Introduction to Wireless Networks

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We are all familiar with highly connected wireless networks such as mobile phone networks, but concerns about reliability, performance, and security have kept this core networking technology from making its way to the shop floor. Instead, the current generation of wireless products used in automation applications typically relies on simple transmitter/receiver pairs, offering no advanced networking.

To make the most of wireless products, automation and process engineers and managers need to understand how these products work with each other, or network.

This paper outlines the very basics of networking:

- Basic network building blocks
- Common network topologies
- Network configuration

Network Building Blocks

All networks are constructed of basic building blocks. Over the past two decades, network engineers have used these basic network building blocks to create a continuing stream of increasingly reliable, fast, power-efficient products that have penetrated many aspects of everyday life.

The following building blocks are used in wireless sensor networks.

The node is the most basic building block in a network. Technically, every device in the network is a node, but for this purpose a node is a wireless networking device that contains one or more sensors and/or actuators and a single radio. Each radio in the network represents a single node, even though that radio may have multiple sensors.

A repeater allows radio signals to travel over longer distances, by receiving the signal, boosting the signal, and then repeating the signal on the transmitter side of the radio.

A router acts as a junction between two or more similar networks to allow the transfer of information between them.

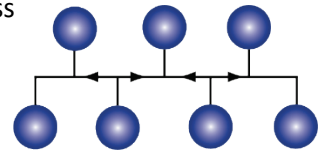
A gateway is a node that interfaces with another network that uses a different protocol. It translates the information into a form the other network can understand. Since most gateways also contain routing functions, think of a gateway as two routers standing back to back and speaking different languages to their respective networks.

Common Network Topologies

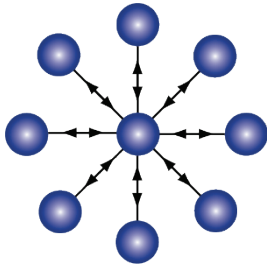
In a discussion of networks, topology refers to how nodes in a network are connected.

Point to point - The most basic form of network is called point to point. As the name implies, in this network two devices are connected to each other.

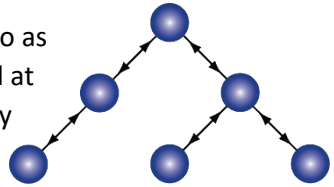
Bus - In a bus network, the nodes are connected through a common communication path, called a bus. In a bus network, the two most common methods for deciding which node can send data at a given moment are master/slave and Carrier Sense, Multiple Access (CSMA):



- In the master/slave method, one device on the bus is the master, and it periodically contacts or polls the other devices—the slaves. Modbus is the preferred master/slave bus networking protocol for networks deployed across large areas or connected to an existing wired network.
- In the CSMA bus structure, during each timing cycle—sometimes called an epoch—the devices on the network wake up, sense whether they can send a message on the network, and if so, send their message.

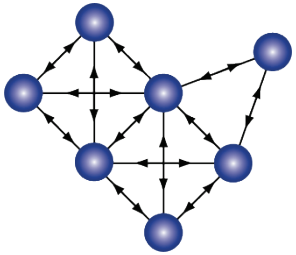


Multi-point to point - When many devices are connected to a single point—for example when a number of nodes connect to a single gateway—it's called multi-point to point. Because of its shape, this network is also referred to as a hub and spoke network, or a star network. An advantage to a star network is that each node is connected to the gateway on its own communications path. If the communication between one node and the master device fails, the rest of the network remains unaffected.



Tree - Adding a repeater to the basic star architecture creates a tree topology. At the lowest level are nodes, referred to as leaves. Their only function is to transmit information to the next highest level. The mid-level devices are repeaters, and at the top is the gateway. In this design, if one of the repeaters fails, the connection between the nodes and their gateway is lost.

Mesh - To improve the reliability, network designers developed an architecture called a mesh. In a true mesh network, each node has limited routing capabilities and maintains a network connection with at least two other nodes. That way, if one link breaks, information has an alternative path to the gateway. The gateway in this case could be any one node in the network.

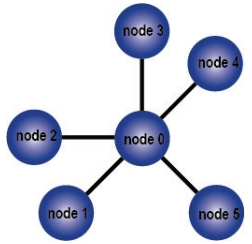


Network Configuration

Addressing

To receive messages, each node in a network must have a unique address. The address is defined when the network is created—that is, when the radio links between nodes, repeaters, and gateways are established.

A wireless sensor network doesn't require the kind of complex, dynamic addressing scheme used for the Internet. Instead, it can use a simple static addressing scheme that relies on two easily accessible rotary switches:



- The left rotary switch sets the network ID, which is the top-level address. It establishes the radio hopping pattern that all nodes on that specific network ID use to communicate with the gateway. Sixteen network IDs are possible, from 0 to 15.
- The right rotary switch sets a device address for the node. It can have a value from 0 to 15.

A network with two rotary switches supports 256 unique addresses, which are the possible combinations of 16 network IDs and 16 device addresses.

The Site Survey

Before a wireless network is installed, a site survey confirms that all components can communicate in the area where they will be located. While this process can be complicated and expensive, wireless network equipment can be engineered to include a built-in site survey tool. When the user requests that a gateway initiate a site survey with a particular node, the tool performs all tests automatically.

Moving Messages Around the Network

Information transmitted between addresses in a wireless network is contained in a formatted block called a packet, which consists of three elements: the header, which includes information like the address to which the packet is being sent and the type of information being sent; the payload, which is the data itself; and a trailer, which indicates the end of the packet.

To reliably transmit this message, efficient networks regulate communications between devices. In general, most networks support the concept of master/slave, where at any moment one device on the network is the master that controls the network and the rest are slaves that respond. A gateway can be the master and all the nodes slaves. Alternatively, if the gateway is connected through to a networked computer, that computer may be the master.

How the network is configured to receive messages affects the performance of the system. To properly understand the capabilities of any wireless system, it is important to understand the message types the network supports.

- Polled - The master polls the slaves to see if they have any messages to send over the network. If a slave has a message, it generates a packet for a specific address and, when signaled by the master, sends this information over the network. In this way the master controls access to the network, ensuring each node has a specific interval in which to communicate its message.
- Cyclic - The slave periodically generates a message to the master based on a specific parameter settings such as “Send the temperature every three minutes.” The slave wakes up from sleep mode, takes a temperature reading, turns on its radio, listens to see if there is any recognizable traffic on the network, and if not, it assembles a packet and sends the packet over the transmitter.
- Event driven - An event—such as an excessive temperature or a low battery—triggers a message. In this situation, the node usually needs quick access to the network, so it can notify the master.

For more information, visit Banner Engineering at www.bannerengineering.com/wireless.