GI-FI: The Emerging Technology of the New Short Range and High Data Rate Wireless Communication Era

Sana Alam, Saba Ahsan

Abstract- Over the past few decades, wireless technologies are evolving at a great pace. This leads to the invention of Gi-Fi (Gigabit Fidelity or Gigabit Wireless) which is ten times faster than the current most prevalent technology Wi-Fi. The key factor of this technology is the provision of data transfer rate measuring in multi gigabits per second. Evolution, architecture, working and features of Gi-Fi such as low power consumption, high data transfer rate, cost effectiveness and enhanced security which provide the basis for the next generation communicating devices are discussed in detail in this paper. This paper also provides comparisons among various wireless technologies and applications of gigabit fidelity.

Index Terms- CMOS , SIG , WECA , MAC , Wi-Fi, Gi-Fi

I. INTRODUCTION

Wireless technologies have always played a vital role in the modern day communication. In 2008, researchers at the NICTA (Australia's Information and Communications Technology Research Centre of Excellence) developed Gi-Fi [1].With Gi-Fi it is possible to transfer large amount of data especially large audio and video files at 5 Gb/s within the radius of 10 meters without interference. The technology uses IEEE 802.15.3c standard and operates at 60 GHz band which is mostly unused, thus providing enhanced security and faster wireless communication. Fabrication imperfections are dealt and are compensated by the full reconfiguration capability of this technology [2]. NICTA researchers have chosen to develop this technology in the 57-64 GHz unlicensed frequency band as the millimeter wave range of the spectrum makes possible high component on-chip integration as well as allowing for the integration of very small high gain arrays [25][26].The Gi-Fi chip is one of Australia's most productive technologies [3].This technology with high level of frequency re-use can declare the communication needs of multiple consumers in a small geographic region [3].

II. EVOLUTION OF GI-FI

The entire communication technology comprises of two major parts 1) Wired Communication 2) Wireless Communication. Previously, wired network has proven its potential but nowadays wireless communication has emerged as a robust and most intellect communication technique [13].The development in the wireless communication technologies finally paves the way for Gi-Fi as depicted in figure 2.1

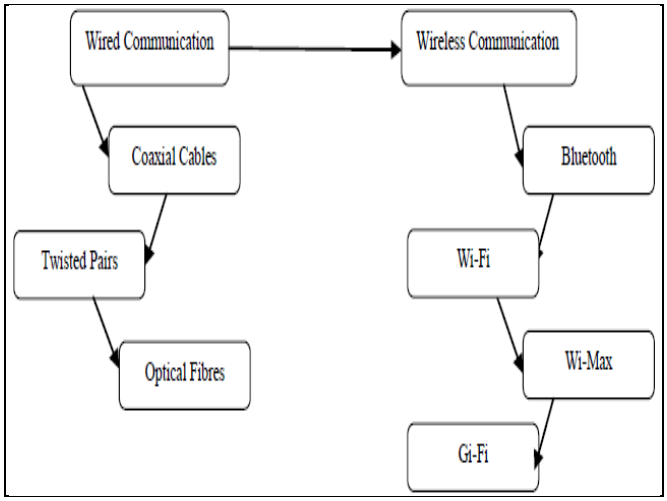

Figure 2.1 Network Evolution (Evolution of Gi-Fi)

2.1 Wired Communication

Initially wired setup was considered to be the only mean of short range and long range communication. Physical cables were used to transfer data among various devices. Most wired networks use Ethernet cables to transfer data between connected PCs[13].

2.1.1. Coaxial Cables

Coaxial Cable is a type of cable that has an inner conductor surrounded by a tubular insulating layer, surrounded by a tubular conducting shield. Many coaxial cables also have an insulating outer sheath or jacket. The term coaxial comes from the inner conductor and the outer shield sharing a geometric axis. Coaxial cable was invented by English engineer and mathematician Oliver Heaviside, who patented the design in 1880 [14][15].

2.1.2. Twisted Pairs

A type of cable that consists of two independently insulated wires twisted around one another. The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction [17]. Unshielded Twisted Pair (UTP) cable is the most populous amongst all Network Transmission Media. UTP is made of eight (8) copper wires intertwined into four (4) pairs [18].

2.1.3 Optical Fibers

The increase in the demand of telecommunication data transmission leads to the development of Optical Fiber. Fiber optic (or "optical fiber") refers to the medium and the technology associated with the transmission of information as light impulses along a glass or plastic wire or fiber.

