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Moving Beyond Zigbee® for Star Networks

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White Paper

Multi-hop mesh protocols, such as Zigbee®, are getting a lot of press for their ability to link together low data-rate Machine-to-Machine (M2M) applications. Zigbee, in particular, is targeting itself as the standard bearer for wireless, low-power meshing protocols. Many of the features of a Zigbee solution touch on the requirements for expanding wireless M2M markets. Low data rate, low power, enhanced range through the mesh and automated on-demand routing of packet data are the key aspects of Zigbee which are responsible for creating such a buzz in the M2M market space.

Requirements for Star Networks

It is important to consider the actual data flow through the network when implementing a Zigbee-type mesh. While all nodes may be capable of communicating with each other, in reality, most networks are point-to-multipoint (or multipoint-to-point, depending on the perspective), and form a star topology. Data flows from a central server to specific end points, which in turn collect data or provide some sort of action. Data from the end points is also able to flow back to the central point. This is the basic network flow for the majority of wireless sensor and control applications, including building automation, telehealth, smart energy and retail. For a star network, a multi-hop mesh is not a requirement; but rather a feature to ensure connectivity from all nodes. In fact, for star networks, the amount of overhead required for a Zigbee network may be restrictive to an optimal solution.

Below is an example of a star network with multiple end nodes, in which all nodes communicate to a single central sever.

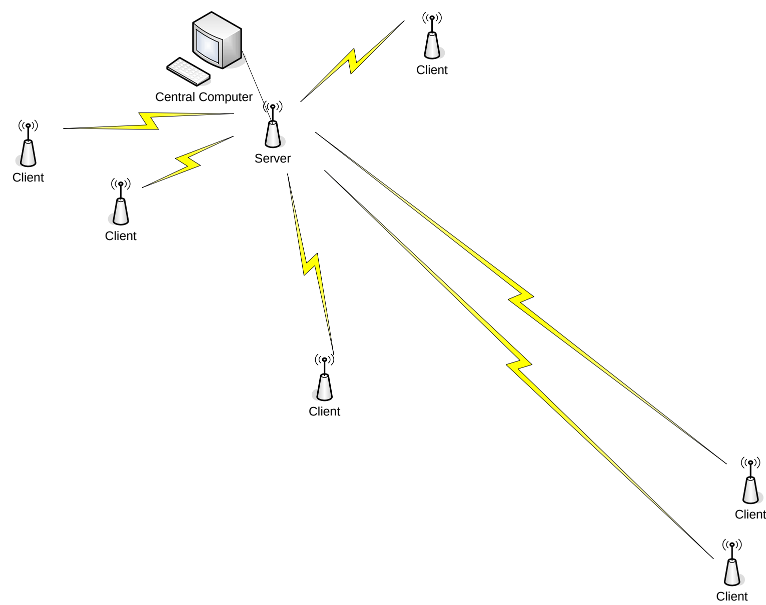

Figure 1: Star Network

Review of Zigbee for Star Applications

Zigbee has a dual layer addressing scheme with a lower layer Institute of Electrical and Electronics Engineers (IEEE) address being hard coded on the nodes, and a dynamically assigned network address being used for transport. Because only the network address is used to route data, an end user must translate between the IEEE address and the network address in order to properly address the packets. This is analogous to how the Address Resolution Protocol (ARP) operates in traditional Ethernet networks. This dual layer addressing is common for routed networks and provides a layer of abstraction from the hardware (IEEE) layer. For star networks, it only serves to provide another layer of complexity to a simple issue of connectivity, as seen in the figure below.

