IOT ARCHITECTURE: ASSESSING YOUR NEEDS AND SELECTING THE RIGHT SOLUTION

Any Internet of Things (IoT) project involves choosing from a complex array of communication devices such as radios and gateways, plus connection methods and protocols, and then ensuring that the assembled solution can deliver the desired business results. Collectively, the end result of these decisions constitutes an IoT architecture.

This white paper examines some of the key choices needed to develop a successful approach to IoT architecture, including selecting the most appropriate wireless protocol, connectivity and cloud computing methods as well as the physical components, such as wireless devices, gateways and routers.

IoT Architecture: Assessing Your Needs and Selecting the Right Solutions

Selecting the right IoT architecture for a project involves assessing your connectivity needs, as well as the available technology, and the technical and operational resources needed to deploy and maintain the application. For many of these decisions, there isn't a single right or wrong answer. Instead, it's a matter of finding a solution flexible enough for both your current and future use cases and the features needed to meet those needs.

For example, several wireless protocols can potentially be used to communicate between devices, but each one has specific benefits and ideal use cases. The one that will work best for you depends on your unique conditions and business objectives.

At Digi, we help customers in a wide range of industries identify their IoT architecture needs by examining some of the following questions and considerations:

IoT architecture functionality considerations:

- Will your IoT architecture need to gather data, such as from a sensor network?
- Will it include monitoring and controls, as in a supervisory control and data acquisition (SCADA) network?
- Will your devices need to send data frequently or only on occasion, such as an alert that a fuel tank is running low?
- What is the physical distance between devices and gateways?
- How quickly must data be sent from end nodes to a gateway?
- Are there strict timing requirements that must be met?
- Will your IoT devices need to connect to the cloud?
- Is power usage a factor and if so, is power readily available?
- If deployed over a large or remote network, such as in an agricultural setting, would battery replacement be difficult or costly?

"Build vs. buy" considerations in IoT device selection:

- Is it cost-effective to build your solution from the ground up?
- Could “off-the-shelf” IoT devices such as radios and gateways provide adequate — or superior — functionality for your project?
- What aspects of the IoT design process build on your organization’s core competency?
- If time-to-market is key, would pre-certified wireless modules represent a significant time savings?
- Would engaging with a vendor for design services allow your team members to make better use of their time and skills?

Managing your deployed devices:

- Do you need to choose a protocol that supports over-the-air (OTA) options to update firmware on your devices?
- In lieu of OTA firmware upgrades, will hands-on upgrades or sending "truck rolls" to update units in the field be expensive or even cost prohibitive?

All of these decisions affect the overall planning, deployment and management of your project as well as the total cost of ownership. Let's review some of these considerations.

Network Topology and Edge Computing

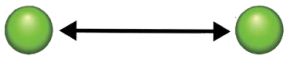
Network topology is a key factor for engineers to consider when designing an IoT network. Options include point-to-point, point-to-multipoint, or mesh networking protocols such as Zigbee® or DigiMesh®. The use case itself may determine which topology makes the most sense. In some cases, it may be necessary to research other organizations in your industry to learn about the advantages and disadvantages of different topologies. The Digi team can help you evaluate the trade-offs.

Point-to-Point or Point-to-Multipoint

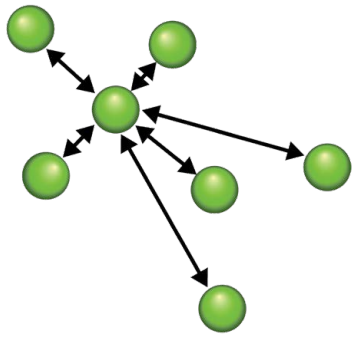
Wireless point-to-point (PTP) and point-to-multipoint (PTMP) topologies are used to communicate between two devices (point-to-point) or from one device to many (point-to-multipoint). These protocols are used in a wide range of applications and use cases where the goal is to replace cables with wireless connectivity.

Factors such as distance, timing and battery power may indicate if a PTP, PTMP or mesh network is the better choice.

Point-to-Point



Point-to-Multipoint



PTP and PTMP protocols offer these features and capabilities:

- For a wireless link to devices that are a mile or two away from each other in an environment with good line-of-sight, PTP might be the easiest solution.
- PTP or PTMP can be an efficient choice for many battery-powered applications. Data can be sent when required, with sleep mode enabled when no communication is needed. In some PTP/PTMP applications, batteries can last for several years.
- By contrast, mesh networks add latency and also consume more power, which means that mains-powered routers or repeaters are usually needed.

