Wireless Gigabit Alliance

WiGig White Paper

Defining the Future of Multi-Gigabit Wireless Communications

July 2010

Introduction

The widespread availability and use of digital multimedia content has created a need for faster wireless connectivity that current commercial standards cannot support. This has driven demand for a single standard that can support advanced applications such as wireless display and docking, as well as more established usages such as network access.

The Wireless Gigabit (WiGig) Alliance was formed to meet this need by establishing a unified specification for wireless communication at multi-gigabit speeds; this specification is designed to drive a global ecosystem of interoperable products.

The WiGig MAC and PHY Specification enables data rates up to 7 Gbps, more than 10 times the speed of the fastest Wi-Fi networks based on IEEE 802.11n. It operates in the unlicensed 60 GHz frequency band, which has much more spectrum available than the 2.4 GHz and 5 GHz bands used by existing Wi-Fi products. This allows wider channels that support faster transmission speeds.

The WiGig specification is based on the existing IEEE 802.11 standard, which is at the core of hundreds of millions of Wi-Fi products deployed worldwide. The specification includes native support for Wi-Fi over 60 GHz; new devices with tri-band radios will be able to seamlessly integrate into existing 2.4 GHz and 5 GHz Wi-Fi networks.

The specification enables a broad range of advanced uses, including wireless docking and connection to displays, as well as virtually instantaneous wireless backups, synchronization and file transfers between computers and handheld devices. For the first time, consumers will be able to create a complete computing and consumer electronics experience without wires.

WiGig and IEEE 802.11ad

IEEE 802.11ad is an amendment to the 802.11 standard that enables multi-gigabit wireless communications in the 60 GHz band. The WiGig specification was contributed to the IEEE 802.11ad standardization process, and was confirmed in May 2010 as the basis for the 802.11ad draft standard.

Specification Overview

The WiGig specification includes key features to maximize performance, minimize implementation complexity and cost, enable compatibility with existing Wi-Fi and provide advanced security. Key features include:

- Support for data transmission rates up to 7 Gbps; all devices based on the WiGig specification will be capable of gigabit data transfer rates
- Designed from the ground up to support low-power handheld devices such as cell phones, as well as high-performance devices such as computers; includes advanced power management
- Based on IEEE 802.11; provides native Wi-Fi support and enables devices to transparently switch between 802.11 networks operating in any frequency band including 2.4 GHz, 5 GHz and 60 GHz
- Support for beamforming, maximizing signal strength and enabling robust communication at distances beyond 10 meters
- Advanced security using the Galois/Counter Mode of the AES encryption algorithm
- Support for high-performance wireless implementations of HDMI, DisplayPort, USB and PCIe

Structure

The WiGig specification defines Physical (PHY) and Medium Access Control (MAC) layers and is based on IEEE 802.11. This enables native support for IP networking over 60 GHz. It also makes it simpler and less expensive to produce devices that can communicate over both WiGig and existing Wi-Fi using tri-band radios (2.4 GHz,5 GHz and 60 GHz).

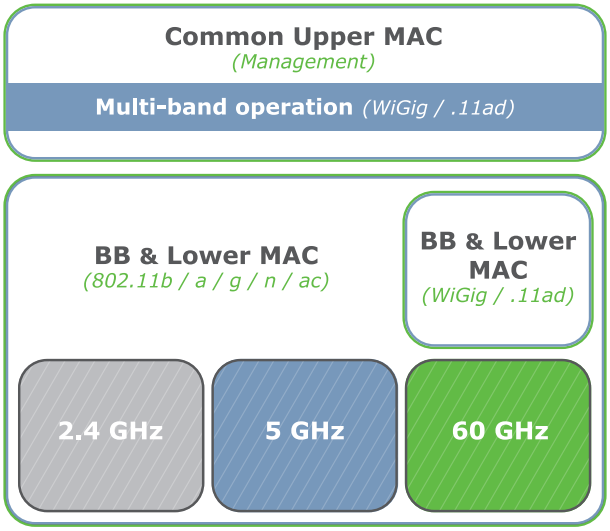

Figure 1. WiGig architecture enables tri-band communications

The WiGig Alliance is also defining Protocol Adaptation Layers (PALs) that support specific data and display standards over 60 GHz. PALs allow wireless implementations of these standard interfaces that run directly on the WiGig MAC and PHY, as shown in Figure 2, and can be implemented in hardware. The initial PALs are audio-visual (A/V), which defines support for HDMI and DisplayPort, and input-output (I/O), which defines support for USB and PCIe.

