ZigBee 3.0—Facilitating the Internet of Things

ABSTRACT

As we move toward a more connected, 'smarter' world through the medium of wireless network technology, the challenge is to achieve the standardization of this technology. Standardization is necessary to facilitate a simple user experience in terms of product choice, set-up, and operation, including the interoperation of products from different manufacturers. These are essential ingredients for consumer confidence and acceptance. Bluetooth® and Wi-Fi® have established themselves as standards in the device-to-device and high data-rate domains, such as audio and video streaming, but the low-power, low-data-rate domain of monitoring and control remains open. ZigBee® has emerged as one of the leading standards in this arena and looks set to form the basis of the low-power wireless world with the advent of ZigBee 3.0. This new version builds on the existing ZigBee standard but unifies the market-specific application profiles to allow all devices to be wirelessly connected in the same network, irrespective of their market designation and function. Furthermore, a ZigBee 3.0 certification scheme ensures the interoperability of products from different manufacturers. Connecting ZigBee 3.0 networks to the IP domain opens up monitoring and control from devices such as smartphones and tablets on a LAN or WAN, including the Internet, and brings the true Internet of Things to fruition.

INTRODUCTION

The world is in the process of embracing the wireless network technology that is destined to bring an unprecedented level of automation to our everyday lives. Many of these wireless networks employ low-power nodes that need to exchange small amounts of data infrequently at low data-rates (typically no more than 250 kbit/s). For example, a temperature sensor in a HVAC (heating, ventilation and air-conditioning) system may need to send a simple temperature measurement to a controller device once every few minutes or only when the temperature changes by a certain amount. The sensor may be located in a relatively inaccessible place without a mains power source and therefore needs a battery with an operational lifetime of years in order to minimize battery replacement. Very low power consumption then becomes a critical requirement.

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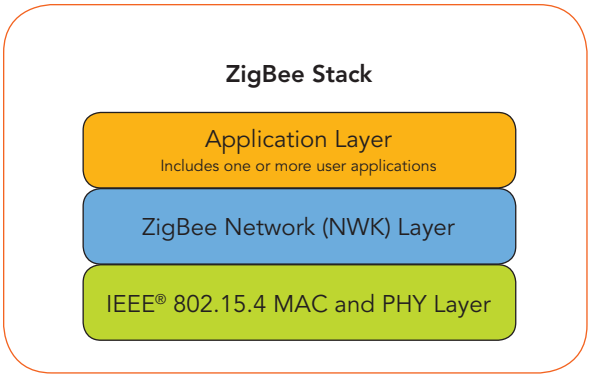


THE ZIGBEE PERSPECTIVE

The ZigBee Alliance has been addressing the above requirements of low-power wireless networks for more than a decade. The IEEE 802.15.4 standard was conceived to meet the low-level needs of these networks and then the ZigBee Alliance rapidly introduced the ZigBee specifications to provide high-level networking functionality on top of IEEE 802.15.4 (such as automated network formation and data packet routing), and a framework for user applications. Thus, IEEE 802.15.4 occupies the bottom layers of the ZigBee protocol stack, the applications sit at the top of the stack, and the ZigBee Network (NWK) layer is sandwiched between them. This simplified view of the ZigBee stack is illustrated above.

Therefore, ZigBee provides networking functionality concerned with the formation and operation of low-power wireless networks, including the routing of data packets between devices. Notably, ZigBee's advanced routing feature adopts a Mesh topology to allow self-healing routes between communicating devices, thus avoiding single points of failure and ensuring reliable packet delivery.

The ZigBee Alliance cites the following features as the main benefits of the ZigBee standard:

- **Reliable and robust:** Mesh network topology eliminates single points of failure and permits networks with a large physical expanse.
- **Low-power:** The ZigBee standard allows the use of (non-routing) devices with autonomous power supplies such as batteries or solar cells. ZigBee Green Power (GP) is available to support such devices by maximizing battery life or facilitating energy harvesting.
- **Scalable:** Supports the expansion of networks to thousands of nodes over a large area.
- **Secure:** Employs security mechanisms such as AES-128 encryption, security keys and frame counters.
- **Global:** Operates in the 2.4 GHz radio band, which is available for unlicensed use all over the world, making applications globally portable.

