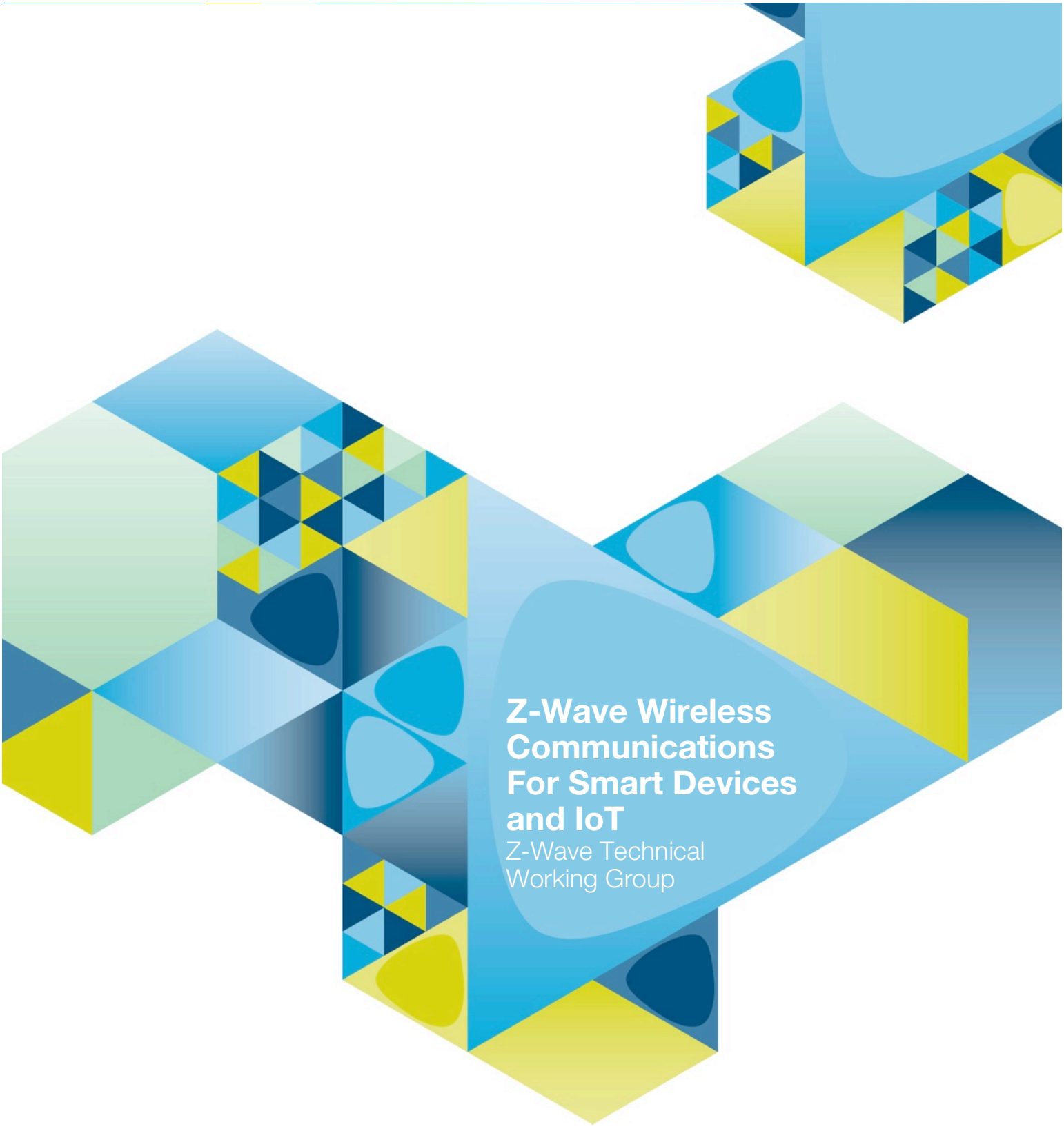

Z-Wave Wireless Communications For Smart Devices and IoT

Z-Wave Technical Working Group

SIGMA DESIGNS

Abstract:

Z-Wave is a low-power, wireless mesh network standard that is widely used for M2M and smart devices in the Internet of Things (IoT), home automation, and security markets. Z-Wave is a complete communications solution, encompassing everything from the physical or hardware layer to the applications layer. Z-Wave is the only low-power wireless communication solution with proven, certified interoperability and interchangeability at the product level. Z-Wave's advantages include low power consumption at the physical level, true self-healing mesh networking, industry-leading battery life for devices such as door locks that require low communications latency, simple product development, IP compatibility, and robust applications level interoperability with over 35 million devices spanning 1,200 products from over 100 different manufacturers.