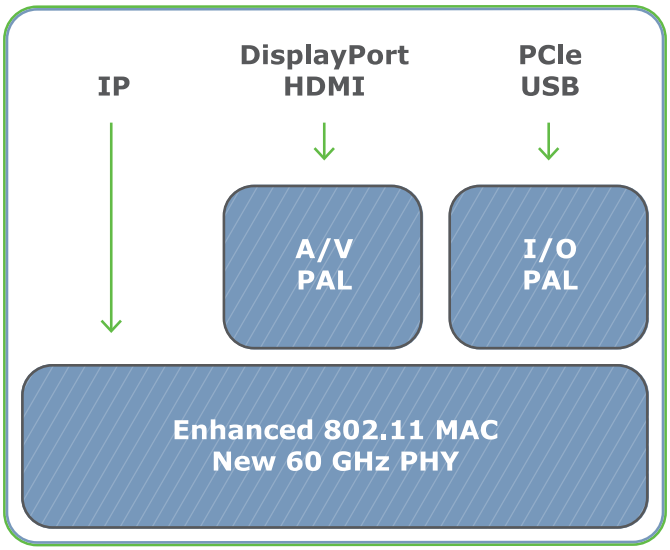

Figure 2. WiGig Protocol Adaptation Layers (PALs)

Physical Layer (PHY)

Like the 2.4 GHz and 5 GHz bands used by Wi-Fi, the 60 GHz band used by WiGig is unlicensed and available worldwide. Within the 60 GHz band, there is variation in the spectrum available in different countries, as shown in Figure 3.

Worldwide, the 60 GHz band has much more spectrum available than the 2.4 GHz and 5 GHz bands – typically 7 GHz of spectrum, compared with 83.5 MHz in the 2.4 GHz band.

This spectrum is divided into multiple channels, as in the 2.4 GHz and 5 GHz bands. Because the 60 GHz band has much more spectrum available, the channels are much wider, enabling multi-gigabit data rates. The WiGig specification defines four channels, each 2.16 GHz wide – 50 times wider than the channels available in 802.11n.

These wide channels enable WiGig to support applications that require extremely fast communication, such as uncompressed video transmission.

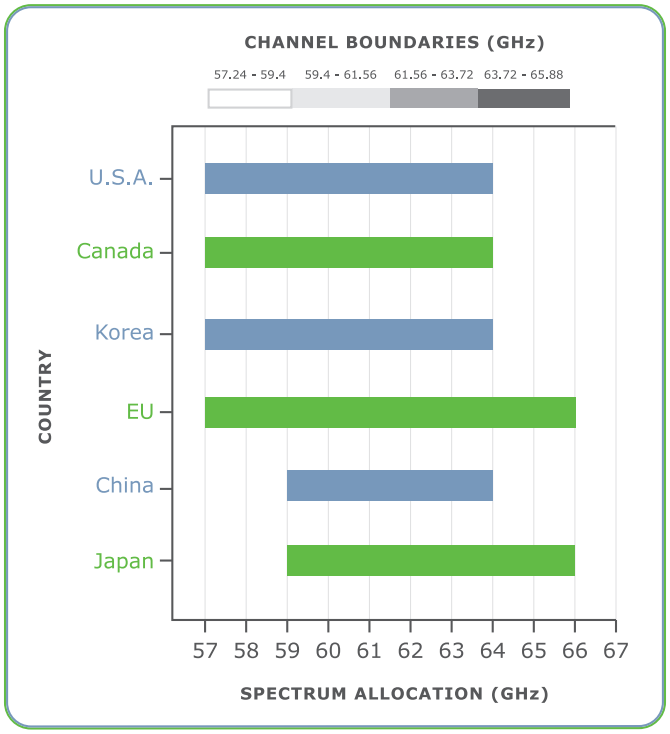

Figure 3. Worldwide spectrum availability in the 60 GHz band used by WiGig

Modulation & Coding Scheme (MCS)

The specification supports two types of modulation and coding schemes, which provide different benefits:

- Orthogonal frequency-division multiplexing (OFDM) supports communication over longer distances with greater delay spreads, providing more flexibility in handling obstacles and reflected signals. Furthermore, OFDM allows the greatest transmission speeds of up to 7 Gbps.
- Single carrier (SC) typically results in lower power consumption, so it is often a better fit for small, low-power handheld devices. SC supports transmission speeds up to 4.6 Gbps.

