

Freescale IEEE[®] 802.15.4 / ZigBee[™]

Software Selector Guide

1 Introduction

Low-cost hardware for the IEEE[®] 802.15.4 LR-WPAN (Low-rate Wireless Personal Area Network) wireless standard in the 2.4 GHz Industrial, Scientific, and Medical (ISM) frequency band is now available as 3rd or 4th generation devices. With the maturity of these devices and associated software has come a plethora of communication, application, and market opportunities.

A major presence in the wireless markets is the ZigBee[™] Alliance (www.zigbee.org) and its standards. The ZigBee wireless protocol standards are intended to provide monitoring, control, and sensory network services in a cost-effective manner that supports low data rates, low power consumption, security, and reliable operation. The standards are communication stacks built on top of the IEEE 802.15.4 MAC/PHY Standard.

NOTE

If readers require background information on the OSI/ISO communication services model used for the IEEE 802.15.4 Standard and higher level services, refer to Appendix A of this document.

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The Alliance supports two basic specifications:

- ZigBee-2007 - this is the more general standard for wireless monitoring and control applications. The 2007 version of the specification supports two general classes of feature sets (or Profiles)
 - ZigBee (Stack Profile 1) – part of the specification released in 2006
 - Targets consumer products in the home and light commercial environments
 - Designed for simpler, plug and forget networks that are typically less than 300 nodes
 - ZigBee Pro (Stack Profile 2) – added in the specification released in 2007
 - Targets commercial and industrial environments
 - Larger (thousands of nodes), more complex networks that require higher level of expertise, security and commissioning
- ZigBee RF4CE - this standard is targeted for a simple, robust remote control network used in consumer applications.

NOTE

ZigBee application attributes are detailed in greater detail in the description of Freescale's ZigBee target codebases.

In addition to use of the ZigBee standards, applications abound for proprietary networks built upon the IEEE 802.15.4 Standard (MAC and PHY) or upon just the 802.15.4 PHY (essentially just the hardware) with full customer services including custom MAC. In addition to hardware solutions, Freescale offers numerous protocol stacks and tools to enable and expedite application development. These tools are intended to support Freescale's 802.15.4 families and are based on a complimentary, unique and user-friendly design environment called the Freescale BeeKit Wireless Connectivity Toolkit (BeeKit).

To further enhance the software experience, the protocol packages and applications are provided through the Freescale BeeKit Wireless Connectivity Toolkit (BeeKit) which is a comprehensive environment of wireless networking libraries, application templates, and sample applications. The BeeKit Graphical User Interface (GUI), part of the BeeKit Wireless Connectivity Toolkit, allows users to create, modify, and update various wireless networking implementations. Features of the BeeKit user-friendly environment are:

- Provides an extension to embedded application environments appropriate to targeted CPU platform.
- Automated validation of solution/project configuration parameters
- Generates workspace files that can be imported into an Integrated Development Environment (IDE) for continued development and debugging through Extensible Markup Language (XML)
- Scalable, easily supports new codebases and functionality
- Provides an IDE where Freescale wireless link and protocol configurations are easily managed
- Complementary tool to targeted family software development tools
- Supports all Freescale codebases
- Applications are de-coupled from the stack implementation to allow for easy code updates and code reuse

This application note is intended to provide background information and guidance on Freescale's 802.15.4 wireless codebases. All codebases are for exclusive use on Freescale hardware platforms, and a brief hardware overview is also given. For more information on the BeeKit Wireless Connectivity Tool, see the *BeeKit Wireless Connectivity Toolkit User's Guide* Freescale document number BKWCTKUG.

2 Freescale IEEE 802.15.4 Hardware Overview

Freescale supplies three primary families of devices (see [Table 1](#)):

- MC1320x - this family is an 802.15.4 transceiver that communicates to an MCU through a SPI serial communication port. These devices are most commonly coupled with a Freescale MCU from the 8-bit HC9S08 family including the MC9S08QE128 device. All codebases support the HCS08 platform.
- MC1321x - this family combines an HCS08A MCU and an equivalent MC1320x transceiver on the same package substrate. This is a lower cost extension to a two device solution and runs the same codebases. Versions of all the codebases support this platform.
- MC1322x - this family features a full 32-bit ARM7 core, transceiver, and peripherals on a single chip. In the package, a serial FLASH provides non-volatile storage. Versions of all the codebases support this platform.