This paper outlines the unique benefits of Z-Wave technology for smart devices and the Internet of Things, including technical considerations, the role of certification and branding, advanced development tools, and the Z-Wave Alliance.

Advantages of a Single Protocol

As the Connected Home, Home Automation, and IoT markets continue to grow dramatically, manufacturers entering or expanding their presence must select a wireless communications protocol for their products. Some hedge their bets by offering multiple protocols, however, this drives up bill of material costs and power consumption. For most devices that are part of the connected home, including sensors, alarms, lighting and shade controls, HVAC controls, and locks, implementing a single wireless protocol makes the most sense. After all, devices designed for these applications all require the same performance attributes, namely: low power, medium bandwidth, Home Area Network (HAN) coverage with high reliability, easy installation, end-consumer relevant retail price point, and enough compatible or interoperable devices and manufacturers to enable a complete home control solution.

Among the many available technology choices, the Z-Wave protocol stands out as the only one offering all desired attributes. Other protocols have specific advantages, but these come at the expense of other considerations – Wi-Fi, for example, has superb bandwidth, more than is needed for command and control applications, but this comes with high power consumption cost, making Wi-Fi based battery-powered devices unrealistic. Bluetooth and Bluetooth LE both offer excellent power profiles and bandwidth, but fall short when it comes to HAN coverage and support for enough devices in a network for complete home control solutions. ZigBee technology comes the closest to providing the right mix of power, bandwidth, HAN coverage, and ease of installation; however it has failed to provide a rich ecosystem of interoperable products from multiple manufacturers. Z-Wave is the one protocol that offers the right balance of bandwidth, range, power consumption, cost, and product-level interoperability across multiple manufacturers, making it the best overall choice for the vast majority of smart device applications.

Why Z-Wave: Technical Considerations

This table shows the current Z-Wave® sub-1 GHz frequency coverage.

COUNTRY/REGION	STANDARD	Z-WAVE FREQUENCY
Australia	AS/NZS 4268	921.4 MHz
Brazil	ANATEL Resolution 506	921.4 MHz
CEPT*	EN 300 220	868.4 MHz
Chile	FCC CFR47 Part 15.249	908.4 MHz
China	CNAS/EN 300 220	868.4 MHz
Hong Kong	HKTA 1035	919.8 MHz
India	CSR 564 (E)	865.2 MHz
Israel		915-917 MHz
Japan 950**	ARIB T96	951-956 MHz
Japan 920**	ARIB STD-T108	922-926 MHz
South Korea	Clause 2, Article 58-2 of Radio Waves Act	919-923 MHz
Malaysia	SKMM WTS SRD/EN 300 220	868.1 MHz
Mexico	FCC CFR47 Part 15.249	908.4 MHz
New Zealand	AS/NZS 4268	921.4 MHz
Russia	GKRCh/EN 300 220	869.0 MHz
Singapore	TS SRD/EN 300 220	868.4 MHz
South Africa	ICASA/EN 300 220	868.4 MHz
Taiwan	NCC/LP0002	922-926 MHz
UAE	EN 300 220	868.4 MHz
USA/Canada	FCC CFR47 Part 15.249	908.4 MHz

Z-Wave's advantages start with the radio frequencies used. The specific frequency varies slightly based on international region, but all Z-Wave communication takes place in the 900 MHz band. Basic physics plays a role – at a given power output level, frequency governs battery life and is regulated by the government. As frequency goes up, so does bandwidth, but range, object penetration, and battery life go down. Z-Wave uses the 900 MHz band as that has been found to have the optimum balance of power consumption, bandwidth, and range. The 2.4 GHz band used by almost all alternative technologies in this application space has the advantage of being a global frequency, however, this comes with the cost of higher than needed bandwidth and power consumption, as well as a very congested spectrum. Since almost all smart devices have to be localized in their form factors and safety approvals, using a globally approved frequency as opposed to a specific frequency selected in firmware is of minimal, if any, advantage.

The Z-Wave Physical and Media Access (MAC/Phy) layers are defined by an International Telegraphic Union standard, ITU-T G.9959. This robust, field-tested international standard is in the public domain and is available free without licensing fees. (For more info, see http://www.itu.int/rec/T-REC-G.9959)

Before leaving the physical layer, consider the actual hardware currently available. Sigma Designs' newest 500 series SoC platform includes:

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  ZM5101 General Purpose Z-Wave SiP Module: This product combines a Z-Wave SoC with a built-in microcontroller and Z-Wave RF transceiver, and crystal and passive RF components in an 8x8mm module. Power is a single 3-volt supply (2.3-3.6V, with built-in battery monitor), and, in sleep mode, power consumption is a mere 1 μ A.