If the network is in a fairly small, fixed geographical area and range is clear, such as in an agricultural setting, PTP/PTMP has many advantages over a mesh network. PTP/PTMP networks are also fairly simple and quick to set up. They work well with communications protocols that have tight timing requirements such as the Modbus protocol, which is used with the programmable logic controllers (PLCs) that are common in industrial applications.

Mesh Networking

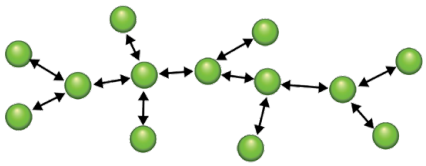
In a mesh networking topology, data passes from node to node across a network that is architected in a mesh. Each of the "hops" from node to node adds latency. Do you need the data back in milliseconds or is one or more seconds sufficient? In an application such as street lighting, the additional latency would be unimportant. In a fast-moving industrial process, however, a nearly immediate response may be necessary for safety and proper functionality.

Mesh networking offers the following features and capabilities:

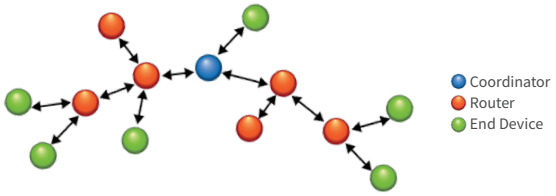
- Mesh networking can support a large number of nodes in a network — a thousand or more, depending on the architecture.
- Data can intelligently find its way from node to node and then to a gateway.
- If one node in the network breaks down for some reason, the network can automatically find a new path to the gateway.
- If a new node is added to a network, the network can automatically discover it and route data to or from the new node.
- Mesh networking provides redundancy by enabling multiple paths from a node or device. It also has the flexibility to adjust when conditions change.
- Sub-networks can be established to segregate data from adjoining networks. This is especially beneficial in dense networks with thousands of nodes, such as in street lighting or in a geographically dispersed deployment like a wind farm or solar farm, where latency is less of a concern.

Mesh networks are available in popular standards, like Zigbee, and also in peer-to-peer networks like DigiMesh. Digi supports both of these protocols in the Digi XBee® product line.

DigiMesh



Zigbee



To identify the optimum protocol for your particular use case, compare the pros and cons of Zigbee and DigiMesh in our related blog post. For a more in-depth discussion, see the Zigbee vs. DigiMesh White Paper.

Key differentiators between Zigbee and DigiMesh:

- Zigbee typically operates in the 2.4 GHz frequency whereas DigiMesh can operate on 2.4 GHz Digi XBee® modules as well as 900 MHz and 868 MHz XBee modules.
- Zigbee uses end nodes, routers and coordinators to represent the end devices, repeaters and gateways.
- DigiMesh is a peer-to-peer mesh network that offers self-healing, dense network operation and sleep modes to extend battery-life, as well as easy setup and configuration.

Cellular, Wi-Fi and Bluetooth

In addition to mesh and PTP/PTMP architecture, it is also possible to connect devices to the cloud via Wi-Fi or cellular in some circumstances. Using the ubiquitous Wi-Fi protocol depends on the availability of Internet at the user's site, as well as their security policies.

Connecting IoT devices to an existing Wi-Fi network may require additional security, and in some cases won't be possible because of the user's corporate policies. Working with hundreds of different wireless access points and varying levels of customer skills with Wi-Fi can also be challenging in residential applications.

Important considerations for cellular applications:

- Cellular radios need to have access to a cellular network, which is readily available in most urban settings but may be more limited in rural areas.
- Data rates and data speed must be considered. LTE-M and LTE Cat-1 protocols work well with most IoT applications that need to send sensor data to the cloud.
- Activations, data plans, SIM management, and remote device management are also factors involved in deploying and maintaining cellular connectivity for IoT.

For a start-up company or an organization implementing their first cellular IoT project, working directly with a major carrier could be difficult at times. On the other hand, a mobile virtual network operator (MVNO) can be more efficient and help you launch your IoT project in a timely manner. Digi also offers data plans, SIM cards, connectivity services, and remote management tools such as Digi Remote Manager® that can help you get your project to market faster.