Table 1. Summary of Freescale IEEE® 802.15.4 Families

Family	Description	Comments
MC1320x	Fully compliant 802.15.4 transceiver (no onboard MCU)	<ul style="list-style-type: none"> • Freescale stacks support 8-bit MC9S08x including the MC9S08QE128 • Usable with other Freescale MCUs
MC1321x	Fully compliant 802.15.4 transceiver (MC13202 equivalent) integrated with a MC9S08A MCU die in a single package	<ul style="list-style-type: none"> • Freescale stacks fully support this device • Standalone device - needs no other MCU • Based on the 8-bit MC9S08 MCU
MC1322x	Fully integrated ARM7 MCU and transceiver in a single device.	<ul style="list-style-type: none"> • Freescale stacks fully support this device • Standalone device - needs no other MCU • Based on the 32-bit ARM7 MCU • Lowest power

3 Freescale Software Solutions

Freescale provides a powerful selection of IEEE 802.15.4 based software solutions. These range from a simple functional “toolkit” to full ZigBee compliant stacks. All solutions are presented as codebases within the BeeKit development environment:

- A given codebase is targeted to one of Freescale’s supported platforms
- The BeeKit project output is compatible with the platform software development tools
 - Freescale’s CodeWarrior Development Studio for the HCS08 platform
 - IAR Systems’ (www.iar.com) IAR Embedded Workbench for the ARM7 platform
- Other custom or open source development tools are not supported
- Various reference documentation and applications examples are included in all codebases.

The following sections describe the available codebases, and [Table 1](#) provides a summary of the codebases and their features.

3.1 Simple Media Access Controller (SMAC)

For each platform, Freescale provides a proprietary Simple Media Access Controller (SMAC) codebase that is a simple ANSI C based function set available as source code and/or libraries. SMAC functions provide control of basic radio and peripheral hardware, messaging capabilities, and simple power management. These building blocks can be incorporated and combined in the user application to construct unique or proprietary MAC or higher level RF transceiver functions. SMAC features include

- Useful for small footprint custom applications
- Useful for hardware evaluation and test
- Supports point-to-point and star network configurations
- Proprietary networks
- Source code, binaries, and application examples provided

3.2 IEEE 802.15.4 2006 Standard-Compliant MAC

The Freescale 802.15.4 Standard-Compliant MAC is a code stack available as object code. The 802.15.4 MAC is used in two ways:

- The 802.15.4 MAC is the heart of all Freescale non-SMAC codebases. All higher level stacks are built on the MAC services
- Customers also use the MAC for developing networking applications based on the full IEEE[®] 802.15.4 Standard but having custom Network Layer and application services. As an example, the ZigBee stacks do not use GTS and beaconing, and custom applications may find these services very beneficial.

The basic MAC is fully 802.15.4 compliant on the HCS08 platform; however, on the ARM platform, beaconing and GTS are not supported. This has no impact on ZigBee stacks as these do not utilize these features.

Features of the MAC include

- Supports star, mesh and cluster tree topologies
- Supports beacons on HCS08 platform
- Supports GTS for low latency on HCS08 platform
- Multiple power saving modes
- AES-128 Security module
- 802.15.4 Sequence support
- 802.15.4 Receiver Frame filtering.
- Source code, binaries, and application examples provided

NOTE

For networking solutions based on the MAC and MAC-based stacks, Freescale provides a library of platform components. The components encapsulate functions such as the task scheduler, timer use, LED and LCD display interfaces, UART, NVM management, and low power library. APIs are provided for all supported functions and are available for the HC(S)08 platform. For more details about the platform components, see the *Freescale Platform Reference Manual*, Document No. FSPRM