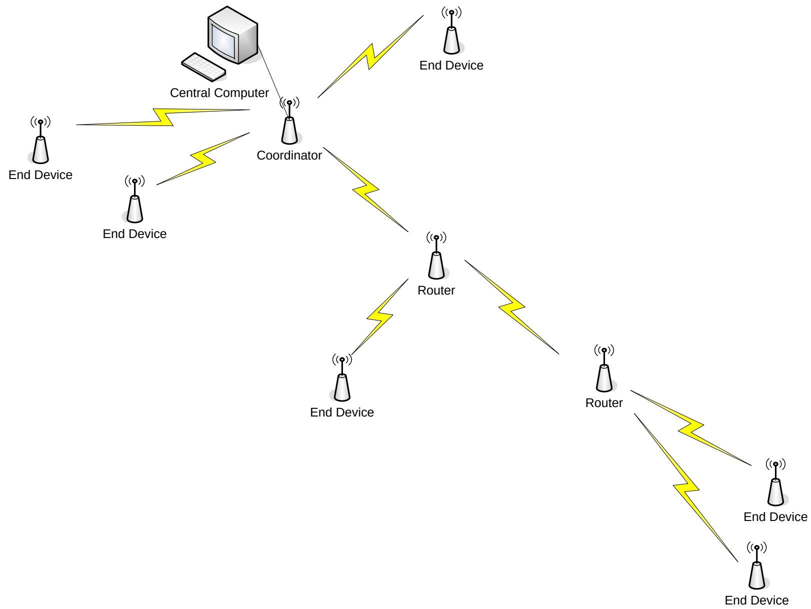

Figure 2: Star Network Implemented Over a Multi-hop Mesh

The Zigbee mesh is based on an underlying radio frequency (RF) protocol defined by the IEEE 802.15.4 standard. The 802.15.4 standard is a direct-sequence spread spectrum (DSSS) modulation system designed to operate in the 868 MHz, 900 MHz, and 2.4 GHz industrial, scientific and medical (ISM) bands. In practice, most transceivers operate at 2.4 GHz, as it provides worldwide acceptance and the higher 250 kbps RF data rates. In many parts of the world though, including Europe, 2.4 GHz DSSS transceivers are limited to 10 mW of radiated output power. Compare this to frequency hopping systems such as Bluetooth® and proprietary RF, which can radiate up to 100 mW per Conformité Européenne (CE) regulations (10x the output power). This limitation reduces the overall power consumption of the module, but it also limits the range of the moduleas well. Zigbee addresses this range issue through multi-hop mesh routing.

Adding routers to provide connectivity has drawbacks though. First, it increases the overall costs of the system as there is a requirement for more transceivers. Second, as each packet is routed through an additional node, the overall latency of the system increases due to the node possessing single transceiver that prevents it from transmitting and receiving at the same time. The latency can be further increased if there is a need to perform a route request prior to transporting the data packet. The complexity of the data traffic can be seen in the following data flow diagram below.

