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GiFi : Analysis of Gigabit Wireless Technology in the 60 GHz Band

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Abstract - *Gi-Fi (Gigabit Wireless Technology) will help us to push wireless communications to faster drive. For many years cables have ruled the world then followed by Optical fibers that played a dominant role for its higher bit rates and faster transmission. However, the installation of cables caused a greater difficulty leading to development of wireless access for communication. The foremost of wireless communication is Bluetooth which can cover 9-10 mts followed by Wi-Fi having coverage area upto 100 mts. But the continuous quest for even better technology despite the substantial advantages of present technologies led to the introduction of new, more up-to-date standards for data exchange rate commonly known as Gi-Fi.*

Gi-Fi is a wireless transmission system which is ten times faster than Wi-Fi and its chip delivers short-range multi-gigabit data transfer in an indoor environment. It will allow wireless transfer of audio and video data up to 5 gigabits per second, low power consumption, usually within a range of 10 meters. The 57-64 GHz band located in the millimetre-wave (mmW) portion of the electromagnetic spectrum, where the wavelength varies from ten millimeters (30 GHz) down to one millimeter (300 GHz) has now been exploited for faster data exchange rate using GiFi. This technology providing low-cost, high broadband access, with very high speed large files exchange within seconds. In this paper, specifically 60GHz frequency, which has emerged as one of the most promising candidates for multi gigabit wireless communication systems has been studied. The gigabit wireless technology, its architecture, advantages and applications have been discussed.

Key Words: Gigabit wireless technology, Bluetooth, IEEE 802.15, millimeter wave, 60 GHz

1.INTRODUCTION

Advancements in the networking technologies have changed the life of people in their private residential space. With the advent of HD multimedia services and broadband communications into the living space, future networks are expected to support high speed device-to-device connectivity with QoS provisioning [1]. The widespread availability and use of high definition multimedia content has created a need for faster wireless. The consumers have more digital infotainment choices than ever before, but at the expense of ever increasing network bandwidth and data transfer demands. The prime concern being that the maximum data rate and QoS that the network is expected to deliver have already being pushed to the limits, which leads to users experience far from satisfying [1].

During the last decade, many telecommunications regulators have followed an initiative started by the US Federal Communications Commission (FCC) and allocated a continuous block of 7 Gigahertz (GHz) of spectrum between 57 and 64 GHz for wireless communications [2]. A major factor in this allocation with a significant impact operation of equipment supporting this band is that the spectrum is "license exempt" or "lightly licensed" – in other words, a user does not have to buy a license from the regulator. The 57-64 GHz band is located in the millimeter-wave (mmW) portion of the electromagnetic spectrum, where the wavelength varies from ten millimeters (30 GHz) down to one millimeter (300 GHz) [2]. Until recently, the millimeter-wave portion of the RF spectrum has been largely unexploited for commercial wireless applications. In addition to the high-data rates that can be accomplished in this spectrum, energy propagation in the 60 GHz band has unique characteristics that make possible many other benefits such as excellent immunity to interference, high security, and frequency re-use [2]. The potential candidate to address the issues of short distance, secure and high bandwidth communication are the mm Waves [1]. Signals in this band don't travel very far. The atmospheric oxygen readily absorbs 60GHz signals and attenuates (15dB/km) them within a short distance of their source [1]. mm Waves are attenuated by obstacles like glass and wall which adds further restriction to the usage on the contrary it means that it can be used for high bandwidth short distance secure communication.

This has led to introduction of Gi-Fi technology. It offers some advantages over Wi-Fi, a similar wireless technology, which offers faster information rate (Gb/s), less power consumption and low cost for short range transmissions. Gi-Fi is developed on an integrated wireless transceiver chip, in which a small antenna is used and both transmitter- receiver integrated on a single chip, are fabricated using the complementary metal oxide semiconductor (CMOS) process. The paper presents the review of Gi-Fi technology, its advantages, applications and related IEEE standards.