3.3 SynkroRF Network

The SynkroRF Network is a Freescale-proprietary general purpose networking layer that sits on top of the Freescale IEEE[®] 802.15.4 MAC. Aimed primarily at consumer electronics applications, it is designed for Wireless Personal Area Networks (WPANs) and conveys information over short distances among the participants in the network. It enables small, power efficient, inexpensive solutions to be implemented for a wide range of applications. Some key characteristics of an SynkroRF Network are:

- Built on the IEEE 802.15.4 MAC/PHY services
- Uses 3 independent communication channels in the 2.4 GHz band (15, 20, and 25).
- 2 network node types; controller and controlled nodes.
- Channel Agility mechanism.
- Low Latency Tx mode automatically enabled in conditions of radio interference.
- Fragmented mode transmission and reception, automatically enabled in conditions of radio interference.
- Robustness and ease of use.
- Essential functionality to build and support a CE network.
- Source code, binaries, and application examples provided

3.4 ZigBee-Based Stacks

Freescale has two independent codebases to support the two ZigBee standard specifications:

- BeeStack™ - supports ZigBee-2007 and ZigBee Pro extensions
- BeeStack Consumer - supports ZigBee RF4CE

3.4.1 BeeStack

Freescale's BeeStack architecture implements the ZigBee-2007 protocol stack including both Stack Profile 1 and Stack Profile 2 (Pro). Based on the OSI Seven-Layer model, the ZigBee stack ensures inter-operability among networked devices. The physical (PHY), media access control (MAC), and network (NWK) layers create the foundation for the application (APL) layers. BeeStack defines additional services to improve the communication between layers of the protocol stack.

At the Application Layer, the application support layer (ASL) facilitates information exchange between the Application Support Sub-Layer (APS) and application objects. Finally, ZigBee Device Objects (ZDO), in addition to other manufacturer-designed applications, allow for a wide range of useful tasks applicable to home and industrial automation.

BeeStack uses the IEEE 802.15.4-compliant MAC/PHY layer that is not part of ZigBee itself. The NWK layer defines routing, network creation and configuration, and device synchronization. The application framework (AF) supports a rich array of services that define ZigBee functionality. ZigBee Device Objects (ZDO) implement application-level services in all nodes via profiles. A security service provider (SSP) is available to the layers that use encryption (NWK and APS), i.e., Advanced Encryption Standard (AES) 128-bit security.

The complete Freescale BeeStack protocol stack includes the following components:

- ZigBee Device Objects (ZDO) and ZigBee Device Profile (ZDP)
- Application Support Sub-Layer (APS)
- Application Framework (AF)
- Network (NWK) Layer
- Security Service Provider (SSP)
- IEEE 802.15.4-compliant MAC and Physical (PHY) Layer

NOTE

For more details on the ZigBee model and protocol, the user is directed to the *ZigBee Specification* at www.zigbee.org.

In addition to the use of two Stack Profiles, ZigBee also embraces the concept of application profiles. The profiles are intended to assure interoperability between like devices for a specific application from different vendors. The application profile specifies a device description and its messaging protocol such that it defines the type, shape, and features of the network. The ZigBee Alliance defines each profile and targets a specific market. Examples include Smart Energy, Home Automation, Health Care, and Remote Control.

Freescale's Beestack supports a number of these application profiles through demonstration software projects. These projects can be used as a starting point for the user to develop their specific application. See [Table 3](#) for BeeStack supported profiles.

3.4.2 BeeStack Consumer

In response to significant market opportunity in the consumer electronics remote control market, the ZigBee Alliance adapted the ZigBee RF4CE Specification in 2009. Freescale's BeeStack Consumer stack

implements the ZigBee RF4CE protocol. It is also a networking layer that sits on top of the IEEE[®] 802.15.4 MAC. It is designed for standards-based Wireless Personal Area Networks (WPANs) of home entertainment products and conveys information over short distances among the participants in the network. It enables small, power efficient, inexpensive solutions to be implemented for a wide range of applications. Targeted applications include DTV, set top box, A/V receivers, DVD players, security, and other consumer products.

