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# Evolution of Gi-Fi and Li-Fi in Wireless Networks

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***Abstract*—** Wireless communication is the transfer of information over a distance without the use of wires. 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. Network architecture for personal communication systems, wireless LANs, radio, tactical and other wireless networks, and design and analysis of protocols are addressed on a regular basis. At present, the major application of Wi-Fi implementation in libraries is limited to information management. This paper elaborates on new and upcoming technology like Gi-Fi and Li-Fi.

***KEYWORDS***: Wireless networking, Li-Fi, Gi-Fi, Critical Issues.

## I. INTRODUCTION

Features of the emerging knowledge society of the digital era include the convergence of information and communication technologies (ICTs) enabling almost seamless access, in the expanding digital space, to vast and varied information and knowledge sources from anywhere, at any time. The spread of telecom facilities—wireless technology and cellphone—into rural areas is enabling rural traders and others to obtain market information for their products, to contact village and/or taluk and district officials, not only to get information but also to obtain certificates and other documents. Availability of ICTs in developing countries is not as widespread as it is in Europe and North America. However, the spread of wireless technologies especially cell phones, has been rapid. New areas and new groups of users are able to access ICT services including wireless local area networks, and long-range wireless links in libraries and information centers.

The idea of increasing the effectiveness of information exchange by sharing the work nationally and internationally is fully recognized, but the panning of information activities on such a scale must take into account the perspective of national and international cooperation. There has been a growing concern for improvement of library services in general and scientific and technological library services in particular for providing effective and efficient information support for carrying out research and education activities. In addition, such information system requires both the use of modern scientific information theory and advanced technology.

### 1.1 CLASSIFICATION AND DESCRIPTION OF SOME REAL TIME WIRELESS NETWORKS:

| Technology | Services/ Features | Coverage Area | Limitations |
|---|---|---|---|
| Cellular | Voice and Data through hand held phones | Contiguous Coverage | Very low Bandwidth |
| Wireless LAN (WLAN) | Traditional LAN with Wireless Interface | Only in Local Environment | Limited Range |
| GPS | Determines Three Dimensional position and velocity | Any place on Earth | Expensive |
| Satellite-based PCs | Mainly for paging | Almost any Place on Earth | Expensive |
| Ad hoc networks | Group of people come Together for short time To share data | Similar to local Area networks | Very limited Range |
| Sensor Networks | Tiny sensors with wireless capabilities | Small terrain | Very limited range |

Table – 1.1:Properties of some real-time wireless networks

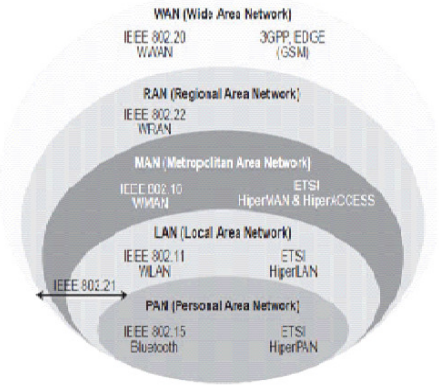


Fig - 1.1: Wireless Networks categories

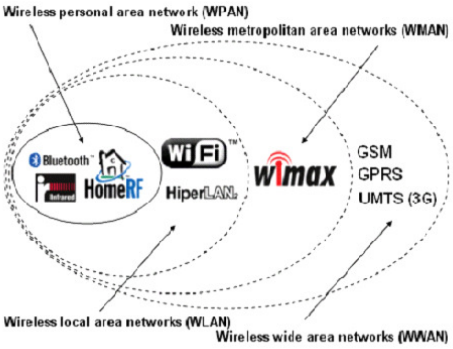


Fig – 1.2:Range of common wireless networks

> To span a distance beyond the capabilities of typical cabling.
> To provide a backup communications link in case of normal network failure.
> To link portable or temporary workstations.
> To overcome situations where normal cabling is difficult or financially impractical.
> To remotely connect mobile users or networks.
The Wireless communication can be via:
> Radio frequency (RF) communication.
> Microwave communication, for example long-range line-of-sight via highly directional antennas, or short-range communication, or
> Infrared (IR) short-range communication, for example from remote controls or via Infrared Data Association (IRDA).
Application may involve point-to-point communication, point-to-multipoint communication, broadcasting, cellular networks, and other wireless networks.