2. Literature Survey

Christopher J. Hansen [3] discussed the working of Wireless Gigabit Alliance, state of the art in millimeter-wave technology, enabling widespread use of the unlicensed 60 GHz bands. The WiGig MAC, PHY, and PAL specifications have been specifically designed to enable a wide range of applications that demand extremely high data rates. By working with other bodies for standardization and certification, it is expected that devices employing WiGig technology will soon be available in the marketplace. High-speed video and computer display streaming, data transfers

and networking, as well as wireless bus are the key applications. The data rate requirements for these applications all exceed the capabilities of today's wireless technologies. Thus, the industry is motivated to pursue the use of 60 GHz communications. Further improvements in complementary metal oxide semiconductor (CMOS) circuit design at 60 GHz, particularly power amplifier efficiency, will help to improve battery life and expand communication range. For next generation systems, it will be also be necessary to develop beam forming techniques specifically designed for non-line-of sight radio channels. Also, improvements in multiple access techniques will allow denser deployments at higher data rates.

Santhan Kumar Reddy [4], presented Gi-Fi or Gigabit Wireless is the world's first transceiver integrated on a single chip that operates at 60GHz on the CMOS process. It will allow wireless transfer of audio and video data up to 5 gigabits per second, ten times the current maximum wireless transfer rate, at one-tenth of the cost, usually within a range of 10 meters. It utilizes a 5mm square chip and a 1mm wide antenna burning less than 2 watts of power to transmit data wirelessly over short distance, much like Bluetooth. The breakthrough will mean the networking of office and home equipment without wires will finally become a reality. In his report he presented that it is a low cost, low power and high broadband chip, which will be vital in enabling the digital economy of the future The GiFi chips is only 5mm in size and use current CMOS technology. The GiFi chip uses only a tiny one-millimeter-wide antenna and less than two watts of power, and the GiFi chip would cost less than $10 to manufacture it. He also said that the core components of a Gi-Fi system is the subscriber station which available to several access points. It supports standard of IEEE 802.15.3C supports millimeter-wave wireless pan network used for communication among computer devices close to one person. An 802.15.3C based system often uses small antenna at the subscriber station. The antenna is mounted on the roof. It supports line of sight operation.

Chang-Soon Choi et.al., [5] in his paper introduced the activities to develop 60-GHz OFDM hardware demonstrators. To support wireless LAN applications, OFDM have been used and implemented for multi-gigabit throughput. The first version of complete 60-GHz hardware demonstrators is convolutional-coded OFDM with FFT bandwidth of 400-MHz, providing maximum data rate of 1.08-bps. The digital baseband processor was implemented on FGPA platform and 60-GHz RF transceivers were realized with 0.25um SiGe BiCMOS technology.

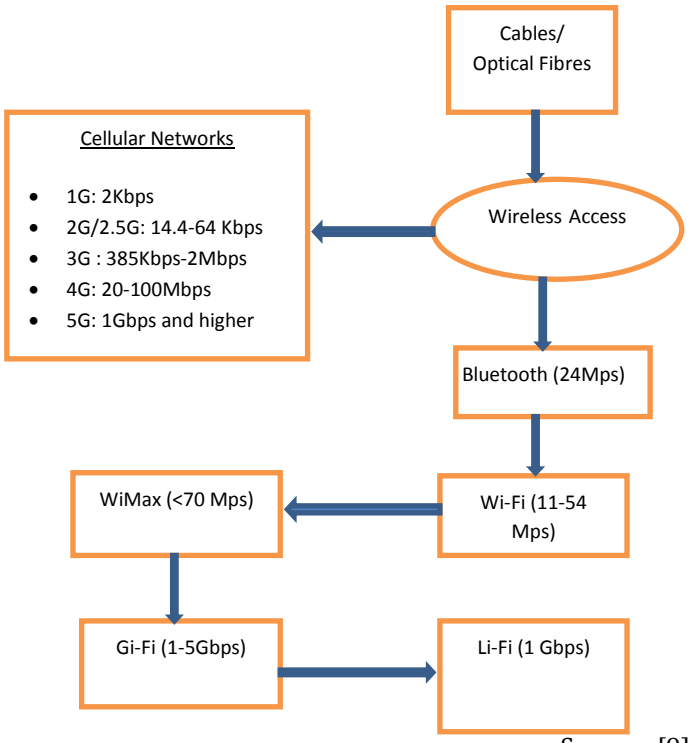
Yonghoon Choi, [6] in this paper presented the application of THz band relying on line of sight (LOS) conditions with narrow beam directive antennas. In case the direct link is interrupted, reflections from the ceiling, walls or other objects could be used to establish a link. This introduces the concept of directed non LOS (NLOS) transmissions. For the multi gigabit wireless transmission each user equipment has ability of advanced antenna techniques like beam forming or beam switching for finding the strongest signal among the LOS.