Some key characteristics of a BeeStack Consumer network are:

- Based on IEEE 802.15.4 Standard
- Use 3 of the standard 802.15.4 communication channels in the 2.4 GHz band, namely, Channels 15, 20, and 25
- 2 network node types, controller node and target node
- Channel Agility mechanism
- Provides robustness and ease of use
- Includes essential functionality to build and support a CE network
- Source code, binaries, and application examples provided

3.5 Software Solutions Summary

As shown, Freescale offers a world class selection of software solutions for IEEE 802.15.4 wireless networks. Complementing the software products are integrated circuits, extensive applications documentation, and hardware reference designs. Freescale provides complete “one-stop shopping” for those needing WPAN systems.

When evaluating the best software product for an application, many considerations can come into play:

- Is a standard protocol/stack required?
 - Some markets are driven by industry and/or government directed dictates and the user must comply with the required standards, such as a ZigBee Application Profile
 - Some markets require compatibility between vendors
 - Although at times more resource-intensive, standard stacks are aimed at flexibility, mobility, and ease-of-use
 - Standards provide different levels of security
- Is the software for hardware test/evaluation or final product? - SMAC and other utilities may not be part of the end use application, but may play a role in evaluation, lab use, and production test.
- How suitable is the standard to the network application?
 - The IEEE 802.15.4 MAC provides useful, reliable, and economic basic messaging service. If a higher communications level standard is not totally suitable, the MAC should be given serious consideration as a foundation to any custom network protocol
 - In addition to the MAC and ZigBee stacks that Freescale provides directly, Freescale Technology Alliance partners provide proprietary stacks that may be suitable to a user’s application (www.freescale.com/zigbee)
- What are the resources impact?

- More powerful protocols and standardization can require bigger memory footprints.
- What are the cost points of the product and how does this impact the protocol selection?
- Developing custom network software with reliable communication is a non-trivial endeavor
 - Use a standard protocol at the highest level of the networking services as possible - the MAC is an excellent starting point
 - Development time for custom protocols and verifying reliability can be very costly in resources and time
- For low-end, low-cost applications, both the SMAC and MAC can be useful development tools.

Table 2 provides a summary of Freescale codebases versus features. Table 3 provides a list of provide ZigBee application profiles.

Table 2. Freescale Communications Codebases vs. Features

Codebase	Description	Target Application	Standard vs. Proprietary	Topologies	Security	Beaconing	Platforms	Comments
SMAC	Simple ANSI C based code stack available as sample source code can be used for developing proprietary RF transceiver applications using a Freescale 802.15.4 transceiver. Targets HCS08 based MCU with an SPI, but can easily be adapted to any processor core.	Can be used for developing proprietary RF transceiver applications using a Freescale 802.15.4 transceiver	Freescale Proprietary	User defined and developed	AES-128 simple block encryption/decryption	No	HCS08	<ul style="list-style-type: none"> • Basic messaging and control services provided as function calls; user must develop their own MAC protocol. • IEEE 802.15.4 compatible only at the PHY level
22xSMAC	Simple ANSI C based code stack available as sample source code can be used for developing proprietary RF transceiver applications using the MC1322x	Can be used for developing proprietary RF transceiver applications using an MC1322x SiP	Freescale Proprietary	User defined and developed	AES-128 CTR, CBC, and CCM encryption/decryption	No	ARM7	<ul style="list-style-type: none"> • Basic messaging and control services provided as function calls; user must develop their own MAC protocol. • IEEE 802.15.4 compatible only at the PHY level • MC1322x has hardware encryption engine