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Saba Ahsan, Department of Computer Engineering, Sir Syed University of Engineering and Technology Karachi, Pakistan.

Sana Alam, Department of Computer Engineering, Sir Syed University of Engineering and Technology, Karachi, Pakistan.

Fiber optic wire carries much more information than conventional copper wire and is far less subject to electromagnetic interference [10]. Optical-fiber transmission lines appear attractive for a variety of communication applications in which twisted copper pairs and coaxial cables are now used [16].

2.2 Wireless Communication

The huge cost of installation of wires and the rise in the demand of communication during mobility causes the wired technology to make a shift towards the wireless communication. In the wireless networks the radio waves or micro waves are used as data transmission modes.

2.2.1 Bluetooth

Bluetooth was invented by telecom vendor Ericsson in 1994 [19].Bluetooth was initially defined under IEEE 802.15.1 standard but is now taken care by a Special Interest Group (SIG)[20]. It has undergone various updates such as Bluetooth 2.0, Bluetooth 2.1, Bluetooth 3.0 and the latest, Bluetooth 4.0. Added technologies such as Enhanced Data Rate (EDR), Alternate MAC/PHY, low energy protocols etc have been implemented in these updates. It works at a frequency of 2.4 GHz with the maximum data transfer rate of 24 Mb/s[21][22].

2.2.2 Wi-Fi

Wi-Fi was officially launched in 1997[23]. Wi-Fi based networks work at 2.4 GHz or 5 GHz. Wireless fidelity includes IEEE 802.11a/b/g standards for wireless local area networks (WLAN)[24].Wi-Fi provides higher data transmission rates (measuring 54 Mb/s) over large distances as compared to the Bluetooth [22].

2.2.3. Wi-Max

Wi-MAX is a family of wireless communications standards initially designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gb/s for fixed stations[11]. It was launched in 2001. Wi-MAX is standardized under 802.16y family of wireless networking where y refers to various Wi-MAX versions. It provides data transmission for much larger coverage areas measuring in kilometers.

III. ARCHITECTURE OF GI-FI

Gi-Fi technology consists of a transceiver integrated on a single silicon chip measuring 5 mm Square and operating at a 60 GHz frequency band based on the CMOS process. The antenna used is 1 mm wide and it supports the line of sight operation [9]. Wireless subscriber station is one of the core components in connecting Gi-Fi based devices. Not only the wireless subscriber station is responsible for connecting customers with the wireless networks but they also provide other notable features like ease of use, increased security and manageability. It has one subscriber station available to multiple access points. Reduced power consumption is another striking factor in the Gi-Fi technology. The Gi-Fi chipset consists of an amplifier to increase the power of a signal, band pass filter to allow the signal between the two specific frequencies (57Ghz-64Ghz) to pass and filter outs all the other signals at the other frequencies and a switch to provide immunity against interference by isolating the transmitter and the receiver[3].

3.1 IEEE 802.15.3c

IEEE 802.15.3c forms the basis of the Gi-Fi technology. The important aspect of the standard is that it defines millimeter-wave based physical layer (PHY) [8]. Three PHY modes have been defined that enable data rates in excess of 5 Gb/s using the 60 GHz band [8]. It is the first wireless standard of IEEE which makes use of the 60 GHz band. The unique features of 802.15.3c are

1) Directional Transmission

2) Aggregation and Block Ack for supporting multi Gb/s [27].

3.2 60 GHz band

NICTA researchers have chosen 57 GHz-64 GHz band for the development of Gi-Fi technology. About 5 GHz of spectrum around 60 GHz frequency is available unlicensed for worldwide use [5]. The narrow beam antennas associated with 60 GHz band allow multiple 60 GHz radios to be installed on the same roof top by providing interference immunity from other 60 GHz links. The high oxygen absorption at 60 GH makes it impossible for the signals to travel far beyond the intended target thus providing high level of security [6]. This fact is depicted in figure 3.2.1[6].This reason causes 60 GHz band to be used for military communications.

