Current Advancements and Future Enhancements in Wireless Communication

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Abstract- *Wireless communication is the transfer of any information over some distance without the use of wires. Radio, or the use of radiated electromagnetic waves, is the only practical way of communicating with people or vehicles that move around on land, on the sea, in the air, or in outer space. It is the use of electromagnetic waves that permits the transmission and reception of information over a distance without the use of wires. Market demands for higher cellular density in urban areas, broadband internet wireless, and better data security, while using a minimum amount of frequency spectrum is driving wireless developments forward at an amazing speed. The evolution of wireless communications from analog to digital to broadband has taken longer and cost more money than most industry observers believed. At the same time WLAN "hotspots" are emerging rapidly. At present, the major applications of Wireless communication are Wi-Fi, WiMax and Zig-Bee. Li-Fi technology, proposed by the German physicist—Harald Haas, provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. Wi-Fi is great for general wireless coverage within buildings, whereas Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues. Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi. Thispaper gives an overview of some of the current advancements in Wireless Communication technology.*

Keywords- Wireless communication, Wi-Fi, WI- MAX, Bluetooth, ZigBee, Li-Fi, High Brightness LED.

I. INTRODUCTION

Wireless communication is generally considered to be a branch of telecommunications. Wireless operations permit Services, such as long-range communications that are impossible or impractical to implement using wires. Wireless communication brings fundamental changes to data networking and telecommunications, and makes integrated networks a reality. Emerging demands for high data rate services and high spectral efficiency are the key driving forces for the continued technology evolution in wireless communications. New technologies are replacing wires in virtually all modes of communication. For example, in addition to widely recognized outdoor connectivity via cellular wide area networks (WANs), wireless local area networks (LANs) and wireless personal area networks (PANs) have also become popular. Wireless LANs (e.g., IEEE 802.11) provide high speed unthread access inside buildings replacing traditional wired Ethernet, and wireless PANs (e.g., Bluetooth) are replacement for wires between common peripherals like mouse, keyboard, PDAs and printers. The major application of Wi-Fi implementation in libraries is limited to information management. Wi MAX (World interoperability for Microwave Access) is a wireless technology mainly designed for bridging the last mile to the end user and providing him with a broadband connection. Bluetooth is wireless technology that enables data exchanges between devices in about a 30-foot range of each other. In recent years Bluetooth has found its niche as a cable cutter, and technologists are integrating it into a variety of devices such as printers, camcorders, handheld computers, and wireless phones. Zig-Bee wireless mesh technology has been developed to address sensor and control applications with its promise of robust and reliable, self-configuring and self-healing networks that provide a simple, cost-effective and battery-efficient approach to adding wireless to any application, mobile, fixed or portable.

II. WI-FI TECHNOLOGY

Wi-Fi (short for "wireless fidelity") is the popular term for a high-frequency wireless local area network (WLAN). The Wi-Fi technology is rapidly gaining acceptance in many companies as an alternative to a wired LAN. It can also be installed for a home network. Wi-Fi is specified in the 802.11b specification from the Institute of Electrical and Electronics Engineers (IEEE) and is part of a series of wireless specifications together with 802.11, 802.11a, and 802.11g. Improvements in transmission speeds will be dramatic. Entry-level IEEE 802.11ac products will provide a data rate of 433 Mbps (megabits per second), which is at least three times faster than that of the most common devices using the current wireless standard, which is IEEE 802.11n. Because the new standard gives manufacturers the flexibility to offer a range of products with different levels of performance, some high-speed IEEE 802.11ac devices will offer wireless transmission in excess of a Gigabit per second—remarkable speeds that put IEEE 802.11ac wireless networks ahead of most wired

networks. In addition, there will be dramatic improvements in wireless reliability, range, and coverage. Homes and apartments now plagued with "dead spots" will enjoy vastly improved reception. Faster file transfer also leads to longer battery life in mobile phones.