Dual radio support is available on some modules, such as Digi XBee 3. These modules offer a main wireless protocol, such as LTE-M, Cat-1, Zigbee, or 802.15.4, along with a built-in Bluetooth link used for configuration and management. Digi XBee3 modules can also use Bluetooth Low Energy (BLE) to send customized advertisements or beacons (e.g., iBeacon) from neighboring devices, a valuable capability for retail and numerous other applications. Digi offers a complete BLE Mobile SDK to help you get started!

Bluetooth enables a technician to configure or troubleshoot a device by linking to it with a mobile phone or tablet app instead of connecting to it with cables and a laptop. This also accelerates the process of initial setup and commissioning.

Drop-in Networking

A variety of different topologies and configurations can be used to set up a wireless network. For example, one method is to connect remote sensors or devices via a wireless link to an intelligent gateway, which then backhauls the data via cellular, Wi-Fi, or Ethernet to the cloud for analysis or storage.

A "drop-in network" involves creating a network specifically for your application. In a SCADA or telemetry environment, a gateway is introduced that has backhaul capability as well as the ability to connect to remote RF nodes to send data back and forth. In some drop-in networking applications, a cellular router connected to devices may be all that is needed. One example is a kiosk or point-of-sale (POS) terminal at a retail store that uses cellular connectivity to process transactions.

An advantage of the drop-in network is that you don't have to contend with the administrative issues involved in joining an existing network. Creating a drop-in network gives you the flexibility to decide which topology best suits the application — mesh, point-to-point or point-to-multipoint — and enables you to control all aspects of the network.

Mesh networks with thousands of nodes communicating frequently back to a gateway work well in applications like solar farms and street lighting. Using a long range 900 MHz radio in a PTP or PTMP application with a drop-in network topology can help you connect devices that are spread out over large geographies like in an oil field or agricultural setting.

Cellular-based Digi XBee 3 modules allow you to bypass the traditional gateway topology by sending data directly from your device to the cloud. This requires a data plan for each

modem implemented in the solution, but fortunately data plan costs have dropped significantly over time and innovative cellular data plans like pooled or tiered plans continue to reduce costs. Digi can partner with you to help determine the best solution for your application.

Edge Intelligence

Edge computing is one of the fastest growing trends in IoT. Edge computing makes a solution more efficient and improves performance by reducing latency. Instead of sending a large volume of data up to the cloud for analysis and action, some of the data processing is performed at the edge — that is, in close physical proximity to where a process is operating or data is being collected. In this way, the device itself can perform some limited decision making in non-critical processes. This lowers latency and reduces traffic through the network, thus lowering cost. Additionally, critical data can quickly trigger service tickets and rapid response.

Battery life is also a key factor with remotely deployed sensors. The greater the volume of data and the greater the frequency of transmitting it over the network, the greater the draw on the battery. The availability of MicroPython in Digi XBee modules enables engineers to create the edge intelligence that helps optimize battery life. For example, if a sensor reading is not changing, the edge device doesn't need to send data, and can conserve battery power by staying in sleep mode. In the case of cellular, this also reduces data charges.

Intelligent Gateways

An intelligent industrial gateway can aggregate data and act on specific sensor data, which helps to optimize communication with cloud-based systems. As discussed above, gateways with programmable languages, like Python, enable users to manage data more efficiently. Instead of just passing data through a gateway via the backhaul protocol by default, users can optimize the solution to reduce the amount of data being sent, thus reducing cellular data fees, and enabling a faster response when some threshold is breached, triggering an alert.

Having other backhaul communication options in a gateway, such as Wi-Fi or Ethernet, is also very useful for IoT applications. When a local network is available, the gateway can be connected to avoid cellular charges. However, when only cellular coverage is available, having options for different carriers both domestic and international can be an advantage, especially for worldwide deployments. Tools like Digi Remote Manager, with capabilities that enable users to manage deployed gateways for diagnostics and troubleshooting, as well as perform remote firmware upgrades, are a must for IoT applications.

IoT Security

Security is another critically important aspect of IoT architecture. Packet encryption is the most basic element of embedded security, while secure boot, protected hardware ports, authentication and secure connections also play important roles.

To minimize risk, IoT designers should assess the security capabilities available in their IoT device hardware and software, and evaluate security techniques at the beginning of any IoT project. For example, Digi XBee modules use secure sessions and integrate the Digi TrustFence® security framework for multi-layered defense.