In recent years, ZigBee devices have been developed using the ZigBee PRO networking protocol. At the application level, the standardization of functionality is addressed per market sector through application profiles (e.g., Home Automation, Smart Energy, Health Care), with the aim of allowing communication between ZigBee-certified products from different manufacturers. Each profile contains a number of ZigBee device types:

- A ZigBee device type (e.g., Light Sensor) is a software entity with functionalities defined by the 'clusters' that it supports.
- A cluster is a set of attributes (parameters) and commands that correspond to a particular functionality (e.g., Illuminance Measurement).

Devices from different profiles cannot always communicate with each other.

The new chapter in the ZigBee story is ZigBee 3.0, which is also based on ZigBee PRO. ZigBee 3.0 maintains all previous functionality but unifies the application profiles to allow all device types to connect wirelessly in the same network.

THE FUTURE OF WIRELESS NETWORKS AND THE IoT

Communications in low-power wireless networks have, so far, been largely between devices within a particular application area, such as smart lighting. The addition of IP connectivity to these networks permits the control and monitoring of the network nodes from smartphones, tablets and other generic IP-connected devices—for example, controlling the lights in a house with a smartphone. This extends low-power wireless networks to the Internet of Things (IoT).

The next step is to enable all wireless devices to communicate, regardless of their market sector, either in a meaningful way or simply for routing purposes. This approach brings all the wireless nodes on a given site into a single network and potentially into the IoT. In the future, these nodes will become proactive in collecting data from their environment, allowing the network to use the data intelligently in a transparent fashion. For example, the network can learn the behaviors of the inhabitants of a smart home and apply appropriate environmental control. This vision of the future will require standardization at the application level. This is a major objective of ZigBee 3.0.

The market traction of low-power wireless networks and the IoT depends on a number of factors, including price and consumer confidence in the technology. Consumer confidence is determined by the security and privacy associated with the technology, as well as ease of use. In this respect, the interoperability of devices from different manufacturers is important. This can only be achieved by using the standardized approach, across all manufacturers, that ZigBee 3.0 offers.

THE NEED FOR ZIGBEE 3.0

ZigBee 3.0 furthers the advance toward a connected technological society by breaking down the barriers between low-power wireless devices from different market sectors to allow fully integrated networks as well as Internet connectivity. This approach is now supported by a supply of low-cost, general-purpose, low-power, high-speed microprocessors that remove the need for tailored hardware platforms for particular application areas.

Thus, an important objective of ZigBee 3.0 is to remove restrictions that prevent nodes in different application areas from participating in the same network. So, for example, device types from the ZigBee Light Link and Health Care application profiles can exist in the same ZigBee 3.0 network. Two device types from different profiles can only communicate in a meaningful way at the application level (e.g., one device providing useful data to another device) when they share a common functional cluster, but packet routing operations at the networking level are performed by a router node irrespective of the device type implemented on the node.

A coherent approach across manufacturers toward the development and marketing of low-power wireless network products is crucial to establishing consumer acceptance and market traction, as well as true interoperability between products from different brands. ZigBee 3.0 provides a standard framework and an improved certification scheme that ensures this interoperability and a worry-free consumer experience.