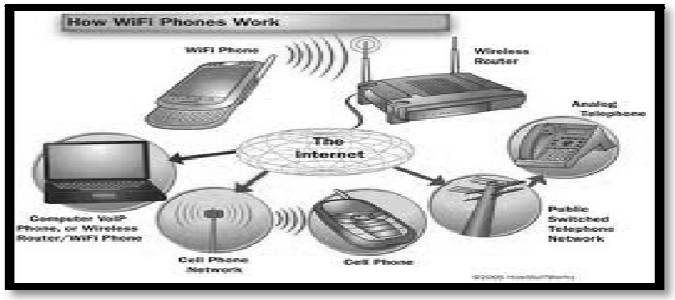

Figure 2.1 Wi-Fi

Wi-Fi has both positive feature and negative feature. And they are (i) Physical Layer- at this layer the following techniques are involves providing the service of Wi-Fi, DSSS (Direct Sequence Spread Spectrum), FHSS (Frequency hope Spread Spectrum), and OFDM (Orthogonal Frequency Division Multiplexing), and IR (Infrared). (ii) Frequency Band- it use 2.4GHz and 5 GHz (iii) Data Rate- It use 1Mbps, 2 Mbps, 5.5 Mbps for 802.11b, and 54 Mbps for 802.11a. (iv) Data and Network Security- RC-4 based stream encryption algorithm for confidentiality, authentication and integrity, limited key management, AES is being considered for 802.11 (v) Operating Range- it can provide the services up to 50 feet for indoors and 1500 feet for outdoors.(vi) Positive Aspects- The speed of Ethernet is very high without wire. It provides the connectivity for many different products from many different companies. It decreases the wireless client cards and access point costs. (vii) Negative Aspects- It security become poor with increase distance and load (viii) Network Topology- it use infrastructure(Ad-hoc also possible). (ix) Access Protocol- it use CSMA/CA the Wi-Fi network architecture consist a set of APs (Access Point) or it consists one or more number of APs and one or more clients. One client is direct connected to the one A P. The AP communicates with the client by broadcasting its Service Set Identifier (SSID) or network name through packets, which is known as beacons. The AP broadcasts the beacons in every 100ms duration with 1Mbps data rate. The connectivity between client and AP is basically depending on settings of the SSID, if the setting is not perfect the connection may be not possible. If there are several APs with the same SSID, the client firmware uses the signal strength as a measure of which AP to connect to. The Wi-Fi network uses radio signals to provide connectivity to the Internet or to the mobile operator's network for connectivity or for used the internet services. It provides services only up to the link layer level, and therefore depends on the wired IP infrastructure for the end to end connectivity as shown in figure 2.2.

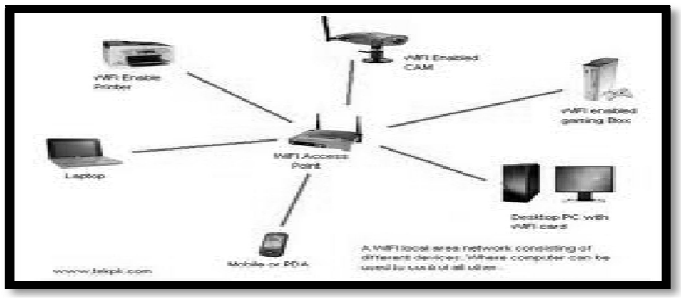

Figure 2.2 Wi-Fi Access Points

The Gateway NAPT provides connectivity to other IP based networks while the AAA server proxy handles access control and authentication of portable terminals. Wi-Fi uses remote authentication dial in user service (RADIUS) protocol together with the extensible authentication protocol (EAP) to authenticate a terminal that is trying to gain access to the network. Each AP in a Wi-Fi network has a limited range in which the client is connect. The actual distance varies depending upon the environment means the client is located in indoor or in outdoor environment. The normally indoor range is 45 - 90 meters and the outdoor range is 300 meters. From the QoS (Quality of Service) point of view, Wi-Fi was not designed with in-built QoS support. It was designed for the best effort data services but we have explored various QoS schemes. There is also an extended IEEE 802.11e standard for delay sensitive multimedia applications such as voice over IP, and video streaming Common applications for Wi-Fi include the Internet, VoIP phone access, and gaming connectivity for consumer electronics such as network televisions, DVD players, and digital cameras.