**1.2 KEY ISSUES:**

1.2.1 RESEARCH CHALLENGES OF WIRELESS NETWORKS:
Since wireless devices need to be small and wireless networks are bandwidth limited, some of the key challenges in wireless networks are data rate enhancements, minimizing size, cost, low power networking, user security and Quality of Service (QoS).

A – Signal Fading:
signals transmitted over a wireless medium may be distorted or weakened because they are propagated over an open, unprotected, and ever changing medium with irregular boundary.

B - Mobility:
Without the constraints imposed by the wired connections among devices, all devices in a wireless network are free to move. To support mobility, an ongoing connection should be kept alive as a user roams around. In an infrastructure network, a handoff occurs when a mobile host moves from the coverage of a base station or access point to that of another one.

C - Power and Energy:
A mobile device is generally handy, small in size, and dedicated to perform a certain set of functions; its power source may not be able to deliver power as much as the one installed in a fixed device. When a device is allowed to move freely, it would generally be hard to receive a continuous supply of power. To conserve energy, a mobile device should be able to operate in an effective and efficient manner.

D - Data Rate:
Improving the current data rates to support future high speed applications is essential, especially, if multimedia service are to be provided. Data rate is a function of various factors such as the data compression algorithm, interference mitigation through error-resilient coding, power control, and the data transfer protocol.

D - Security:
Security is a big concern in wireless networking, especially in m-commerce and e-commerce applications. Mobility of users increases the security concerns in a wireless network. Current wireless networks employ authentication and data encryption techniques on the air interface to provide security to its users.

E - (QoS) Quality of Service:
Quality of Service is a measure of network performance that reflects the network's transmission quality and service availability. For each flow of network traffic, QoS can be characterized by four parameters:
o Reliability
o Delay
o Jitter
o Bandwidth
There are several important issues related to QoS in wireless networks that do not get addressed in the wire line environment. These issues arise because wireless networks are inherently different from wire line networks. Several important wireless network characteristics include handoff, dynamic connections, and actuating transport QoS. The traffic

**2. CURRENT TRENDS IN WIRELESS NETWORKS:**
**2.1 Mobile network:**

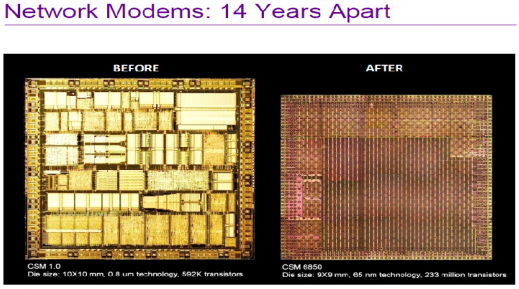


Fig – 2.1: network modem evolution

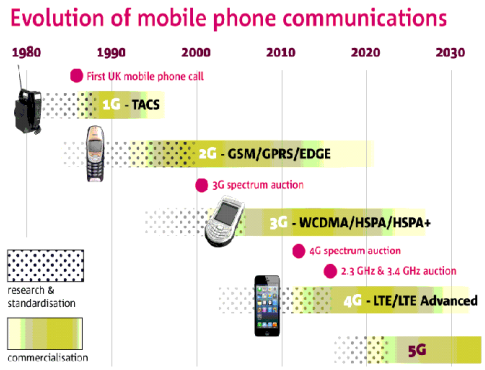


Fig – 2.2 evolution of mobile networks

2.2 GI-FI technology:

Gigabit Wireless is the world's first transceiver integrated on a single chip that operates at 60GHz on the CMOS (complementary metal–oxide–semiconductor) 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. In fact, Gi-Fi is a wireless transmission system which is ten times faster than Wi-Fi and it is expected revolution networking in offices and homes by implementing

High-speed wireless environments. It utilizes a 5mm square chip and a 1mm wide antenna burning less than 2milli watts of power to transmit data wirelessly over short distances, much like Bluetooth.