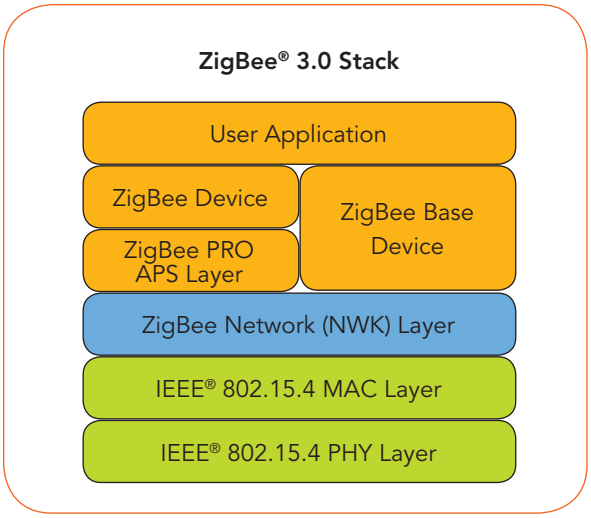
THE NATURE OF ZIGBEE 3.0

ZigBee 3.0 redefines and refines the previous scheme based on ZigBee PRO to allow increased interoperability.

The ZigBee PRO networking standard provides a sufficiently small software footprint for use on low-power devices that may be autonomously powered from batteries or energy harvesting. Alternatively, ZigBee Green Power can be used to minimize the power consumption of self-powered transmit-only sensors, including switches.

Application profiles targeted at particular market sectors are not a feature of ZigBee 3.0, but a range of device types still exists and these device types are consistent with those of the earlier application profiles. The device types employ clusters from the ZigBee Cluster Library (ZCL), where a cluster is the smallest interoperable functional unit. In ZigBee 3.0, the ZCL contains all available clusters and thus provides a complete toolbox from which all devices take their clusters and associated functionality.

The ZigBee 3.0 software stack incorporates a 'base device' that provides consistent behavior for commissioning nodes into a network. A common set of commissioning methods is provided, including Touchlink, a method of proximity commissioning.



ZigBee 3.0 provides enhanced network security. There are two methods of security that give rise to two types of network:

- **Centralized security:** This method employs a coordinator/trust center that forms the network and manages the allocation of network and link security keys to joining nodes.
- **Distributed security:** This method has no coordinator/trust center and is formed by a router. Any ZigBee router node can subsequently provide the network key to joining nodes.

Nodes adopt whichever security method is used by the network they join.

ZigBee 3.0 supports the increasing scale and complexity of wireless networks, and copes with large local networks of greater than 250 nodes. ZigBee also handles the dynamic behavior of these networks (with nodes appearing, disappearing and re-appearing in the network) and allows orphaned nodes, which result from the loss of a parent, to re-join the network via a different parent.

The self-healing nature of ZigBee Mesh networks also allows nodes to drop out of the network without any disruption to internal routing.

The backward compatibility of ZigBee 3.0 means that applications already developed under the ZigBee Light Link 1.0 or Home Automation 1.2 profile are ready for ZigBee 3.0. The Smart Energy profile is also compatible with ZigBee 3.0 at the functional level, but Smart Energy has additional security requirements that are only addressed within the profile.

ZigBee's Over-The-Air (OTA) upgrade feature for software updates during device operation ensures that applications on devices already deployed in the field can be seamlessly migrated to ZigBee 3.0. OTA upgrade is an optional functionality that manufacturers are encouraged to support in their ZigBee products.

NXP AND ZIGBEE 3.0

As a ZigBee Alliance promotor member and an active contributor to the working groups on the ZigBee 3.0 standard, NXP is taking its established commitment to ZigBee forward to ZigBee 3.0. For more than a decade, NXP's family of JN51xx wireless microcontrollers has included members optimized for ZigBee applications. Currently, all the microcontrollers in the JN516x and JN517x series support ZigBee 3.0. Free NXP support software is available for ZigBee 3.0 on JN516x/7x, including a ZigBee PRO stack and associated application programming interfaces (APIs), a wide range of ZCL clusters, Green Power features, ZigBee Lighting and Occupancy (ZLO) device types and example device software that can be used as a basis for custom application development.

For more information on NXP's products and support for ZigBee 3.0, please visit **www.nxp.com/zigbee.**

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