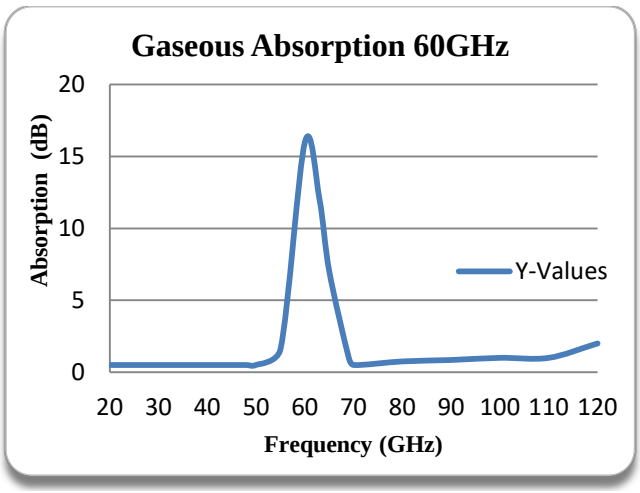

Figure 3.2.1 Oxygen Attenuation vs. Frequency

IV. WORKING OF GI-FI

The working principle of Gi-Fi uses the TDD for transmission and reception of signals. Time Division Duplex is the application of the Time Division Multiplexing in which a single frequency channel is used for transmission and reception as shown in the figure 4.1[29]. In the case of unbalanced traffic the capacity is managed by dynamically allocating different amount of slots depending upon the need in either direction. TDD is mostly suitable for small distances which are in accordance to the limitation imposed on the range (10 meters) for the Gi-Fi technology.

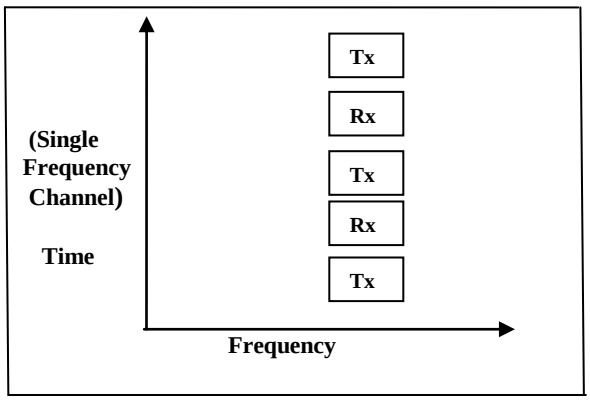

Figure 4.1 Time Division Duplex

Data files are converted from IF range to RF 60GHz range with the help of 2 mixers; the output is fed into a power amplifier. The amplifier further supplies the signal to the millimeter wave antenna. The incoming signals include the conversion from the RF signal to the IF signal centered at the 5GHz and then further converted to the normal ranges [3][28]. To avoid leakage due to direct conversion, heterodyne construction is used for this process. The total data is transferred within few seconds due to availability of 7GHz spectrum. The entire procedure is explained in the figure 4.2.

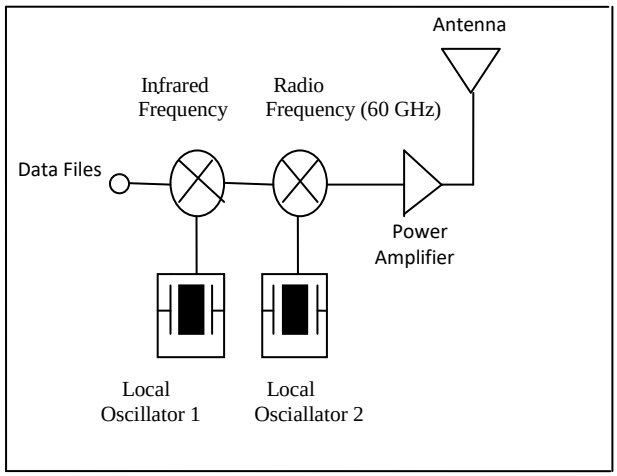

Figure 4.2 Working of Gi-Fi

V. FEATURES OF GI-FI

5.1Cost Effective

The tiny Gi-Fi chip costs about $10 which simply makes this technology more suitable to be widely used in the near future. Thus, it gives the users advantage to enjoy high data rates at low prices. This results in lower installation costs and faster network deployments. This would simply make Gi-Fi technology more feasible to be used in a number of communication devices without the significant price increase in these devices. Since the technology is based on IEEE 802.15.3c which is the open standard so the mass adoption and mass production would lead to the further price drop in the Gi-Fi chipset.

5.2 High Data Rates

High data transfer rate is the need of the modern age for high speed streaming and internet access. The data transfer rates provided by the Gi-Fi is 10 times the current maximum wireless transfer rates. The data transfer rate is 5 Gb/s provided that the communicating devices are placed within 10 meters distance to each other. As a result of which the high definition movies could be downloaded to the computer system or cell phones within seconds.

5.3 Low Power Consumption

The power consumption of Gi-Fi is less than 2 milli watts which is quite less than the amount of power consumed by other wireless communication technologies. Thus, making the system based on this technology more energy efficient.

