Enabling Large Scale Industrial IoT Deployments through Mesh Networking

The digital transformation of industrial operations and manufacturing processes is one whose foundation is based on connectivity. To accomplish the basic tenets of industry 4.0, cyber-physical systems must be able to share data packets at low latency. Thus, ensuring data transfer is done at near real-time and issues that affect connectivity do not occur, as this could lead to downtime, is a necessity when implementing industry 4.0 models. The increasing integration of Industrial IoT (IIoT) solutions within industrial facilities and the need for location awareness are also important considerations for any IIoT deployment.

To overcome the challenges with sharing large data sets at low latency and enabling communication across multiple IIoT devices, industrial facilities still rely on radio frequency identification (RFID) tags, and wireless communication to design interconnected systems. Although these technologies offer a pathway to building connected environments, specific challenges hamper their ability to support large scale IIoT deployments. For RFIDs, the cost of purchasing a tag is approximately $45 and RFID readers cost approximately $2,300 each. This puts their use for large IIoT deployments out-of-reach for most enterprises. In the case of wireless communication or discrete Wi-Fi, network range challenges, geographical limitations, and electromagnetic interference in industrial facilities affect its reliability and resilience.

Enterprises who intend to implement industry 4.0 models or deploy large scale IIoT deployments within expansive facilities must deal with the reliability challenges that affect performance levels of the aforementioned technologies. Thus, a more reliable solution that supports communication across large scale IIoT and the drive for smart facilities is required.

Enter Bluetooth 5.0 and its mesh networking specifications.

Launched in July 2017, Bluetooth mesh networking is aimed at leveraging Bluetooth 5.0 technology to develop mesh networks with every device or node on the network having the ability to communicate with other devices within the network. This ability creates a many-to-many device communications network with limitations on the number of devices that can be connected to the network.

The release of Bluetooth mesh networks included the introduction of the Bluetooth Low Energy (BLE) protocol which is a low-power variant compared to its classical version. Unlike other low energy protocols and options such as ultra-low power Wi-Fi and other Low Power Wide Area Networks (LPWAN) options, BLE aims at also minimizing the energy consumption rate of the nodes or devices within its network.

In terms of communication, the BLE standard follows the publish/subscribe model. Communications among nodes are message-oriented and the publisher node sends or floods data packets about specific topics through the network. Subscriber nodes that find the topics relevant confirm receipt of the message and execute its required actions. The action could be to return data back to the sender or depending on the node type, to resend the data to other nodes in the mesh network.

To ensure low energy consumption of all the nodes within a mesh network, a friendship feature, also known as the friend node, is used to store and relay data to low-power nodes which maintain their limited consumption powers while asking for and receiving messages from the friend node. The BLE mesh network protocol stack and architecture are designed to enable real-time networking over large areas, function optimally in harsh industrial environments, and to connect other sub-networks within an ecosystem.

Industrial IoT Deployments and its Current Challenges

The approximately 30 billion IIoT devices used across industrial facilities need low latency, real-time communications to achieve their deployment goals and Bluetooth mesh networking provide applicable use cases for this. To understand the revolutionary capabilities of Bluetooth mesh networks, insight into the connectivity solutions currently used for industry 4.0 Implementations and their limitations can help.

In Brownfield facilities populated with legacy devices, connecting these devices to IIoT networks comes with multiple challenges. While IIoT devices can communicate with networks using Internet Protocols (IP), legacy devices can't. Thus, legacy devices are either replaced or rewired to get them connected to Ethernet networks.

The rewiring or replacement process is capital-intensive and above the financial capacity of many industrial enterprises. Multiplying these expenses across diverse facilities and tens of devices is one of the reasons why only 6% of manufacturers have considered a complete implementation of industry 4.0.

In Greenfield facilities, the fragmentation of communication protocols in the industrial sector has created chasms that limit the deployment of IIoT solutions at a larger scale. Although unification standards such as the OPC Unified Architecture exists, bridging the gap between the varying systems OEMs offer is still a challenge to IIoT Implementations.