**2.2.1 Features:**

This Gi-Fi technology allows wireless uncompressed high-definition content and operates over a range of 10 meters without interference. Gi-fi chip has flexible architecture. It is highly portable and can be constructed in everywhere. Entire transmission system can be built on a cost effective single silicon chip that operates in the unlicensed, 57-64 GHz spectrum band. Gi-Fi technology also enables the future of information management, is easy to deployment with the small form factor.

a) Capacity of High Speed Data Transfer:

The data transfer rate of Gigabit wireless technology is in Gigabits per second. Speed of Gi-Fi is 5 Gbps; which is 10 times the data transfer of the existing technologies. Providing higher data transfer rate is the main invention of Gi-Fi. An entire High-Definition (HD) movie could be transmitted to a mobile phone in a few seconds, and the phone could then upload the movie to a home computer or screen at the same speed.

b) Interference in Data Transfer:

It uses the 60GHz millimeter wave spectrum to transmit the data, which gives it an advantage over Wi-Fi. Wi-Fi's part of the spectrum is increasingly crowded, sharing the waves with devices such as cordless phones, which leads to interference and slower speeds.

c) Power Consumption:

Power consumption of the present technologies such as Wi- Fi and Bluetooth are 5mili watts and 10mili watts but chip of Gi-Fi uses a tiny one-millimeter-wide antenna and it has less than 2mili watts of power consumption that in comparison to the current technologies is very less.

d) Provides High Security:

Gi-Fi technology is based on IEEE 802.15.3C and this standard provides more security since it provides optional security in the link level and service level. 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 the military for satel lite-to satellite communications.

Table 2.1: Comparison of Gi-Fi to Existing Technologies

| Characteristics | Bluetooth | Wi-Fi | Gi-Fi |
|---|---|---|---|
| Specification Authority | Bluetooth SIG | IEEE, WECA | NICTA |
| Development Start date | 1998 | 1990 | 2004 |
| Primary device | Mobile phones, PDAs, Consumer electronics, Office, Industrial Automation Devices | Notebook, Computers, Desktop, Computer servers | Mobile phones, Home devices, PDAs, Consumer electronics, offices, Industrial Automation Devices |
| Power consumption | 5mW | 10mW | <2mW |
| Data transfer rate | 800Kbps | 11Mbps | 5Gbps |
| Range | 10 meters | 100 meters | 10 meters |
| Frequency | 2.4 GHz | 2.4GHz | 57-64GHz |

2.2.2 Applications of GI–FI Technology:

I) Gi-Fi technology has many attractive features that make it suitable for use in many places and devices. Gi-Fi echnology offering reduced the chip size and power consumption, can be used to send and receive large amounts of data in a variety of applications .

II) This technology can be effectively used in wireless pan networks, Inter-vehicle communication systems, Ad-hoc information distribution with Point-to-Point network extension, media access control (MAC), imaging and other applications.

III) Gi-Fi technology is able to transfer gigabits of data within seconds and therefore it can be used for huge data file transmission and it is expected that this chipset replaces HDMI cables and could develop wireless home and office of future.

IV) Gi-Fi technology also can be used in broadcasting video signal transmission system in sports stadiums and mm-Wave video video-signals transmission systems. The technology could also be used for beaming full HD video in real-time and could be used by notebooks and other computers to wirelessly connect virtually all the expansion needed for a docking station, including a secondary display and storage.

2.3 Li Fi:

A new era in wireless communication is soon going to hit the world. A German physicist, Herald Hass who discovered a method to transfer data through illumination which he called it as D-light (or LI-FI). LI-FI which is a very advanced version of WI-FI is basically, light fidelity" which uses visible light communication instead of radio wave communication as in WI-FI. As speed of light is way faster than radio waves hence it can be used with a speed of around 250 times more than any high speed broadband.

**2.3.1 APPLICATIONS OF Li-Fi:**

Li-Fi technology can find application in a wide variety of fields. A detailed discussion of its various applications is given below.