III. WI-MAX TECHNOLOGY

Wi-MAX (World interoperability for Microwave Access) is a wireless technology mainly designed for bridging the last mile to the end user and providing him with a broadband connection. Wi-MAX is based on standards developed by IEEE and ETSI, notably the IEEE 802.16 range of standards and the HIPERMAN standards. Wi-Max can be used in different frequency bands in the range 2-66 GHz. It is claimed to be useful for urban, suburban and rural areas, sometimes with a non line of sight condition between base station antenna and subscriber station antenna. The 802.16 standard, the "Air Interface for Fixed Broadband Wireless Access Systems," is also known as the IEEE Wireless MAN air interface. This technology is designed from the ground up to provide wireless last-mile broadband access in the Metropolitan Area Network (MAN), delivering performance

comparable to traditional cable, DSL, or T1 offerings. The principal advantages of systems based on 802.16 are multi-fold: the ability to quickly provision service, even in areas that are hard for wired infrastructure to reach; the avoidance of steep installation costs; and the ability to overcome the physical limitations of traditional wired infrastructure. Providing a wired broadband connection to a currently underserved area through cable or DSL can be a time-consuming, expensive process, with the result that a surprisingly large number of areas in the US and throughout the world do not have access to broadband connectivity. 802.16 wireless technologies provides a flexible, costeffective, standards based means of filling existing gaps in broadband coverage, and creating new forms of broadband services not envisioned in a "wired" world. Wi-Max will be used in urban, suburban and rural areas, particularly where other broadband means are not available or installations are expensive. Competition to DSL will not be fierce in areas where it is already established due to its relatively low costs and high penetration. Furthermore, a high density of Wi-Max base stations will be needed in urban and suburban areas to serve customers with self-installable CPE and reasonable data rates. In fact, the cell sizes under these conditions are only a few hundred meters. Wi-Max is likely to play an important role in serving rural areas. There, cell sizes of 5-10 km are possible requiring outdoor antennas at the customer premises. The speed can be increased by strengthening the signals. For a fixed transmitting power and antenna gain, this means lower range. Thus, ranges are lower if more speed is desired, e.g., for 26 Mb/s the 1-2 km range for terrain type B would drop down to 700 mbps.

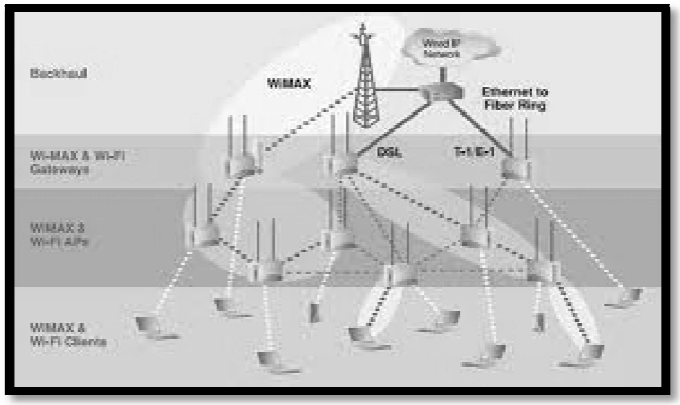

Figure 3.1 Wi-Max

IV. BLUETOOTH TECHNOLOGY

Bluetooth is named after Herald Blatand "Bluetooth", a Viking 10th century king. Herald had a penchant for surrounding himself with the right group of people, which enabled him to strategically secure new lands for Viking settlements. Herald conquered all of Denmark and Norway and made the Danes Christian. Thus Herald's conquest inspired the name of a global wireless specification achieved through the cooperation of many leading companies within the computer and telecommunications industries. The technology operates in a globally available frequency band ensuring communication compatibility worldwide. The Bluetooth wireless communication technology is poised to make a significant impact in many applications. The activity surrounding the technology underlies its need in the community, but also foreshadows the need to understand the impact current wireless services operating in the same unlicensed (UL) band will have on Bluetooth pico-net performance. Both Bluetooth wireless personal area networks (WPAN) and 802.11b wireless local area networks (WLANs) share the same 2.4 GHz UL frequency band and provide complementary wireless solutions for connectivity. The main principle in mind when developing the Bluetooth Protocol Architecture has been the maximization and the reuse of existing protocols for different purposes at the higher layers. The one main advantage is that existing (legacy) applications can be adapted to work with the Bluetooth Technology. The Bluetooth Protocol Architecture also allows for the use of commonly used application protocols on top of the Bluetooth Specific protocols. In simpler terms, this permits new applications to take full advantage of the capabilities of the Bluetooth technology and for many applications that are already developed by vendors; they can take immediate advantage of hardware and software systems, which are also compliant with the Specification. One way to use Bluetooth technology is as a wireless personal LAN. Frequent travelers could connect their mobile phones, PDAs, and laptops together to allow communication across devices using Bluetooth technology.