Diverse system types and communication protocols also lead to interoperability challenges. This coupled with the need to include legacy devices within IoT networks are important considerations for enterprises interested in large scale deployment of IIoT devices.

The energy consumption rate of large scale IIoT deployments has been a cause for concern for enterprises interested in implementation. According to statistics, IoT devices accessing wireless networks through Wi-Fi consume more energy than wired networks. The research went on to state that wireless access through cellular networks can consume 23 times more energy than Wi-Fi. This is in relation to the energy consumption capacity of 4G networks and 5G's consumption rates have not yet been ascertained.

Enabling Large Scale Industrial IoT Deployments through BLE Mesh Networks

Bluetooth mesh networks bring three major benefits to industrial IoT applications. These are an increased network range compared to peer-to-peer connections, enhanced resilience, and a low energy consumption rate.

Where network range and coverage is concerned, Bluetooth mesh networks mean that IIoT devices and sensors no longer have to be within 20 meters of its networking hub to stay connected to an IoT system. IIoT devices simply need to be within range, 30 meters, of another IIoT device or sensor thus creating a series of networked devices that extend the range of IIoT deployments.

The device or node-centric architecture of Bluetooth mesh networks means there's no single point of failure. Thus, if one IIoT device becomes defective, data packets are transferred around it to the other devices within the network. This optimizes the resilience of IIoT network which enables large scale deployments.

Conditioned machine monitoring IIoT applications provide an excellent case study to understand the resilience and range of Bluetooth mesh networks. In a scenario where a manufacturer intends to continuously monitor machine utilization across a large shop floor to determine overall equipment

effectiveness levels (OEE), Bluetooth mesh networks provide the connected support needed for this real-time IIoT application.

With the sensors within individual equipment acting as nodes, Bluetooth mesh networks can create a connected system where interoperability is ensured. Captured data can then be transferred through the network to a centralized location or IoT Platform. The platform provides the computing resources for OEE calculations while the Bluetooth mesh network provides the scaled network for collecting machine data.

Interoperability also means messages from centralized IoT platforms or individual devices can be sent via a friendship node to the machine sensors. Thus, if the manufacturer intends the sensor to increase its measurement of the duration a machine is used for a new production schedule, that specific message can be sent through the network. This enables the manufacturer to reconfigure the functions of individual sensors within large-scale machine monitoring IIoT ecosystems.

The low energy consumption rate of BLE mesh networks is the third major benefit large-scale IIoT deployments can take advantage of. On average, the power requirements needed to operate a wireless sensor is expended on; data sensing or acquisition, data processing, and data networking. For real-time IoT applications, conventional wireless sensors working round the clock consume a lot of energy to manage these operations.

BLE mesh networks reduce the energy consumption rate of its sensors by eliminating the need for constant data networking and data acquisition operations. In this case, low power nodes or BLE devices which go to sleep until messages attributed to them are sent. This means a BLE IoT device will utilize the bare minimum energy it needs to stay alert until it receives a message addressed to it from the friend node.

Applying BLE standards to large-scale IIoT deployments ensure that many of the IIoT devices within a network consumes minimal energy thus reducing the recurrent costs associated with managing IIoT applications for industrial enterprises. A real-world example is the use of a smart material handling system equipped with object detection and navigation sensors on the autonomous guided vehicle (AGV), as well as, the navigation sensors embedded across the expansive layout of large shop floors.

In this scenario, BLE navigation sensors and object detection sensors do not need to function at full capacity when the AGV navigates the shop floor until it comes within the range of a specific sensor. This reduces energy consumption while ensuring the autonomous system functions optimally within industrial facilities.

Conclusion

Challenges with developing IoT solutions and provisioning devices are major reasons why approximately 76% of DIY IoT implementations fail. Thus, for large-scale deployments using the right tools is essential for a successful implementation.

ON Semiconductor's RSL 10 mesh platform provides a versatile development kit for IIoT OEMs and industrial enterprises interested in large-scale IIoT deployments within the harsh environment of industrial facilities. Learn more about ON Semiconductor's Bluetooth Low Energy mesh network platform here.