The two types of schemes share common elements such as preamble and channel coding. This reduces implementation complexity for manufacturers of WiGig devices.

Medium Access Control (MAC) Layer

The MAC layer of the WiGig specification includes new features that support advanced usage models, facilitate integration with Wi-Fi networks, reduce power consumption and provide strong security.

WiGig Beamforming

Use of the 60 GHz band allows extremely fast communication, but also presents the challenge that propagation loss is higher than in the 2.4 GHz and 5 GHz bands.

The WiGig specification addresses this challenge using adaptive beamforming, a technique that enables robust multi-gigabit communications at distances greater than 10 meters.

Beamforming employs directional antennas to reduce interference and focus the signal between two devices into a concentrated "beam." This allows faster data transmission over longer distances.

Support for beamforming is defined within the PHY and MAC layers of the WiGig specification. During the beamforming process, two devices establish communication and then fine-tune their antenna settings to improve the quality of directional communication until there is enough capacity for the desired data transmission.

Another key benefit is that if an obstacle blocks the line of sight between two devices - if someone walks between them, for example - the devices can quickly establish a new communications pathway using, for example, beams that reflect off walls, as shown in Figure 4.

Figure 4. Beamforming

Network Architecture

The specification defines a new network architecture that enables two devices to communicate directly with each other, allowing new uses such as rapidly synchronizing two devices and transmitting audio-visual data to a projector or TV. In addition, the specification also supports existing 802.11 network architectures, including the use of a shared access point as in today's Wi-Fi networks.

Seamless Multi-band Operation

A communication session can be rapidly and seamlessly transferred between a 60 GHz channel and any lower-frequency Wi-Fi channel, including channels in the 2.4 GHz or 5 GHz band. This innovation enables seamless fallback to 2.4 GHz or 5 GHz Wi-Fi if 60 GHz WiGig connectivity is not available.

Multi-band operation provides a greatly improved user experience. Users with multi-band devices will be able to continue accessing the network, without interruption, if their device switches from a 60 GHz to a lower-frequency Wi-Fi channel. They will always experience performance that is at least as good as today's Wi-Fi products, and will be able to automatically take advantage of the additional speed of 60 GHz WiGig whenever it is available.

WiGig and Wi-Fi Alliance Partnership

WiGig Alliance and Wi-Fi Alliance established a cooperation agreement in May 2010 to share technology specifications for the development of a next-generation Wi-Fi Alliance certification progam. This agreement further encourages the development of products supporting 60 GHz technology to expand existing Wi-Fi capabilities.

Power Management

WiGig devices can take advantage of a new scheduled access mode to reduce power consumption. Two devices communicating with each other via a directional link may schedule the periods during which they communicate; in between those periods, they can sleep to save power. This advanced capability allows devices to more precisely tailor their power management to their actual traffic workload, and is especially important for cell phones and other handheld battery-powered devices.

Advanced Security

The WiGig specification builds on the strong security mechanisms used in IEEE 802.11. WiGig uses Galois/Counter Mode, a highly-efficient mode of operation that is designed to support communication speeds of 10 Gbps and above, provides strong encryption based on the Advanced Encryption Standard (AES), is government-recommended, and can be implemented in hardware for performance and efficiency.

Protocol Adaptation Layers (PALs)

PALs allow wireless implementations of key computer and consumer electronics interfaces over 60 GHz WiGig networks. PALs make it easier for implementers to

produce devices with built-in support for specific uses such as wireless connections to displays.