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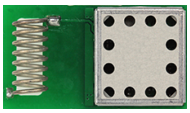
  ZM5202 General Purpose Z-Wave Module: The combination of a Z-Wave SoC with a built-in microcontroller and Z-Wave RF transceiver, with crystal and passive RF components in a module that provides 128kB Flash and 16kB SRAM, makes it ideal for single microcontroller products.

- 

  ZM5304 Z-Wave Serial Interface Module with Antenna: This module takes the RF design effort out of Z-Wave, and includes a Z-Wave modem and built-in antenna. It comes with full FCC modular approval and is pre-scanned for CE approval, reducing time to market by making hardware integration and approval very simple.

Z-Wave's advantages don't stop at the MAC/Phy layers; layers 3 and 4 have several advantages as well, not the least of which is 12 years of proven operation and continuous improvement in true mesh networking topology. Z-Wave's networking layers define a network of 231 devices, plenty for most residential and light commercial applications. They define a mesh network topology where line-powered devices function as two-way signal repeaters. This mesh network provides an extended communication area while maintaining low transmit power, improved coverage around obstacles, redundant and fault tolerant links, and enables battery-powered devices to communicate over large areas. Z-Wave's mesh uses several discovery and routing mechanisms that start with source routing for the lowest possible latencies and progress, if needed, to an ad hoc on-demand routing mechanism, known as Explorer Frame, that ensures message delivery even in the most dynamic network configurations. Explorer Frame is key to plug-and-play discovery of new devices and to dynamic self-healing of network links that may get corrupted due to changing environmental conditions. Z-Wave's mesh network does not require a "coordinator" or master device to create routes and direct traffic like other popular mesh networks. This eliminates the single point of failure found in most other popular mesh networking technologies.

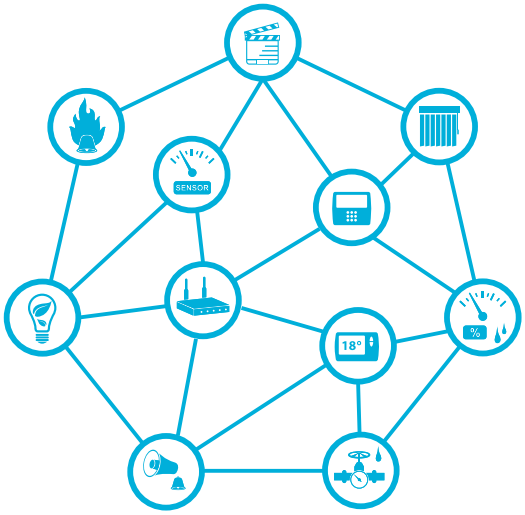


Figure 1 Mesh Network

Figure 1. Packet travels to last repeater in path to door lock

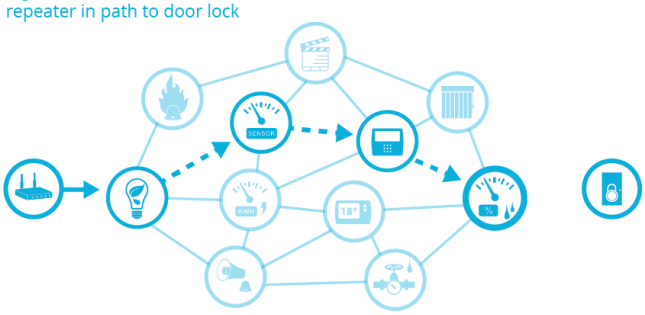
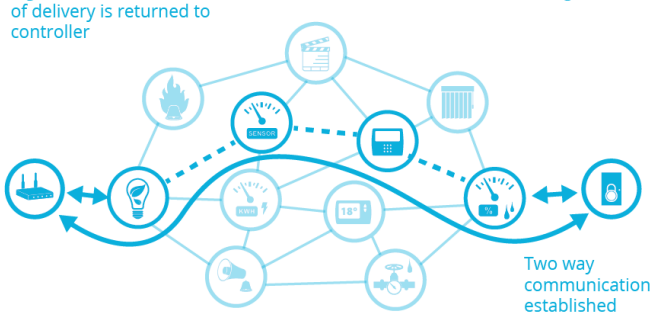


Figure 2. Last repeater in path sends wake up signal to door lock

Figure 3. DOOR LOCK IS AWAKE - Packet is delivered and acknowledgement of delivery is returned to controller



To maximize battery life while still providing low latency communications, Z-Wave takes advantage of its unique FLiRs (frequently listening routing slave) technology. This technology is used in battery-powered devices such as door locks and thermostats, or any battery powered device. FLiRs uses an industry-standard technique, “beaming”, to wake up FLiRs devices. This enables devices to “listen” for a beam while using barely more power than when completely asleep.