Table 2. Freescale Communications Codebases vs. Features

Codebase	Description	Target Application	Standard vs. Proprietary	Topologies	Security	Beaconing	Platforms	Comments
IEEE 802.15.4-2006 MAC	Freescale's core 802.15.4 MAC/PHY codebase. Foundation for all other stacks excluding SMAC codebases	Useful for proprietary, non-ZigBee stacks making 802.15.4 MAC beaconing and GTS	Standard / IEEE 802.15.4 MAC	Star and Cluster Tree	Standard IEEE 802.15.4 AES-128	HCS08 - Yes / ARM7 - No	HCS08 / ARM7	The ARM7 platform is non-fully MAC compliant as it does not support beaconing and GTS
BeeStack	Codebase supports ZigBee 2007 standard and the ZigBee Pro modifications	Supports Profiles 0x01 and 0x02 and can be extended to other standard ZigBee profiles	Standard / ZigBee 2007 / Pro	Mesh, Tree, and Star Networks	Adds ZigBee Security Services	ZigBee Standard does not use beaconing	HCS08 / ARM7	
BeeStack Consumer	Codebase supports the ZigBee RF4CE standard for consumer electronics	Consumer electronics, primarily remote control applications	Standard / ZigBee RF4CE	Multiple Star w/ inter-PAN communication	Adds ZigBee RF4CE Security	ZigBee Standard does not use beaconing	HCS08 / ARM7	
SynkroRF	Codebase supports proprietary network for consumer electronics (MAC based)	Consumer electronics, primarily remote control applications	Freescale Proprietary	Multiple Star w/ inter-PAN communication	Data confid., authentic., and replay protect	Not used	HCS08 / ARM7	

Table 3. Freescale Supported ZigBee Application Profiles

Application Profile	BeeStack	BeeStack Pro	RF4CE
Home Automation	Yes	Yes	
Smart Energy	Yes	Yes	
Health Care	Yes	Yes	
Remote Control			Yes

Appendix A

Networking Comm Model

A.1 Relating the ZigBee Network and the IEEE 802.15.4 Models to the OSI Communication Model

Network-aware devices, whether wired or wireless, are commonly described by the Open Systems Interconnection (OSI) Reference Model. This abstraction model was developed by the International Standards Organization (ISO), starting in the 1980s, to describe communication related protocols and services. The 7-layer model (Figure A-1) is generic and applies to all network types and all media types. Not all networks (in fact *most* do not) use the full model, but the model is a useful reference with which to relate communication networks.

Starting with Layer 1 closest to the media, the Physical Layer (PHY) describes the physical properties of the communications network which can include the electrical properties, signaling properties on the media (wireless or wired), connectors, data encoding, i.e., anything to do with the actual raw data transmission.

Layer 2 or the Data Link Level, is divided into the Medium Access Control (MAC) sublayer and the Logical Link Control (LLC) sublayer. The MAC sublayer is closest to PHY, is serviced by the PHY and typically provides service to the LLC. The MAC generically determines who is allowed access to the physical medium at a time. Generically, the LLC sublayer sits above the MAC and provides multiplexing of protocols transmitted over the MAC, optional flow control, and any requested detection and retransmission of dropped packets.

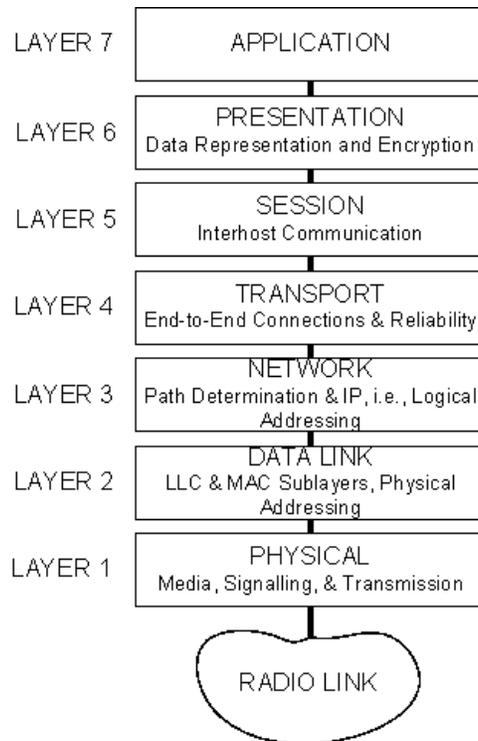


Figure A-1. The 7-Layer OSI Communication Model

The five additional layers (from bottom to top) are:

- Network (Layer 3) - Path determination and IP (logical addressing).
- Transport (Layer 4) - End-to-end connections and reliability.
- Session (Layer 5) - Interhost communication.
- Presentation (Layer 6) - Data representation and encryption.
- Application (Layer 7) - User application running on top of the network

After this very quick overview of the OSI model, the IEEE 802.15.4 Standard can be related to it. The 802.15.4 Standard is limited to the PHY and MAC Layers. Also note that the 802.15.4 Standard is not meant to be “all things to all people.” The IEEE 802.15.4 Standard specifically targets the following goals:

- 250 kbps over-the-air data rate
- Star or peer-to-peer operation
- Guaranteed time slots (GTSs) for communication and beaconing
- Carrier Sense Multiple Access, Collision Avoidance (CSMA-CA) channel access
- Acknowledged messaging for reliable data transfer
- Low power
- Short range operation
- Reasonable battery life
- Simple and flexible protocol

Figure A-2 shows how the OSI Model has been adapted in the 802.15.4 Standard.

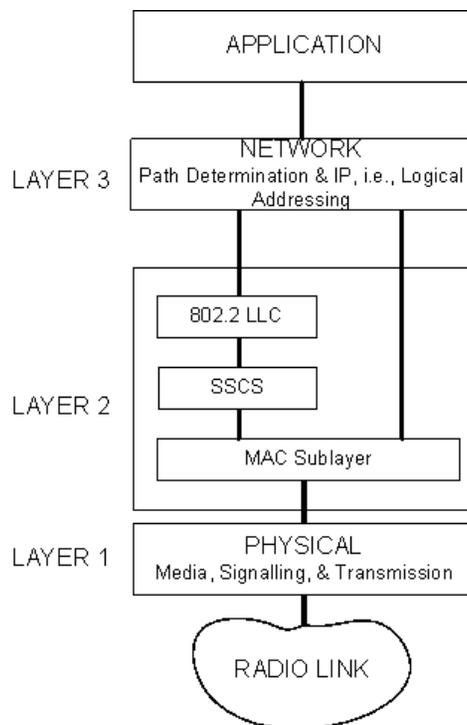


Figure A-2. The 7-Layer OSI Communication Model Adapted to the IEEE 802.15.4 Standard

For the IEEE 802.15.4 Standard PHY, two services are provided to the upper levels which include the PHY data service and the PHY management service. The features of the PHY include activation/deactivation of the radio transceiver, radio channel selection, energy level detection (ED) and received signal quality (LQI), clear channel assessment (CCA), and transmitting and receiving packets across the 2.4 GHz ISM frequency band.

For the IEEE 802.15.4 Standard MAC, it provides the MAC data service and the MAC management service. The MAC data service enables transmission of MAC protocol data units (MPDU) across the PHY data service. The MAC sublayer features include beacon management, channel access, GTS management, frame validation, acknowledged frame delivery, and association and disassociation. The MAC also provides support for implementing defined security mechanisms.

Generically, the LLC sublayer sits above the MAC and provides multiplexing of protocols transmitted over the MAC, optional flow control, and any requested detection and retransmission of dropped packets. However, the IEEE 802.15.4 Standard has modified and defined Layer 2 to:

- Allow an IEEE 802.2 LLC to access the 802.15.4 MAC Sublayer through a service specific convergence sublayer (SSCS) as defined in Annex A of the IEEE 802.15.4 Standard. Use of the LLC and SSCS is one defined path, but is not the path typically used by applications and is not the path used by ZigBee networks.
- Allow direct access to the MAC by the upper layers. Proprietary networks and ZigBee networks use this path.

The 802.15.4 Standard shows the OSI upper layers as having been collapsed to just two layers as shown in Figure A-3. The Network Layer typically provides network configuration, manipulation, and message routing. The Application Layer provides the intended function of the device sitting on the 802.15.4 Standard network. The network and application layer are not specifically defined by the IEEE 802.15.4 Standard and are up to the user.