PALs enable highly efficient implementations because they are defined directly on the WiGig MAC and PHY, rather than layered on other protocols and can be implemented in hardware. This maximizes performance and reduces power consumption. PALs defined to date are:

Audio-Visual (A/V)

The A/V PAL allows wireless transmission of audio-visual data. An example might be transmitting movies from a computer or digital camera to a TV set or projector. This PAL supports wireless implementations of HDMI and DisplayPort interfaces, as well as the High-bandwidth Digital Content Protection (HDCP) scheme used to protect digital content transmitted over those interfaces. It scales to allow transmission of both compressed and uncompressed video.

Input-Output (I/O)

The I/O PAL defines high-performance wireless implementations of widely used computer interfaces over 60 GHz. Definitions exist for USB and for PCIe.

USB is typically used to connect external peripherals and other devices to a host; the USB PAL enables multi-gigabit wireless connectivity between USB devices, and facilitates the development of products such as USB docking stations.

PCIe is typically used within computers to connect the CPU and memory to I/O controllers that support storage, network cards and other interfaces. It is also used to connect to media and visual processors to enhance picture quality or offload processing from the CPU. Implementation of the PAL enables multi-gigabit wireless synchronization between devices and connection to storage and other high speed peripherals.

Usage Models

The WiGig specification and PALs enable multi-gigabit wireless implementations of a broad range of new and existing usage models, as shown in Figure 5.

Summary

The WiGig specification utilizes the unlicensed 60 GHz band worldwide to provide data rates up to 7 Gbps. Based on the 802.11 standard, it includes native support for Wi-Fi over 60 GHz; products with tri-band radios will be able to transparently switch among 2.4 GHz, 5 GHz and 60 GHz networks ensuring optimal performance. The WiGig Alliance is also specifying PALs that define wireless implementations of A/V and I/O interfaces, facilitating advanced applications such as wireless docking, high-speed synchronization and connection to displays.

The publication of the specification enables manufacturers to create a global ecosystem of interoperable WiGig products. The specification is available to members of the WiGig Alliance, who are able to develop next-generation wireless products under royalty-free terms. For more information, including how to become a member, visit www.wigig.org.

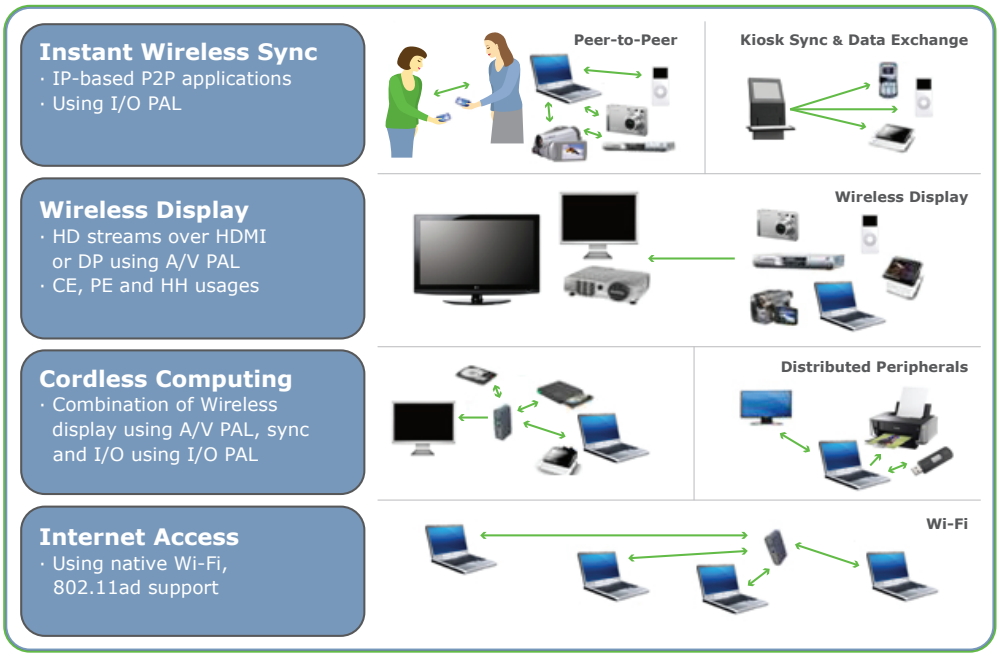

Figure 5. Usage Models