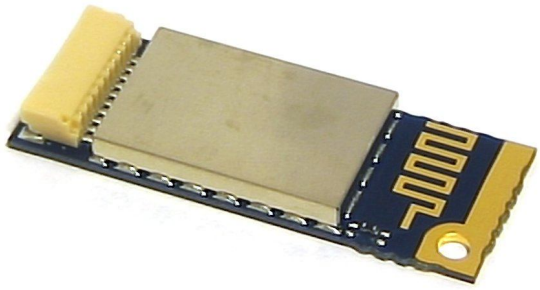

Figure 4.1 Bluetooth

V. ZIG-BEE TECHNOLOGY

Zig-Bee wireless mesh technology has been developed to address sensor and control applications with its

promise of robust and reliable, self configuring and self-healing networks that provide a simple , cost effective and battery efficient approach to adding wireless to any compliant device application, mobile, fixed or portable. A typical IEEE 802.15.4-based, Zig-Bee compliant device is shown in Figure 4.The IEEE standard at the PHY is the significant factor in determining the RF architecture and topology of Zig-Bee enabled transceivers. The IEEE standard brings with it the ability to uniquely identify. Every radio in a network as well as the method and format of communications between these radios, but does not specify beyond a peer-to-peer communications link a network topology, robust schemes or network growth and repair mechanisms.

Figure 5.1 Zig-Bee

IEEE 802.15.4 PHY/MAC and Zig Bee's layers: The IEEE 802.15.4 PHY layer includes features such as receiver energy detection (ED), link quality indication (LQI) and clear channel assessment(CCA).The network addressing follows 64-bit IEEE and 16-bit short addressing, supporting over65,000 nodes per network. The IEEE 802.15.4 MAC sub layer controls the access to the radio channel using unslotted CSMA-CA (Carrier Sense Multiple Access with Collision Avoidance) method. It is also responsible for flow control via acknowledgement and retransmission of data packets, frame validation, and network synchronization as well as support to upper layers for robust link operation.

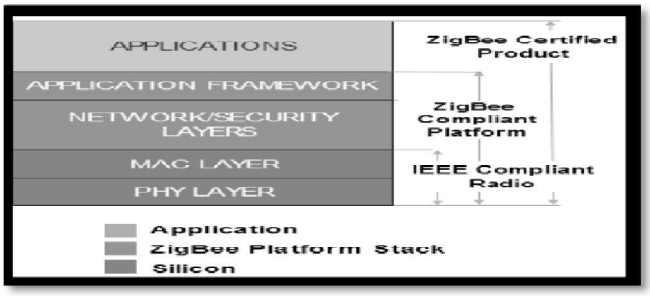

Figure 5.2 Zig-Bee Stack Protocol

The MAC structure has been designed to keep the complexity to a minimum while making the system sufficiently robust for transmissions on a noisy channel. The IEEE 802.15.4 MAC defines four frame structures: A beacon frame, used by a coordinator to transmit beacons. A data frame, used for all transfers of data .An acknowledgment frame, used for confirming successful frame reception. A MAC command frame, used for handling all MAC peer entity control transfers. - Data frame The LR .Zig-Bee defines the Security in form of MAC layer security that secures MAC command, beacon, and acknowledgment frames. Zig-Bee may secure messages transmitted over a single hop using secured MAC data frames, but for multi-hop messaging Zig-Bee relies upon upper layers (such as the NWK layer) for security. The MAC layer uses the Advanced Encryption Standard (AES-128) as its core cryptographic algorithm and describes a variety of security suites that use the AES algorithm. These suites can protect the confidentiality, integrity, and authenticity of MAC frames. The NWK layer also makes use of the Advanced Encryption Standard (AES-128). Zig-Bee Stack Zig-Bee Application Profile Layer consists of the Application Profile Support (APS) sub layer, the Zig-Bee Device Object (ZDO) and the manufacturerdefined application objects. Responsibilities of the APS sub-layer include maintaining tables for binding, which is the ability to match two devices together based on their services and their needs, and forwarding messages between bound devices. Another responsibility of the APS sub-layer is discovery, which is the ability to determine which other devices are operating in the personal operating space of a device. The responsibilities of the ZDO include defining the role of the device within the network (e.g., Zig-Bee coordinator or end device), initiating and/or responding to binding requests and establishing a secure relationship between network devices. The application objects that are "vendordefined" implement the actual applications according to the Zig-Bee-defined application descriptions.