Keang-Po Ho et.al., [7] has discussed in his paper that using the unlicensed 60-GHz millimeter-wave band, an antenna array driven by CMOS circuitry enables low-cost multi-gigabit broadband wireless transmission. The CMOS transceiver can consistently achieve data rates up to 3.8 Gb/s for video area network operation. Using beam-search techniques, the antenna arrays steer the beam to avoid line-of-sight blockage.

Biglarbegian et.al., [8] said in their paper that an array of 2×2 patch antennas has been designed, optimized and fabricated based on the system criteria for the recently developed wireless indoor network standards. The designed patch gives 13 dBi radiation gain at 60 GHz with 42º beam width. This very low cost and low-profile antenna can be utilized in most of the emerging wireless devices at 60 GHz.

3. Network Evolution

The wireless technologies evolved over a period to time and presently available are shown in Fig.1. These techniques have made possible services such as far distance communications. Bluetooth, Wi-Fi, WiMAX (Worldwide interoperability for microwave access) and other wireless communication technologies have become indispensible in the communication world and have contributed advancements in technologies and groundbreaking solutions to internet connection and in transfer of information such as data, audio, videos and so on, at different data on rates. Gi-Fi is an appropriate technology for short distance data transmission however Wi-Fi still gains from being able to provide wireless coverage over a greater distance [9].



Source : [9]

Fig-1 : Wireless Technologies with data rates

4. GiFi

4.1 Architecture

Gi-Fi technology supports IEEE 802.15.3C standard millimeter wave wireless networks that are used majorly for communication between computer devices. It incorporates one subscriber station that is made available for different access points. The subscriber station basically comprises of a small antenna that is mounted on the top in order to support the line of sight operations. In order to avoid any interference, it transmits multiples signals across the path of transmission, at the same time having different frequencies [10].

This millimeter-Wave WPAN can operate within the new and clear band together with 57-64 GHz unaccredited band outlined by FCC 47 CFR 15.255. The millimeter-wave WPAN can enable high existence (close physical spacing) with all different microwave systems in the 802.15 family of WPANs [11].

4.2 Working principle

In Gi-Fi technology time division duplex (TDD) is used for both transmission and receiving. The data files are up converted from IF range to RF60Ghz range by using 2 mixers and will be fed to a power amplifier, which feeds millimeter wave antenna. The incoming RF signal is first down converted to an IF signal cantered at 5 GHz and then to normal data ranges. Here heterodyne construction is used for this process to avoid leakages due to direct conversion and due to availability of 7 GHz spectrum the total data will be will be transferred within seconds.

TDD (Time Division Duplex)

Time Division Duplex is the application of time division multiplexing to separate outwards and return signals. It emulates full duplex communication over half duplex communication link. TDD has strong advantage in the case where asymmetry of the uplink and downlink data speed is variable. As uplink traffic increases, more channel capacity can dynamically be allocated to that and as it shrinks it can be taken away [12].

4.3 Advantages

Gi-Fi technology permits wireless uncompressed high definition content and operates over a range of 10 meters without interference. Gi-Fi chip has flexible architecture. It is highly convenient and can be constructed in all over the place. The complete transmission system can be built on a cost-effective single silicon chip that operates in the unlicensed, 57-64 GHz spectrum band [10]. The following are the few advantages of the Gi-Fi technology

Small in size

The size of Gi-Fi chip is 5×5 millimeter and can be placed in different kinds of devices. The chip has a tiny 1 millimeter antenna and uses 60 GHz millimeter wave spectrum.

Capacity of High Speed Data Transfer

Speed of Gi-Fi is about 5 Gbps which is 10 times the data transfer of the present existing technologies. A complete High-Definition (HD) movie can be transmitted to a mobile handset in a few seconds, and the handset can upload the movie to a home computer or screen at a similar speed [10].

Security

Point-to-point wireless systems operating at 60 GHz have been used for many years by the intelligence community for high security communications and by military, for satellite-to satellite communications. The combined effects of O2 absorption and narrow beam spread results in high security and low interference [13].