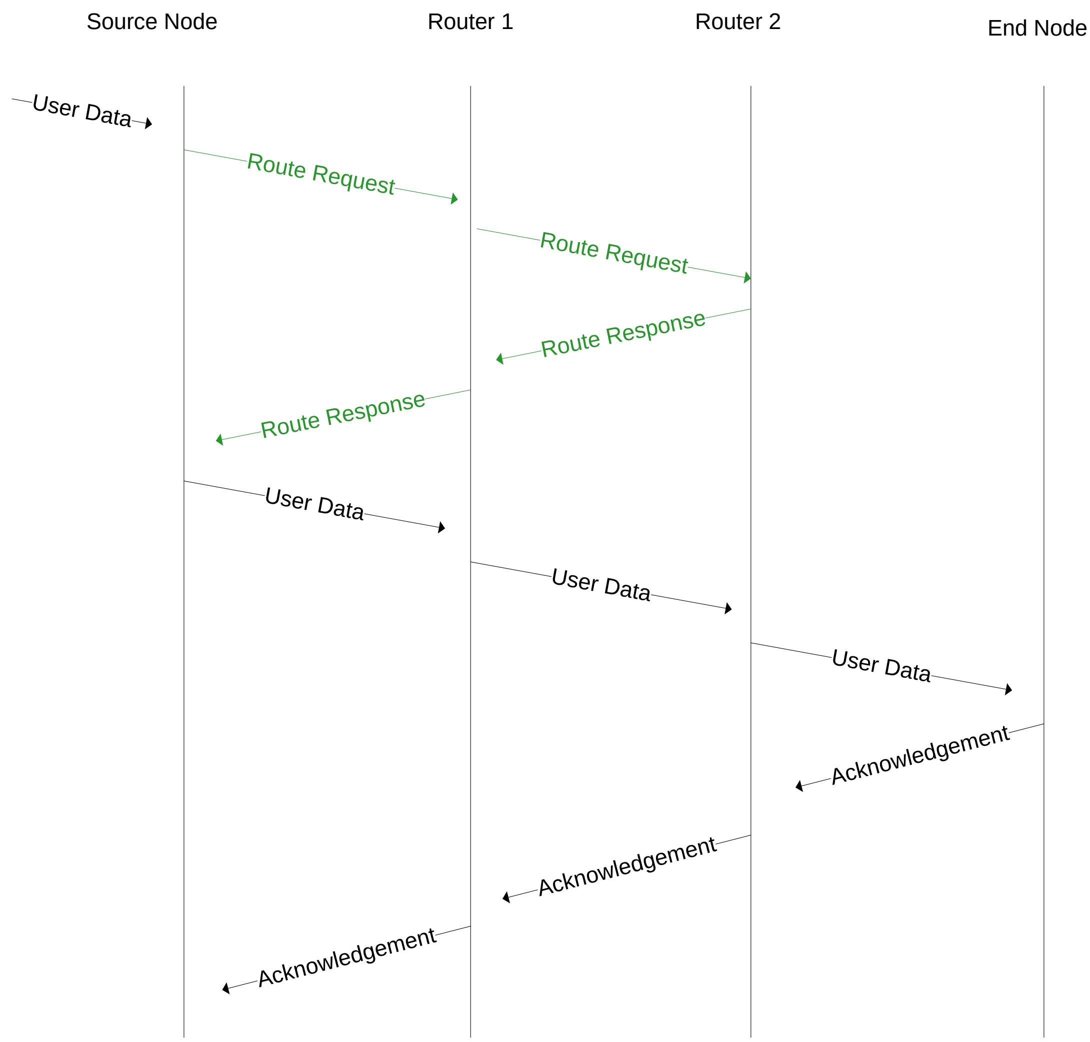

Figure 3: Zigbee Packet Delivery

In the above figure, if it is assumed that each of the 10 transmissions takes at least 10 ms (and that would not take into account the need to retransmit any data), then it would take over 100 ms for the user to receive their acknowledgement back.

Zigbee Pro, the third major revision of the Zigbee spec, addresses this by implementing source routing. Source routing can reduce the amount of route requests that are required, but adds additional overhead to the data packets sent across the air by including each of the hops' network addresses in the packet. The high latency can restrict Zigbee networks from being able to effectively stream data from one point to another. If the Zigbee nodes above can only transmit 100 bytes of data with every packet transmission, than at 100 bytes every 100 ms, the actual data rate is only 8 kbps; less than the 9600 baud rate that many applications use for data transfer. It is much less than the 115,200 that many more applications require. Due to these restrictions, all data must be managed as discrete packets which are sent at infrequent intervals.

Finally, if additional routers are required to provide connectivity, then the end user is responsible for providing the infrastructure to support the intermediate routers. Additional nodes result in additional costs, additional power sources and must be placed in a location that enables them to provide optimum coverage.

Solutions

These coverage issues can often be resolved by substituting for the lower power intermediate router with higher power transmitters at each end of the link. Moving from 10 mW to 100 mW will provide a 10 dBm gain in the link budget; roughly 2.5x increase in range. In addition, for non CE markets such as North America, higher output powers up to 1W are available in order to provide additional coverage. Once free from the constraints of Zibgee's power and data rate restrictions, end users can select from a wealth of standard and proprietary solutions that suit their M2M applications.

One comparative example that offers a solution over a traditional Zigebee transceiver is the Laird Technologies LT2510 series of frequency hopping serial to wireless modules. Designed for industrial M2M applications, the LT2510 series offers best-in-class range and throughput in a small, cost-effective form factor. The LT2510 series features an intelligent server/client architecture ideal for point-to-point and star networks. The intelligence of these devices abstracts the complex underlying RF protocols, and their higher output power eliminates the need for multiple devices to provide connectivity over large distances. The LT2510 series allows for an unlimited number of clients to automatically sync to a single server, the central point in a star system. The end user then is presented with a direct serial link from their host device to the host connected to the central server. With ranges up to 2.5 miles, the LT2510 series provides a large coverage area for star networks. The diagram below shows the same user data being sent over a comparable LT2510 system.