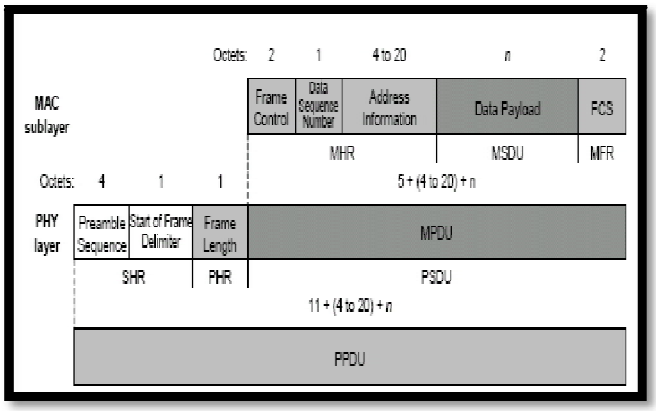

Figure 5.3 Zig-Bee Layers

VI. Zig-Bee APPLICATIONS

Zig-Bee networks handle multiple traffic types with their own unique characteristics, including periodic data, intermittent data, and repetitive low latency data. The characteristics of each are as follows: 1) Periodic data – application defined rate (e.g. wireless sensor or meter). Data is typically handled using a beaconing system whereby the sensor wakes up at a set time and checks for the beacon from the PAN coordinator, it then requests to join the network. If the coordinator accepts it, data is passed by the sensor before it goes to sleep again. This capability provides for very low duty cycles. (2) Intermittent data – either application or external stimulus defined rate (e.g. Wireless light switch). Data can be handled in a beaconless system or disconnected. In disconnected operation, the device will only attach to the network when communications is required thus saving Considerable energy. (3) Repetitive low latency data – Allocations of time slots. (e .g. medical alerts and security systems). These applications may use the guaranteed time slot (GTS) capability when timeliness and critical data passage is required. GTS is a method of QoS that allows each device a specific duration of time as defined by the PAN coordinator in the Super frame to do whatever it requires without contention or latency.

VII. LI-FI TECHNOLOGY

Transfer of data from one place to another is one of the most important day-to-day activities. The current wireless networks that connect us to the internet are very slow when multiple devices are connected. As the number of devices that access the internet increases, the fixed bandwidth available makes it more and more difficult to enjoy high data transfer rates and connect to a secure network. But, radio waves are just a small part of the spectrum available for data transfer. A solution to this problem is by the use of Li-Fi. Li-Fi stands for Light-Fidelity. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through an LED light bulb (shown in Fig. 7.1) that varies in intensity faster than the human eye can follow. Li-Fi is the term some have used to label the fast and cheap wireless communication system, which is the optical version of Wi-Fi. Li-Fi uses visible light instead of Gigahertz radio waves for data transfer. Li-Fi bulb The idea of Li-Fi was introduced by a German physicist, Harald Hass, which he also referred to as ―data through illumination‖. The term Li-Fi was first used by Haas in his TED Global talk on Visible Light Communication. According to Hass, the light, which he referred to as D-Light, can be used to produce data rates higher than 10 megabits per second which is much faster than our average broadband connection . Li-Fi can play a major role in relieving the heavy loads which the current wireless systems face since it adds a new and unutilized bandwidth of visible light to the currently available radio waves for data transfer. Thus it offers much larger frequency band (300 THz) compared to that available in RF communications (300GHz). Also, more data coming through the visible spectrum could help alleviate concerns that the electromagnetic waves that come with Wi-Fi could adversely affect our health. Li-Fi can be the technology for the future where data for laptops, smart phones, and tablets will be transmitted through the light in a room. Security would not be an issue because if you can‘t see the light, you can‘t access the data. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