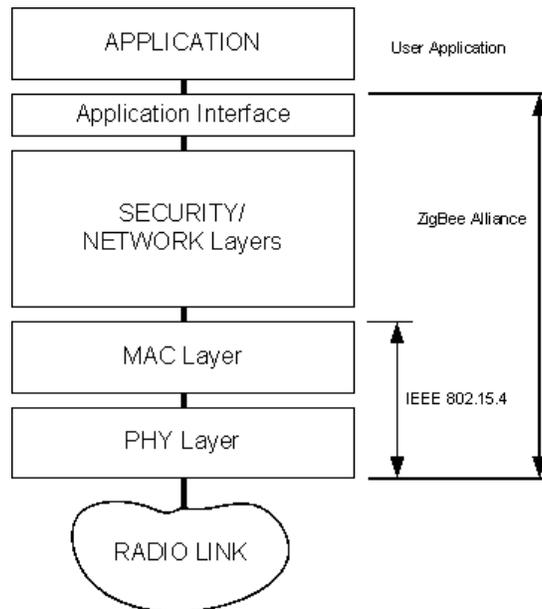


Figure A-3. The Communication Model Adapted to a ZigBee Stack

The model can now be extended to the ZigBee environment. A ZigBee stack is built upon the 802.15.4 Standard and uses the 802.15.4 model where the Network Layer has direct access to the MAC. The ZigBee Network (NWK) Layer provides network topology management, MAC management, routing, discovery protocol, and security management. The ZigBee network can overlay its security service to the additional security service available in the MAC layer. The user application builds on the ZigBee stack through its Application Interface (API). The ZigBee Alliance has what are called application profiles for specific application categories. These allow standardization of the functionality which helps compliance and interoperability between different vendors' products.

A.2 Comparing Levels of Communications Standards Compliance

The 802.15.4 Standard applications generally fall into three basic categories:

- Proprietary communication services, compliant only with the IEEE 802.15.4 Standard PHY Layer.
- IEEE 802.15.4 Standard MAC compliant services with proprietary upper layer/applications services.
- Full ZigBee network compliance built upon the 802.15.4 Standard and a ZigBee software stack.

More complex models and applications imply larger memory footprints, more MCU performance, and higher cost which are demanded by greater capability.

A.2.1 IEEE 802.15.4 Standard PHY Compliant with Proprietary MAC and Communication Services

These proprietary applications benefit little from standardization or interoperability. Also, the supplied services of the 802.15.4 Standard MAC may not meet the needs of the communications service, nor provide useful services to speed application development. There can be a number of reasons to go to a proprietary solution:

- Product Cost (consumer applications) – A very low performance or consumer application can be very sensitive to cost. A very small memory footprint with a low performance MCU can translate to the lowest cost solution.
- Protocol requirements – An example could be an RS232 wireless link. This is not a true networking application but a point-to-point link, so the 802.15.4 Standard MAC offers no significant advantage. Packet formats and packet timing are completely defined by the developer and since applications are custom and usually smaller in scope and complexity than a standards based solution, initial application prototyping may be faster. Quality of service (QOS) becomes most important with reliability of data “going through” uppermost, even at the sacrifice of link bandwidth. Unique protocol features regarding retries and flow control are required, while trying to retain maximum throughput.
- Unique application requirements – With very low power, reasonable bandwidth, and low cost, the 802.15.4 Standard hardware has been considered and used in a wide range of unique applications. RF monitoring and ID for cattle, remote controls, very low rate video monitoring, and very low rate sensor monitoring are some examples. Sleep times can be very long and battery life can be the most important parameter. Alternately, maximizing the limited 802.15.4 Standard bandwidth (250 kbps over-the-air) can be most important. Highly variable data rate and reporting can be important

depending on circumstance. The list goes on. The ultimate conclusion is that the 802.15.4 Standard MAC capabilities for these applications do not fit the bill.