The Z-Wave standard and technology don’t stop at the local smart device network but go on to define and deliver a technology called Z-Wave over IP (Z/IP). Z/IP defines a standardized bridge and router design where every Z-Wave endpoint in a given network is automatically assigned an IPv4 or IPv6 address. Direct IP communication is provided to each Z-Wave end point using UDP and TLS1.1 protocols. The newest release of Z/IP Gateway, 2.0, scheduled for Q1 2015, will feature mDNS discovery, multi network association, and will be released as source code that developers can modify to fit their unique needs.

Z-Wave’s designers are well versed in direct IP communications to end-devices using IP header compression techniques such as 6LoWPAN. However, this is unnecessary and very inefficient in comparison to using native Z-Wave communications to end devices. Z-Wave over IP provides the best of both worlds – direct IP communication with every end point and Z-Wave’s industry leading mesh protocol.

Certification and Branding

While all of the above are necessary to compete in the competitive smart device wireless communications market, Z-Wave alone has gone further, with the most comprehensive set of device profile definitions and the industry's strongest product certification and branding program. Z-Wave is the only standard to require product-level certification and interoperability. Other standards such as ZigBee require communications-level interoperability but make product-level interoperability an option. Additionally, on the branding and labeling front Z-Wave stands for one interoperable ecosystem of products where others allow their brand to be used over multiple specifications and standards, causing confusion in the market. Z-Wave offers product-level interoperability with over 1,200 certified devices already available. It is this product-level certification that provides the interoperability and interchangeability that make Z-Wave the lifestyle technology of choice for virtually every North American security provider, as well as the leading technology in virtually every multi-technology hub currently offered in the market.

Z-Wave's clearly defined device profiles and uniform software stack also ensure compatibility between brands and between generations of devices. ("No device left behind" is Z-Wave's informal motto—even first-generation devices, released in 2003 are still compatible with today's Z-Wave protocol.)

Advanced Toolsets

The Z-Wave SDK delivered by Sigma Designs provides product developers with some key features that make developing Z-Wave based smart products faster, easier and more powerful than their competitors. One such feature is the Z-Wave Application Framework (ZAF) development environment. High-level commands, extensive command and device definitions, and mature, robust, field-tested code bases make creation of new Z-Wave devices fast and easy, while guaranteeing interoperability.

Z-Wave's Installation and Maintenance Application Tool (IMA) provide powerful hooks and algorithms for measuring and monitoring the performance of the network either locally or remotely. IMA tools make building in installation and maintenance routines easy. Use of these routines greatly reduces installation time and eliminates the need for multiple truck rolls. For example, using IMA tools a service provider can remotely investigate and troubleshoot the health of a customer's Z-Wave network.

Benefits of the Z-Wave Alliance

Lastly, the Z-Wave technology, developer community and product ecosystems are supported by the Z-Wave Alliance, a trade association for manufacturers and developers of Z-Wave devices. The Alliance acts as the standards development organization (SDO) for the Z-Wave technology, creates and maintains the product certification standards and provides the Z-Wave Compliance Test Tool (CTT) a software test harness that further decreases time-to-market, and helps reduce certification costs. Additionally, the Alliance provides developer training and best practice coaching for Z-Wave manufacturers.

The Z-Wave Alliance Member Marketing Committee is charged with Z-Wave evangelism and produces, on average, 12 trade shows each year worldwide while maintaining various websites, a certified products catalog, and social media feeds in support of Z-Wave and its member companies. Alliance members continually support the needs of the press and media. The Z-Wave Alliance currently has over 300 members, and can provide speakers for appropriate functions.

Summary

When considering a wireless communications technology for smart home devices, Z-Wave is clearly a leader. Z-Wave is the only technology to offer product level interoperability and strong certification and branding programs. Over 35-million Z-Wave enabled devices have been shipped. The Z-Wave protocol can be found in over eight million home automation controllers and security panels installed worldwide. Virtually every North American home security company uses Z-Wave for door locks, thermostats, and lighting controls. The Z-Wave protocol is additionally strong in the energy management and elderly-care markets and can be found at major retailers including Lowes, Home Depot, Staples, and Amazon. With such widespread use, assured interoperability, ease of development and technical advantages at every layer, Z-Wave is the ideal wireless protocol for smart connected devices and the IoT.

You can learn more about the Z-Wave protocol at z-wave.sigmadesigns.com.

For more information on the Z-Wave Alliance please visit www.z-wavealliance.org.

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