Figure 7.1 Li-Fi Bulb

A. Working of Li-Fi Technology

A new generation of high brightness light-emitting diodes forms the core part of light fidelity technology. The logic is very simple. If the LED is on, a digital 1 is transmitted. If the LED is off, a digital 0 is transmitted. These high brightness LEDs can be switched on and off very quickly which gives us a very nice opportunities for transmitting data through light . The working of Li-Fi is very simple. There is a light emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use an array of LEDs of perhaps a few different colors, to obtain data rates in the range of hundreds of megabits per second. The block diagram of Li-Fi system is shown in Fig. 7.2

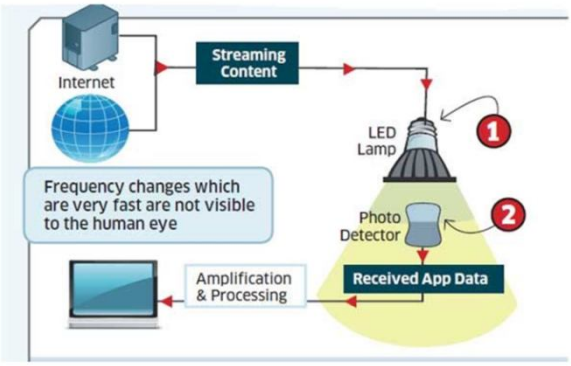

Figure 7.2 Block Diagram of Li-Fi Working

The data can be encoded in the light by varying the flickering rate at which the LEDs flicker on and off to generate different strings of 1s and 0s.The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans. Light-emitting diodes (commonly referred to as LEDs and found in traffic and street lights, car brake lights, remote control units and countless other applications) can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously, even though it is in fact 'flickering'. The on-off activity of the bulb which seems to be invisible enables data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. By varying the rate at which the LEDs flicker on and off, information can be encoded in the light to different combinations of 1s and 0s. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC), though it is popularly called as Li-Fi because it can compete with its radio-based rival Wi-Fi. Figure 7.3 shows a Li-Fi system connecting devices in a room.

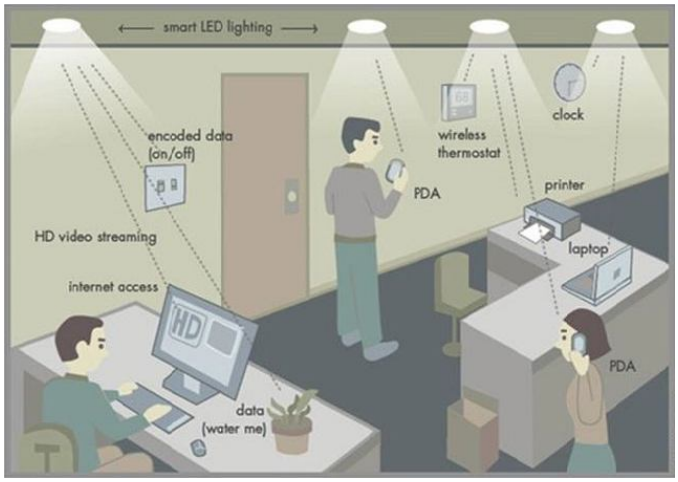

Figure 7.3 Li-Fi system connected in a room

VIII. LI-FI AND WI-FI COMPARISON

Li-Fi is the name given to describe visible light communication technology applied to obtain high speed wireless communication. It derived this name by virtue of the similarity to Wi-Fi. Wi-Fi works well for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and for relieving radio interference issues.Speed of Wi-Fi –150 Mbps Bluetooth- 3 Mbps IrDA-4 Mbps and Li-Fi >1 Gbps.

Table 8.1 Comparison between Li-Fi and Wi-Fi

Li-Fi / Wi-Fi comparison

Parameter	Li-Fi	Wi-Fi
Speed	***	***
Range	*	**
Data density	***	*
Security	***	**
Reliability	**	**
Power available	***	*
Transmit/receive power	***	**
Ecological impact	*	**
Device-to-device connectivity	***	***
Obstacle interference	***	*
Bill of materials	***	**
Market maturity	*	***

* low ** medium *** high

One of the major demerits of this technology is that the artificial light cannot penetrate into walls and other opaque materials which radio waves can do. So a Li-Fi enabled end device (through its inbuilt photo-receiver) will never be as fast and handy as a Wi-Fi enabled device in the open air. Also, another shortcoming is that it only works in direct line of sight. Still, Li-Fi could emerge as a boon to the rapidly depleting bandwidth of radio waves. And it will certainly be the first choice for accessing internet in a confined room at cheaper cost.