No Interference

The technology utilizes 60GHz millimeter wave spectrum to transmit the data, which offers benefit over Wi-Fi. Wi-Fi's part of the spectrum is increasingly crowded, which leads to interference and slower speeds. However, the millimeter wave spectrum (30 to 300 GHz) is a bit unoccupied, and the new chip is hundreds of times faster than the average home Wi-Fi technology [10].

Low Power Consumption

The power consumption of Gi-Fi wireless technology in the range of 2 milli watts and is much less in comparison to the current wireless technologies [14].

Removing Cables

Cables and optical fibers played a dominant role for its higher bit rates and faster transmission, however, installation of cables caused a greater difficulty and thus led to wireless access. Gi-Fi technology removes need for cables to connect consumer electronic devices and all the devices in the range of 10 meters can be connected in order to transmit the data wirelessly [12].

The disadvantage of Gi-Fi is its restriction to shorter distance in comparison to Wi-Fi technology and also being a new technology, there is lack of skilled people who can deploy the technology

4.4 Standards

Institute of Electrical and Electronic Engineers (IEEE) standards IEEE 802 form the background of wireless gigabit technology. IEEE 802 refers to a family of IEEE standards dealing with local area networks and metropolitan area networks. More specifically, the IEEE 802 standards are restricted to networks carrying variable-size packets [3]. The services and protocols specified in IEEE 802 map to the lower two layers (Data Link and Physical). Further, IEEE 802 splits the OSI Data Link Layer into two sub-layers named Logical Link Control (LLC) and Media Access Control (MAC).

IEEE 802.15.3c-2009 is the published standard in 2009 which is related to GIFI technology. The task group TG3c developed a millimeter-wave-based alternative physical layer (PHY) for the existing 802.15.3 Wireless Personal Area Network (WPAN) Standard 802.15.3-2003. This mm Wave WPAN is defined to operate in the 57–66 GHz range. The millimeter-wave WPAN allows very high data rate, short range (10 m) for applications including high speed internet access, streaming content download (video on demand, HDTV, home theater, etc.), real time streaming and wireless data bus for

cable replacement. A total of three PHY modes were defined in the standard [15].

- Single carrier (SC) mode (up to 5.3 Gbit/s)
- High speed interface (HSI) mode (single carrier, up to 5 Gbit/s)
- Audio/visual (AV) mode (OFDM, up to 3.8 Gbit/s).

4.4 Applications

Application of Gi-Fi Technology extends to homes and offices appliances, wireless pan network, inter vehicle communication system, adhoc information distribution, media access control (MAC), imaging, video information transfer and other applications [9].

House hold Application

Consumers could typically download a high definition movie from a kiosk in a matter of seconds to music player or smart phone and having got home could play it on a home theatre system or store it on a home server for future viewing, again within a few seconds, high speed internet access, streaming content download (video on demand, HDTV, home theatre, etc.), real time streaming and wireless data bus for cable replacement [10].

Video information transfer

By using present technologies video swapping takes hours of time, whereas by this we can transfer at a speed of Gbps. Information Transfer Data transfer rate is same for transfer of information from a PC to a cell or a cell to a PC. It can enable wireless monitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for an intervening personal computer and the transfer of files among cell phone handsets and other handheld devices like personal digital audio and video players [10].

Inter-vehicle communication system

The data exchange between vehicles is made possible by adhoc networks. These short- distance connections are spontaneously created between the vehicles as the need arises and can organize themselves without the help of any external infrastructure [10].

Wireless PAN Networks

The use of Gi-Fi in wireless PAN networks can take a better perspective in today's technology as the data files are transferred to RF 60GHz range by making use of two mixers from an IF (Intermediate Frequency). The output is then stored in a power amplifier, that stores a millimeter wave antenna within. Due to a higher availability of 7 GHz spectrum, it results in higher data rates in a number of networks [14].

5. Conclusion

In this paper Gi-Fi technology is reviewed that will allow wireless transfer of audio and video data up to 5 gigabits per second, ten times the current maximum wireless transfer rate, at one-tenth of the cost, usually within a range of 10 meters that operates at 60GHz on the CMOS process. This technology removes cables and provides high speed data transfer rate. Gi-Fi technology has number of applications and can be used in many places and devices such as smart phones, wireless pan networks, media access control and mm-Wave video-signals transmission systems. This chip could also replace HDMI cables and develop wireless home and office of future. GIFI technology has the potential to bring wireless broadband to the enterprise in an entirely new way.

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