**i) Medical and Healthcare**

Due to concerns over radiation, operating rooms do not allow Wi-Fi and even though Wi-Fi is in place in several hospitals, interferences from computers and cell phones can block signals from medical and monitoring equipment. Li-Fi solves these problems. Lights are an essential part of operating rooms and Li-Fi can thus be used for modern medical instruments.

**ii) Airlines and Aviation**

Wi-Fi is often prohibited in aircrafts. However, since aircrafts already contain multiple lights, thus Li-Fi can be used for data transmission.

**iii) Power Plants and Hazardous Environments**

Wi-Fi is not suitable for sensitive areas like power plants. However, power plants still require fast and interconnected data systems for monitoring grid intensity, demand, temperature etc. In place of Wi-Fi, Li-Fi can provide safe connectivity throughout the power plant. Li-Fi offers a safe alternative to electromagnetic interference due to radio waves in environments such as petrochemical plants and mines.

**iv) Underwater Explorations and Communications**

Remotely operated underwater vehicles or ROVs work well except in situations when the tether is not long enough to fully explore an underwater area or when they get stuck. If instead of the wires, light were used then the ROVs would be freer to explore. With Li-Fi, the headlamps could also then be used to communicate with each other, data processing and reporting findings back to the surface at regular intervals, while also receiving the next batch of instructions. Radio waves cannot be used in water due to strong signal absorption.

**v) Traffic**

Li-Fi can be used for communications between the LED lights of cars to reduce and prevent traffic accidents. LED headlights and tail-lights are being implemented for different cars. Traffic signals, signs and street lamps are all also transitioning to LED. With these LED lights in place, Li-Fi can be used for effective vehicle-to-vehicle as well as vehicle-to-signal communications. This would of course lead to increased traffic management and safety.

**vi) RF Spectrum Relief**

Li-Fi networks can be used to relieve the radio spectrum off of excessive capacity demands of cellular networks.

**vii) RF Avoidance**

Li-Fi can be used as a solution to any situation in which hypersensitivity to radio frequencies is a problem and radio waves cannot be used for communication or data transfer.

**viii) Indoor Wireless Communication**

Li-Fi is very well suited for indoor wireless communication and data transmission. Li-Fi makes use of a free, unlicensed spectrum and is not affected by RF noise.

**ix) Retail Analytics**

Li-Fi can find wide application in retail analytics. Most retail stores consist of a rich lighting environment comprising of abundant sources of light which may be utilized for Li-Fi. Li-Fi could be used to track the behaviour of individual shoppers.

**x) Hidden Communications**

Li-Fi is extremely useful for applications in which communications must be hidden. These involve various military and defense-based communications as well as communications in hospitals.

**xi) Line of Sight Applications**

Li-Fi can also be used in situations where line of sight makes a difference, such as in vehicle to vehicle communication as previously discussed as well as in indoor GPS systems.

**xii) Spatial Reuse**

Li-Fi can act as an alternative in regions with high density wireless communication where 500 or more users may be contending for Wi-Fi. This would lead to low access speeds for the users. Li-Fi can be used to share some of the load of Wi-Fi.

**xiii) Smart Class**

Li-Fi can find application in the new smart class technology which is quickly becoming imperative for progressive schools and colleges in the world. Using this technology, teachers show the class a 2D/3D animation on a large screen. They can explain different topics, zoom in to show the important details and freeze and annotate for appropriate emphasis.

## 3. RESEARCH RESULTS:

3.1 Gi-Fi:
In recent years, new wireless local area networks (WLANs) such as Wi-Fi and wireless personal area networks (WPAN) such as Bluetooth have become available. Wireless USB, which matches the same range but roughly the same 480Mbps peak speed of its wired equivalent. In new trends Gi-Fi wireless technology has been developed and can be replacement for technologies such as Bluetooth and ultra-wideband (UWB). The process of Gi-Fi would use a chip that transmits at an extremely high 60GHz frequency versus the 5GHz used for the fastest forms of Wi-Fi. The sheer density of the signal would allow a chip to send as much as 5 gigabits per second. While the spectrum would limit the device to the same 33-foot range as Bluetooth or UWB, it could theoretically transfer an HD movie to a cell phone in seconds. Mixing and signal filtering used in Gi-Fi technology would keep the signal strong versus the longer-ranged but slower and more drop-prone Wi-Fi option of today. The chip in Gi-fi would likely cost is less.