IX. Li-Fi APPLICATIONS

There are numerous applications of this technology, from public internet access through street lamps to auto-piloted cars that communicate through their headlights. Applications of Li-Fi can extend in areas where the Wi-Fi technology lacks its presence like medical technology, power plants and various other areas. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals where Wi-Fi is banned because they are prone to interfere with the radio waves. All the street lamps can be transferred to Li-Fi lamps to transfer data. As a result of it, it will be possible to access internet at any public place and street. Some of the future applications of Li-Fi are as follows:

a) Education systems: Li-Fi is the latest technology that can provide fastest speed internet access. So, it can replace Wi-Fi at educational institutions and at companies so that all the people can make use of Li-Fi with the same speed intended in

a particular area.

b) Medical Applications: Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes with the mobile and pc which blocks the signals for monitoring equipments. So, it may be hazardous to the patient's health. To overcome this and to make OT tech savvy Li-Fi can be used to accessing internet and to control medicalequipments. This can even be beneficial for robotic surgeries and other automated procedures.

c) Cheaper Internet in Aircrafts: The passengers travelling in aircrafts get access to low speed internet at a very high rate. Also Wi-Fi is not used because it may interfere with the navigational systems of the pilots. In aircrafts Li-Fi can be used for data transmission. Li-Fi can easily provide high speed internet via every light source such as overhead reading bulb, etc. present inside the airplane.

d) Underwater applications: Underwater ROVs (Remotely Operated Vehicles) operate from large cables that supply their power and allow them to receive signals from their pilots above. But the tether used in ROVs is not long enough to allow them to explore larger areas. If their wires were replaced with light — say from a submerged, high-powered lamp — then they would be much freer to explore. They could also use their headlamps to communicate with each other, processing data autonomously and sending their findings periodically back to the surface. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

e) Disaster management: Li-Fi can be used as a powerful means of communication in times of disaster such as earthquake or hurricanes. The average people may not know the protocols during such disasters. Subway stations and tunnels, common dead zones for most emergency communications, pose no obstruction for Li-Fi. Also, for normal periods, Li-Fi bulbs could provide cheap high-speed Web access to every street corner.

f) Applications in sensitive areas: Power plants need fast, inter-connected data systems so that demand, grid integrity and core temperature (in case of nuclear power plants) can be monitored. Wi-Fi and many other radiation types are bad for sensitive areas surrounding the power plants. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. This can save money as compared to the currently implemented solutions. Also, the pressure on a power plant‘s own reserves could be lessened. Li-Fi can also be used in petroleum or chemical plants where other transmission or frequencies could be hazardous.

g) Traffic management: In traffic signals Li-Fi can be used which will communicate with the LED lights of the cars which can help in managing the traffic in a better manner and the accident numbers can be decreased . Also, LED car lights can alert drivers when other vehicles are too close.

h) Replacement for other technologies: Li-Fi doesn‘t work using radio waves. So, it can be easily used in the places where Bluetooth, infrared, Wi-Fi, etc. are banned.

X. CONCLUSION

This paper has described the fundamentals of Wireless communication, Wi-Fi, Wi-MAX, Bluetooth and Zig-Bee networking. Persistent technological evolution in wireless communications is needed mainly due to emerging demands for broadband packet-based services. In this paper, we briefly discussed the current advancements in wireless communication. The use of Wi-Fi technology Users access the information from the departments, hostels and computer centers and also from the libraries. Wi-Fi technology has highlighted the importance of achieving capability among databases and information products, hardware and software, input formats, processing, data exchange, output formats has to be address. Its main focus is utilizing the resource in a productive manner. We are witnessing today the emergence of global network infrastructure, wherein WLAN are rapidly getting interconnected. Furthermore, a high density of Wi-MAX base stations will be needed in urban and suburban areas to serve customers with self installable CPE and reasonable data rates. Currently the interoperability between Zig-Bee implementations is an issue. There are no standards governing mesh networks. Bridges must be constructed between the different mesh networks. The concept of Li-Fi is attracting a lot of eye-balls because it offers a genuine and very efficient alternative to radio based wireless. It has a bright chance to replace the traditional Wi-Fi because as an ever increasing population is using wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This concept promises to solve issues such as the shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

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