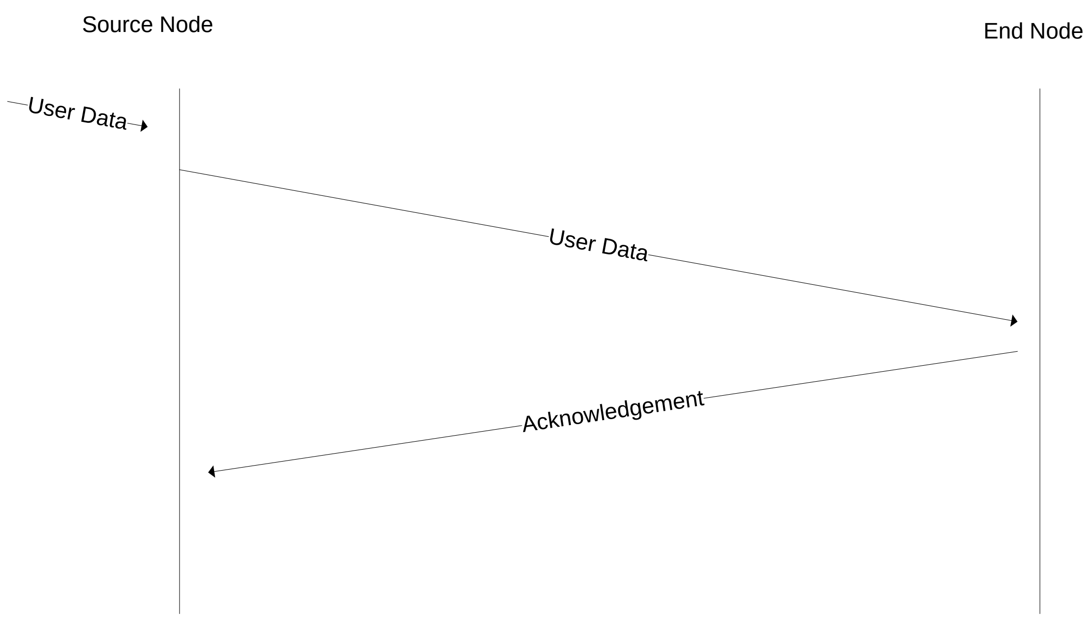

Figure 4: LT2510 Packet Delivery

Since the LT2510 series is offered with higher output power, the entire link can be managed with just the two principle nodes. There is no need for intermediate routers or a routing protocol. The data flows from the source to the destination, and the acknowledgment can be received in as little as 6.5 ms with no retries. Acknowledgements in less than 30 ms are typical for most networks. With optimal configurations, line rates of 115,200 are possible in order to allow for streaming data across the wireless link.

The table below highlights a model comparison of some of the key attributes of a LT2510 100 mW transceiver versus a typical Zigbee 10 mW transceiver.

Table 1: Comparison of LT2510 100 mW vs. Generic Zigbee 10 mW Transceiver

Feature	Generic Zigbee Transceiver	LT2510 Transceiver
Output Power Radiated in CE Markets	10 mW	100 mW
Receiver Sensitivity	-96 dBm*	-98 dBm (@280 kbps RF Rate)
Point-to-Point Range (with 10d Bm Fade Margin)	.5 Miles	1.5 Miles (2.5 Miles for 125 mW Module)
Number of Nodes to Cover a 1.5 Mile Distance	2- End Points + 2- Routers	2- Just the End Points
Addressing	Complex (Network and IEEE)	Simple (MAC only)
Latency for 1.5 Mile Transmission (with Requests, no Retries)	100 ms (Assuming 10 ms Per Hop)	6.5 ms
Throughput	<8 kbps Over 2 Hops	>115.2 kbps

*Numbers based on average transceiver, not a specific transceiver

While the LT2510 series modules do provide a very easy, fully certified implementation for a serial to wireless network, they also provide a number of advanced features which the original equipment manufacturer (OEM) host can use to optimize performance. These features include a reduced idle current draw of less than 10 mA, 50 µA sleep states with the ability to wake up and transmit in less than 26 ms, and advanced application programming interface (API) features to quickly redirect transmitted data using API headers. In addition, the LT2510 series has RF modes that allow for a 500 kbps RF data rate, twice the rate of 802.15.4 Zigbee networks. The combination of easy-to-use, quick time to market, and global certifications allows the OEM to integrate the LT2510 modules into their designs for star networks quickly and cost-effectively.

Summary

Star networks present unique challenges, from managing the number of end nodes, ensuring connectivity, and balancing data from and to the source point. These challenges are enough without adding the unnecessary overhead from a multi-hop mesh solution. Star networks can benefit from a simpler, more effective solution. Zigbee has some great features which make it a powerful protocol for M2M communications, but that does not mean it is optimized for all networks. Identifying the key requirements and selecting a wireless solution which is optimized for star networks can reduce the time to market and also provide for a more robust solution.

About the Author

Chris Downey has been with Laird Technologies for over three years. He has been responsible for the network design and troubleshooting for a Tier 1 data communications network, systems administration in a nationwide enterprise network, and also was formally a field applications engineer for embedded wireless modules. Mr. Downey is currently a product manager for wireless modules at the Lenexa, Kansas facility. He has a BS in Electrical Engineering

About Laird Technologies, Inc:

Laird Technologies designs and manufactures customized, performance-critical products for wireless and other advanced electronics applications.

The company is a global market leader in the design and supply of electromagnetic interference (EMI) shielding, thermal management products, specialty metal products, signal integrity components, and antenna solutions, as well as radio frequency (RF) modules and wireless remote controls and systems.

Custom products are supplied to all sectors of the electronics industry including the handset, telecommunications, data transfer and information technology, automotive, aerospace, defense, consumer, medical, mining, railroad and industrial markets.

Laird Technologies, a unit of Laird PLC, employs over 12,000 employees in more than 49 facilities located in 16 countries.