Ultimately, the primary reasons for proprietary solutions seem to be cost (inexpensive MCU with small memory footprint) or unique protocol/application requirements. These may be benefits, but trade-offs exist that the developer should consider before embarking on a proprietary solution. Since packet timing is not inherently defined by proprietary systems, the embedded system needs to be written to allow easy portability across differing architectures. Also, “MAC” layer timing, packet messaging, channel management, addressing schemes, etc. must be defined by the developer to provide a scalable solution. To maximize the benefits of a proprietary solution, approaches to a proprietary “MAC” layer should be simple in nature or different than the 802.15.4 Standard approach. If the custom “MAC” solution is complex, then the development time and validation of the complex approach will begin to undermine the benefit of rapid prototyping and lower system costs. Additionally, as the developer adds features to their proprietary “MAC” layer over time, the solution may begin to approach the functionality of the 802.15.4 Standard MAC. If this occurs, then starting with the 802.15.4 Standard MAC solution may be faster, cheaper, and more reliable. Another disadvantage of proprietary solutions is that no standard security service is provided.

A.2.2 Full IEEE® 802.15.4 Standard Compliance (PHY and MAC) and Proprietary Communication Services

The next level of compliance uses a full 802.15.4 Standard service through the MAC layer. The advantages of this approach are the additional features and services available through the 802.15.4 Standard:

- Star or peer-to-peer operation for true networked applications
- Channel management via CSMA-CA services, channel scan
- Guaranteed time slots (GTS) for communication and beaconing
- Acknowledged messaging for reliable data transfer
- Standard simple and flexible protocol
- Optional AES-128 security
- Expandable to other compliant applications

From a business perspective, larger volume customers may have a requirement for sourcing from multiple vendors. Also, on a standards-based application it is typically easier to port only the application to different platforms via the 802.15.4 Standard MAC rather than a proprietary solution. With more vendors having a standard solution available, this may provide longer term competition for cost, quality and delivery. From a reliability point of view, a standard has many more developers than a proprietary solution, so the 802.15.4 Standard codebase is shared across a larger group of users. This means that reliability will improve over time faster than a proprietary solution.

In this model, the higher layer functions such as the Network and Application layers must still be written. The question arises then of why not use the full set of ZigBee network services. The answer is similar to the full proprietary solution where the application network architecture and services require unique features that are not met by the ZigBee network services. Also, in some cases the full application can still yield a smaller memory footprint than a full ZigBee stack.

Trade-offs for the 802.15.4 Standard MAC approach provide a mixed benefit. The MAC certainly has a richer set of functionality and services from which to build than a proprietary SMAC application. The application software need not develop services such as address management, acknowledged messaging, and use of time slots for better communication. Another huge advantage in some applications is embedded security services. The potential downside is the need for the application to develop the network architecture and service; however, this is really the compelling reason not to use the ZigBee stack. To justify use of the MAC without the higher level standard ZigBee services, there must be the need to meet special network features such as ROS, net architecture, or GTS and beaconing (which ZigBee networks do not support).

Although there is 802.15.4 Standard compliance, a proprietary Network layer will probably not allow compliance to other vendors. Development time can also be longer to write and test potentially complicated network protocol.

A.2.3 Full ZigBee Network Stack

A ZigBee network stack is built upon the IEEE 802.15.4 Standard and adds upper level services. The application interfaces to the standard stack through an applications interface (API). Here exists all the advantages of a fully standardized communications stack including full compatibility across applications and vendors. There are also the marketing benefits of a public certification process, leveraged marketing awareness and branding via the ZigBee Alliance. Time-to-market can also benefit because the user need not develop all the protocols and services associated with the upper layer services such as the Network Layer.

The ZigBee network solution preserves many of the advantages of the 802.15.4 Standard (low power, reasonable cost, services) with the benefit of the standardized upper level services. In addition to a defined API, the ZigBee network solution also offers several “application profiles” that provide users a standard set of messages and commands for a given application. This insures an even greater level of compatibility across vendors. A developer may be able to purchase part of a system solution from another vendor as opposed to developing it in-house. The goal of the full ZigBee network approach is to maximize the market applications and nodes through standardization and drive system cost down even further.

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