WHITE PAPER

Understanding the Zigbee® Green Power v1.1 Multi-Sensor and How it Compares to Battery-Powered Zigbee® 3.0 End Devices

By Bram Van den Bosch, Director of System Architecture

With the ratification of the Zigbee® Green Power v1.1 specification in June 2018, the Zigbee Alliance is making another step in enabling ultra-low power sensors. Zigbee Green Power is one of the features of Zigbee 3.0 that sets this protocol apart from other smart home standards. From its inception, Green Power has been completely focused on reducing energy consumption to enable the ultra-long battery life or energy harvesting applications it is targeting. As a result, it has made some different tradeoffs when compared to traditional Zigbee 3.0 battery powered end nodes.

Energy Consumption

> "Green Power further reduces energy consumption."

Green Power devices and traditional Zigbee 3.0 end nodes use the exact same PHY and MAC (IEEE 802.15.4), which give both devices the exact same nJ/bit figure for exchanging data. When compared to the already efficient Zigbee 3.0 end nodes, Green Power further reduces energy consumption by decreasing the number of bits that the Green Power protocol requires to have exchanged over the air. This is achieved by optimizing the sizes of the packets a Green Power node needs to send, and by reducing the number of packets it sends for a given task.

Green Power has always placed a very strong focus on keeping packet sizes as small as possible:

- Where Zigbee end devices rely on 64-bit MAC addresses, Green Power has introduced 32-bit Source ID to uniquely identify the devices.
- Green Power uses some cross-layer optimizations to avoid overhead in the packet structure. For example, it allows combining reports from different clusters inside a single packet, thus saving the overhead associated with having to use separate packets.
- Green Power splits the functionality over the Green Power devices and the backbone nodes very asymmetrically. Green Power devices are kept as simple as possible, while the intelligence needed for routing is offloaded to the backbone network (the Zigbee 3.0 router devices). This also allows Green Power devices to save on the size of the packet headers required.

With the introduction of the new Multi-Sensor feature, Green Power goes one step further and also optimizes the application level payload by exploiting the pre-knowledge of the type of reports a given sensor can send over its lifetime. Instead of indicating the meta-information with respect to data type and data format in every report sent, the Multi-Sensor feature provides this meta-information once during commissioning, and the reports only carry the actual measurement values. This feature is most interesting for sensors that have a lot of application data to exchange. These are typically devices that combine multiple sensors, like temperature and humidity, hence the feature was named "Green Power Multi-Sensor."

"Green Power goes one step further and also optimizes the application level payload."

Let's look at a typical scenario, where an indoor environment sensor sends a report to indicate the current temperature, humidity and illumination levels. As shown in the table below, all the optimizations mentioned above allow the total transmit time for a Green Power device to be reduced by a factor of 5 compared to Zigbee 3.0 end nodes.

Table: Total Transmit Time Comparison for Indoor Environment Sensor Implementation

	Reports to be Transmitted by Indoor Environment Sensor (Excluding PHY Preamble)	Total Transmit Time (Absolute)	Total Transmit Time (Relative)
Zigbee 3.0 End Node	3 Separate Reports of 53 Bytes Each	5664 µs	100%
Green Power Device w/o Multi-Sensor Feature	1 Combined Report of 45 Bytes	1632 µs	28%
Green Power Device with Multi-Sensor Feature	1 Combined Report of 31 Bytes	1184 µs	20%

To put this in perspective, a reduction by a factor five, means an increase of better life-time with a factor five, so for instance, going from changing batteries once per year, to changing batteries once per 5 years.

Reliability

Zigbee 3.0 end nodes count on a MAC level (single hop) and APS level (end-to-end) acknowledgement mechanism to trigger retries and ensure reliability. Retries can be triggered at different layers, resulting in the very high reliability numbers for which Zigbee 3.0 is known.

In an energy-harvesting context, there is, however, no guarantee that the Green Power device will have enough energy available to perform such retries. As such, Green Power takes a different approach. To maximize reliability with a limited energy budget, Green Power leverages the powered Zigbee 3.0

"This energy is used to enable smaller harvesters, extend battery life, or increase reliability by sending the report itself multiple times."

backbone network, and increases the probability that the Green Power frame is received, by having all Zigbee routers act as potential proxies. Although this does not enable the same reliability levels achieved by Zigbee 3.0 end devices, it is by far good enough for the large majority of sensor use cases.

In the Green Power approach, no energy is spent on trying to receive MAC level and APS level (end-to-end) acknowledgements, and on polling for the APS level acknowledgements. Instead, this energy is used to enable smaller harvesters, extend battery life, or increase reliability by sending the report itself multiple times – all depending on the requirements of the specific application.

Memory Footprint

Green Power devices are kept as simple as possible. They use an asymmetric approach that allows them to deal only with the application-level aspects – and, to a lesser degree, some commissioning aspects – while all other networking and support-related aspects, like routing and binding, are offloaded to the Zigbee backbone network.

This enables Green Power devices to be implemented on platforms with less real estate, allowing smaller and less costly solutions. Where Zigbee 3.0 end nodes are typically equipped with at least 256 KB program memory and 16 KB data memory, the 32 KB program memory and 1 KB data memory of a Green Power device is often sufficient.

Conclusion

Green Power is a beautiful aspect of Zigbee 3.0, and the new Multi-Sensor feature makes Green Power even more powerful. Green Power seamlessly integrates with Zigbee 3.0 networks. It is also a feature that can stand fully on its own when Green Power sensors form a star network around a simple Green Power gateway. It can make the difference for ultra-low power networks, or for networks with devices based on energy harvesting. It deals with the quirks and tweaks of irregular power supply, while continuing to operate as one would expect. Green Power is a unique differentiator for Zigbee 3.0 that makes it a more complete solution than any of its competing standards.

“Green Power is a unique differentiator for Zigbee 3.0 that makes it a more complete solution that any of its competing standards.”

About the Author

Bram Van den Bosch is Director of System Architecture at Qorvo, responsible for SW and standardization aspects of the company’s low-power wireless products. He has been involved with the Zigbee Alliance for more than 10 years, with various contributions to Zigbee RF4CE and Zigbee Green Power.

For more information, please visit **www.qorvo.com**.