5.4 Additional Features

- Some other additional features are as follows:
- It eliminates the use of cables between communicating entities that are placed within a range of 10 meters. With the help of this development we can have truly wireless homes and offices.
- Narrow beam antennas used in the technology and high oxygen absorption rate results in the enhanced wireless security. Moreover, the security and privacy content are also ensured by the encryption technology used in Gi-Fi.
- Portability provides ease of use and makes this technology feasible to be easily deployed.
- With high level of frequency re- use it can fulfill the customer needs of multiple customers within a small geographic region [9].

VI. APPLICATIONS OF GI-FI

One of the most important uses of Gi-Fi is in cellular networks enabling Gi-Fi based cell phones to download or access data at a data transfer rate measuring in Gbps. The videos downloaded can then be transferred to the PCs within seconds for further use and storage. Another application of Gi-Fi is in inter vehicle communication system. It is possible to establish connection between the vehicles spontaneously as the need arises by using this technology. The vehicles can then communicate with one another for possible alignment or for any other purpose [4].

Gi-Fi chip could easily be embedded into devices thus providing the basis for the home automation based system. Wireless PAN based on this technology enables high speed communication and transfer of data among the connected devices including laptops and other personal digital assistants.

VII. COMPARISON OF GI-FI WITH VARIOUS WIRELESS TECHNOLOGIES

This section provides the detail analysis and comparison of Gi-Fi with the existing wireless technologies as depicted in Table 1.

Giga bit Fidelity based on the IEEE 802.15.3c standard offers a data transfer rate of 5 Gbps operating in the frequency range of 57- 64 GHz band which is much higher as compared to the data transfer rates of Wi-Fi, Wi-Max and Bluetooth. Wi-Fi allows the data communication to take place at a data transfer rate of 54 Mbps using 2.4 GHz UHF and 5 GHz SHF band radio waves[7].IEEE 802.11n standard is used for Wi-Fi. Wi- Max based on IEEE 802.16 standard was created by Wi-Max Forum. Wi-MAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 Mbps data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations [30][31]. BluetoothTM wireless technology is a proposed publicly available specification for radiofrequency (RF), short-range, point-to-multipoint voice and data transfer. It also supports point-to-point connections. It operates in the 2.4 GHz ISM (industrial, scientific and medical) band [32] and is based on the IEEE 802.15.1 standard. Table 1 demonstrates the small power consumption associated with Gi-Fi as compared to the large power consumptions of Bluetooth, Wi-Fi and Wi-Max. Wireless networks are more prone to intruder attacks hence different security measures are taken to prevent wireless signals and data from unauthorized access. Table 1 lists down different security techniques used by the various wireless technologies.

Table 1 Comparison of Gi-Fi and other Wireless Technologies

Characteristics	Bluetooth	Wi-Fi	Wi-Max	Gi-Fi
IEEE Standard	802.15.1	802.11 x (802.11a, 802.11 b, 802.11g, 802.11n)	802.16	802.15.3c
Specification Authority	Bluetooth SIG	IEEE WECA	WiMax Forum	NICTA
Data Transfer Rate	1 Mb/s, 3 Mb/s, 24 Mb/s	11 Mb/s, 54Mb/s, 144 Mb/s	30-40 Mb/s 1 Gbps for Fixed Wi-Max	5 Gbps
Operating Frequency	2.4-2.485 GHz (ISM band)	2.4 GHz(ISM band) 5 GHz (U-NII band)	2-11 GHz	57-64 GHZ
Network Range	1 meter, 10 meters, 30 meters	30 – 100 meters	30 miles	10 meters
Security Techniques	128 bit AES	WEP, WPA, WPA2	X.509, PKMv2	Service level and link level security
Power Consumption	5 mW	10 m W	20 W[12]	<2mW

VIII. CONCLUSION

Over the past few years, the enhancement in the wireless technology is occurring at a great pace. One of the latest advancement in this field is the advent of Gi-Fi technology. This technology not only eliminates the need of cables but it also makes the communication and transfer of data possible within seconds with the data transfer rate measuring in Gbps. Comparison of Gi-Fi with other similar wireless technology leads to the fact that it has a great future in the world of wireless technologies because of its cost effectiveness, low power consumption, high data transfer rate and high security provision. Thus in the near future Gi-Fi could replace the existing wireless technologies. Possibility exists that in the near future many communicating devices like smart phones and media access control and millimeter wave based transmission systems would use this technology.

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