### 3.1.1 Benefits of GI-FI Technology:
The most important benefits of the Gi-Fi technology are as follows:

a) Removing Cables:
For many years cables ruled the world. Optical fibers played a dominant role for its higher bit rates and faster transmission. But the installation of cables caused a greater difficulty and thus led to wireless access. The standard's original limitations for data exchange rate and range and high cost of the infrastructures have not yet made it possible for Wi-Fi to become a good replace for the cables. Gi-Fi technology Removes need for cables to connect consumer electronics devices and all the devices can be connected in order to transmit the data wirelessly.

b)Cost of Chip is low:
Gi-Fi's chip uses only a tiny one-millimeter-wide antenna and less than 2mili watts of power. Low-cost chip allows technology to be readily incorporated into multiple devices. The chip in Gi-fi would likely cost less to build . Then a small design would allow cell phones and other small devices to add the technology without significantly drive up the price. Gi-Fi is based on an open, international standard. Mass adoption of the standard, and the use of low-cost, vmass-produced chipsets, will drive costs down dramatically, which is very less in compare to present technologies.

c) Privacy and Security:
Encryption technology in Gi-Fi ensures privacy and security of content. About 70 per cent of firms have deployed their WLAN in a secure firewall zone but are still using the old WEP protocol, which does not protect the application layer effectively, so better encryption is urgently needed.

### 3.2 LI-FI:
Li-Fi can be regarded as light-based Wi-Fi, i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li-Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information. It makes use of the visible portion of the electromagnetic spectrum which is underutilized. Li-Fi can be considered better than Wi-Fi because there are some limitations in Wi-Fi. Wi-Fi uses 2.4 – 5 GHz radio frequencies to deliver wireless internet access and its bandwidth is limited to 50-100 Mbps. With the increase in the number of Wi-Fi hotspots and volume of Wi-Fi traffic, the reliability of signals is bound to suffer. Security and speed are also important concerns. Wi-Fi communication is vulnerable to hackers as it penetrates easily through walls. In his TED talk, Professor Haas highlighted the following key problems of Wi-Fi that need to be overcome in the near future:

a) Capacity: The radio waves used by Wi-Fi to transmit data are limited as well as expensive. With the development of 3G and 4G technologies, the amount of available spectrum is running out.
b) Efficiency: There are 1.4 million cellular radio masts worldwide. These masts consume massive amounts of energy, most of which is used for cooling the station rather than transmission of radio waves. In fact, the efficiency of such stations is only 5%.
c) Availability: Radio waves cannot be used in all environments, particularly in airplanes, chemical and power plants and in hospitals.
d) Security: Radio waves can penetrate through walls. This leads to many security concerns as they can be easily intercepted. -Fi addresses the aforementioned issues with Wi-Fi as follows:
a) Capacity: The visible light spectrum is 10,000 times wider than the spectrum of radio waves. Additionally, the light sources are already installed. Hence Li-Fi has greater bandwidth and equipment which is already available.
b) Efficiency: LED lights consume less energy and are highly efficient.
c) Availability: Light sources are present in all corners of the world. Hence, availability is not an issue. The billions of light bulbs worldwide need only be replaced by LEDs.
d) Security: Light of course does not penetrate through walls and thus data transmission using light waves is more secure.
and Wi-Fi. He also cites another advantage of Li-Fi being that the latency of Li-Fi is in the order of microseconds where as that of Wi-Fi is in the order of milliseconds.

