigBee wireless connections or wired DNP3 communication protocols, are easily integrated.

For locations with a higher density of smart equipment requiring communication via serial or Ethernet ports, one or more gateways could be used. Depending on the site-specific requirements, these gateways could be used in addition to RTUs, or by themselves if the hardwired I/O and PLC logic capabilities of an RTU weren't required. These gateways would gather and pre-preprocess the acquired data as needed.

Multiple RTU and gateway sites in close proximity would communicate with each other over common Wi-Fi if needed. When maintenance and operations personnel did need to go onsite, they would use the same Wi-Fi or wired Ethernet ports to connect their computers.

Each of these hubs would communicate to the cloud using the best local wireless data connection such LTE, 3G/4G or even GPRS. All of these devices are TagLink-capable, and each could be easily configured to report their data to a cloud-based WebAccess system for ready dissemination to a variety of platforms. And once the data is published to the cloud, users with proper security credentials could display it as needed anywhere in the world on PCs, laptops, smartphones and tablets.

The individual amounts of data from each field device and hub are relatively small compared to internet-scale data. But in an industrial environment, the important factor is sometimes the responsiveness of the data more than the quantity. TechRadar.com puts it this way: "It won't only be the sheer volume of the data, but the velocity and variety of the data that the cloud will have to manage and deal with … the data coming off a car, plane, train, industrial machinery, production line or building will be used to make critical decisions in real-time, and will need to be combined with other data, some of which will be historical" (Reference 3).

This hub-to-cloud design concept has the required performance and is flexible, easy to implement, and able to grow in stages. The entire architecture is scalable to precisely fit any size system. Hardware communication hubs are a powerful and economical solution for many applications.

Conclusion and Outlook

Field devices and instruments offering IIoT data are proliferating, but technical personnel still must implement robust systems to harvest the information from these devices in a useful manner. The issue is compounded by the fact that the most important data is often in extremely remote and challenging locations, and comes in a wide variety of protocols.

Fortunately, a class of hardware communication hubs exists to address these needs. RTUs are specialized to control field devices, while industrial gateways are tailored to handling multiple data streams. Both of these products are available with uplink capabilities to send the industrial field data to IT-friendly cloud-based platforms.

Other enabling technologies such as TagLink and WebAccess help designers navigate raw data and turn it into useful information that can be published via the cloud, and then put into the hands of end users via a variety of viewing platforms.

References:

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