Prototyping, Testing and Development Resources

As you plan your IoT architecture, there are many resources available to help you.

Development Kits

IoT development kits are extremely useful for testing out the requirements and functionality of a product design. Development kits are relatively low cost and contain all of the hardware needed to analyze different options for your wireless network. Tests can be run through several different development kits to determine which one performs best in the proposed application.

IoT development kits make it easy for OEMs, makers, and even students to prototype IoT solutions quickly and affordably. Development kits are available through Digi distributors. Simply find the kit you want on the Digi site, then click the View Purchase Options button to find a distributor.

IoT Development Tools

Digi offers an award-winning tool suite, Digi XBee Tools, for developers who are designing applications with Digi XBee modules. This suite includes hardware and software to help teams rapidly develop, build, deploy and manage their IoT applications.

Digi also offers tutorials and videos to help developers prototype and test their designs. See our blog post, Digi XBee Tutorials and Resources for Developing Wireless Applications, for a directory of these resources.

Support Services for Prototyping and Product Development

Utilizing services that specialize in the prototyping and testing of IoT systems can help accelerate the design and development phases of your project. Digi Wireless Design Services offer a full range of support services, from ideation to complete development and certification.

Performing a site survey in the actual location where you plan to deploy your solution can help avoid issues that can't be anticipated in the lab. Real world environments rarely present the most ideal RF conditions. Obstacles like buildings, walls, trees, and other structures can easily disturb a wireless network. A site survey can help you determine which antennas are best suited to the environment, what potential sources of RF interference or "noise" are present, and if there are any unique conditions that may affect the development of your solution.

Additional IoT Architecture Considerations

There are a number of other small but significant factors that should be considered during the planning stages of your IoT project.

These include:

- Will a GPS/GNSS service be needed for the devices you're monitoring? If so, can GPS be incorporated into the cellular modem you've chosen or would it be better to use a separate GPS modem? (See our blog post, Geo IoT: Quickly and Easily Add GPS Location Services to Your IoT Application.)
- Will your solution be deployed in only one region, such as North America, or will it be used worldwide? This will likely have implications for the product SKUs in your IoT device selection, as well as for certifications and related costs. (See our blog post, Going Global with Your Cellular Deployment.)
- After devices are deployed in the field, how will you manage firmware upgrades, diagnostics and troubleshooting? (See our blog post, What Is IoT Device Management?)
- Will your solution be subject to temperature extremes? If so, which components of your solution might be limited by temperature?

Summary

IoT deployment takes a good deal of research, planning, and testing to be successful. Carefully examining the available choices in hardware, software and architecture, as well as testing your design with a development kit can save time, money and difficulties down the road.

Working with the right partner can help you ensure that your solution will be successful and deliver the expected ROI.

As an end-to-end IoT solution provider, Digi can partner with you to identify the right protocols, RF hardware, software, and professional services to make your project a success. **Contact us** today to start the conversation.

Why Digi?

Digi is a complete IoT solutions provider, supporting every aspect of your project, from mission-critical communications equipment to design and deployment services to get your application designed, installed, tested, and functioning securely, reliably and at peak performance.

Digi builds its products for high reliability, high performance, security, scalability, and versatility so customers can expect extended service life, quickly adapt to evolving system requirements, and adopt future technologies as they emerge. Digi embedded modules, routers, gateways, and infrastructure management solutions support the latest connected applications across verticals, from the enterprise to transportation, energy, industrial and smart cities use cases.

Our solutions enable connectivity to standards-based and proprietary equipment, devices, and sensors, and ensure reliable communications over virtually every form of wireless or wired systems. Our integrated remote management platform helps accelerate deployment and provide optimal security using highly efficient network operations for mission-critical functions such as mass configuration and firmware updates, as well as system-wide monitoring with dashboards, alarms, and performance metrics.

Company Background

- Digi has been connecting the “Internet of Things” — devices, vehicles, equipment and assets – since 1985
- Digi is publicly traded on the NASDAQ stock exchange: DGII
- Headquartered in the Twin Cities of Minnesota, Digi employs over 700 people globally, and has connected over 100 million devices worldwide

As an IoT solutions provider, Digi puts proven technology to work for our customers so they can light up networks and launch new products. Machine connectivity that’s relentlessly reliable, secure, scalable and managed — and always comes through when you need it most. That’s Digi.

Learn more on our About Digi page.

Contact a Digi expert and get started today

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