Table - 3.1: Advantages of using Li-Fi

| | |
|---|---|
| Light | LEDs produce more light per watt than do incandescent bulbs |
| ON-OFF Time | LEDs can light up very quickly |

| | |
|---|---|
| Toxicity | Unlike fluorescent lamps, LEDs do not contain mercury |
| Free Band | Li-Fi makes use of a free band that does not need any licensing |
| High Speeds | It offers theoretical speeds in order of Gigabits per second |
| Airlines | Li-Fi Can be used safely in aircrafts without affecting airline signals unlike Wi-Fi |
| Healthcare | It can be integrated into medical devices and in hospitals as no radio waves are involved |
| Traffic Control | Li-Fi can be used on highways for traffic control applications cars can have LED based headlights and LED based backlights that can communicated with those of other cars and prevent traffic accidents |
| Street Lamps | Every Street lamp can be converted into a free data access point |
| Spectrum Relief | The issues of the shortage of radio frequency bandwidth can be sorted out by Li-Fi |

With the above benefits encouraging us to adopt this new technology, the actual need for Li-Fi can be confirmed from Cisco's Visual Network Index which suggests that user demand is increasing faster than gains in spectral efficiency. By 2015, traffic from wireless devices is expected to exceed that from wired devices. Such increases in network traffic require significant changes in how we think of wireless communication and Li-Fi may be the change that we need.

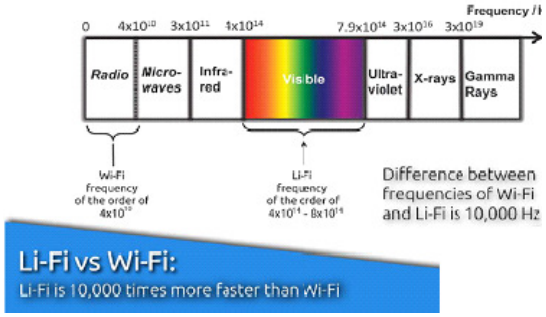


Fig – 3.1: Spectrum of Wi-Fi and Li-Fi

| Parameter | Li-Fi | Wi-Fi |
|---|---|---|
| Speed | High | High |
| Spectrum | 10,000 times broader than that of Wi-Fi | Narrow spectrum |
| Data density | High | Low |
| Security | High Security due to non-penetration of light through walls | Less secure due to transparency |
| Reliability | Medium | Medium |
| Bandwidth | High due to broad spectrum | Low |
| Transmit/Receive power | High | Medium |
| Ecological Impact | Low | Medium |
| Device-to-device connectivity | High | High |
| Obstacle Interference | High | Low |
| Bill of materials | High | Medium |
| Market Maturity | Low | High |
| Latency | In order if microseconds | In order of milliseconds |

### 3.2.3 SOME LIMITATIONS OF LI-FI

Despite its many advantages, Li-Fi like any other technology also comes with a number of limitations and disadvantages. These are enumerated below:

1) The main problem is that light cannot pass through objects, so if the receiver is inadvertently blocked in any way, then the signal will immediately be cut out. If the light signal is blocked one could switch back over to radio waves.

2) Reliability and network coverage are the major issues to be considered by the companies while providing VLC services. Interference from external light sources like sunlight, normal bulbs; and opaque materials in the path of transmission will cause interruption in the communication.

3) High installation cost of the systems can be complemented by large-scale implementation of VLC though adopting this technology will reduce further operating costs like electricity charges, maintenance charges etc.

4) We still need Wi-Fi and we still need radio frequency cellular systems. You can't have a light bulb that provides data to a high-speed moving object or to provide data in a remote area where there are trees, walls and obstacles.

## 4. CONCLUSION:

4.1 Gi-Fi:

Gi-Fi has given and it is conspicuous that more research should be done in the field of this new wireless technology and its applications The comparison is performed between Gi-Fi and existing wireless technologies in this paper shows that these features along with some other benefits that make it suitable to replace the existing wireless technologies. It removes cables that for many years ruled over the world and provides high speed data transfer rate. Gi-Fi technology has much 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.

4.2 Li-Fi:

Researchers are developing micron sized LEDs which flicker on and off 1000 times faster than larger LEDs. They provide faster data transfer and also take up less space. Moreover, 1000 micron sized LEDs can fit into area required by 1 sq. mm large single LED. A 1 sq. mm sized array of micron sized LEDs could hence communicate 1000×1000 (i.e. a million) times as much information as a single 1mm LED. The Li-Fi Consortium asserts that it is possible to achieve speeds greater than 10Gbps. Researchers at the Heinrich Hertz Institute in Berlin,

Germany, have achieved data rates of over 500 megabytes per second using a standard white-light LED.

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