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A Comparison between Li-Fi, Wi-Fi, and Ethernet Standards

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Abstract: ***The LiFi, WiFi, and Ethernet technologies form three types of high frequency technologies for communication networks. The WiFi and Ethernet use the radio frequency waves for communications, while the LiFi technology uses light as medium of communications. Hence, the LiFi frequency band are in the Tera Hz range compared to GHz of WiFi and Ethernet. The Li-Fi solves bandwidth issues, and they are suitable for confined space communications. The vast presence of light sources in today's world offer great opportunity to utilize such technology for communications. Several location can be prime for its use such as banks, hospitals, buildings, etc… Inspite these benefits, LiFi still suffers from multiple issues such as interference from various light sources, service interruptions by opaque surfaces, and high implementation costs. The Ethernet technology is known to be high reliability technique, but lacks mobility and flexibility. It is imperative to investigate each technology application areas and features to help design better communication networks.***

Keywords: IEEE802.11, networking, communications, WiFi, LiFi, Ethernet

1. Introduction

There has been a drastic change in how mobile communication devices are being used with data transfer and with mobility scenarios. Mobile users have been trafficking more data than voice while using these mobile devices leading to change of communication environment. According to [1], the number of mobile devices subscription outlook during 2014 - 2020 will be as shown in Table 1.

Table 1: Mobile subscription outlook as stated by [1]

Subscriptions	*2014*	*2020*
Total mobile	7.1 billion	9.2 billion
Mobile broadband	2.9 billion	7.7 billion
Smartphones	2.6 billion	6.1 billion
Mobile PCs, tablets and routers	250 million	400 million

From Table 1, the vast number of mobile devices as well as the rapid growth of subscribers are evident. Also, it worth noting that the mobile PCs, tablets, and routers growth is much slower than mobile broadband devices and smart phones. To support the aforementioned growth, new connectivity technologies have emerged in the communication market. These include the LiFi, WiFi, and Ethernet technologies which follow various standards on how systems are built and how they communicate. The features list and differences between the LiFi and WiFi technologies are listed in Table 2. These three technologies are focused on high speed communications and would be interesting to compare these techniques against each other.

In this article, the technology specifications of LiFi, WiFi, and Ethernet systems will be discussed. A comparative study of QoS of the three systems will be tabulated and conclusions will be drawn.

Table 2: Basic differences between LiFi and WiFi standards

Feature	*LiFi*	*WiFi*
Full form	Light Fidelity	Wireless Fidelity
Operation	LiFi transmits data using light with the help of LED bulbs.	WiFi transmits data using radio waves with the help of WiFi router.
Interference	Do not have any interference issues similar to radio frequency waves.	Will have interference issues from nearby access points (routers)
Technology	Present IrDA compliant devices	WLAN 802.11a/b/g/n/ac/ad standard compliant devices
Applications	Used in airlines, undersea explorations, operation theaters in the hospitals, office and home premises for data transfer and internet browsing	Used for internet browsing with the help of WiFi kiosks or hotspots
Advantages	Interference is less, can pass through salty sea water, works in dense region	Prone to interference, can't pass through sea water, works in less dense region
Privacy	light is blocked by the walls, therefor more secured on data transfer	For RF signal, dry walls are transparent, therefore need to employ techniques to achieve secure data transfer.
Data transfer speed	About 1 Gbps	WLAN-11n offers 150Mbps, About 1-2 Gbps can be achieved using WiGig/Giga-IR
Frequency of operation	10,000 times frequency spectrum of the radio (In the Tera Hz range)	2.4GHz, 4.9GHz and 5GHz

Data density	Works in high dense environment	Works in less dense environment due to interference related issues
Coverage distance	About 10 meters	About 32 meters (WLAN 802.11b/11g), vary based on transmit power and antenna type
System components	Lamp driver, LED bulb (lamp) and photo detector will make up complete LiFi system.	requires routers to be installed, subscriber devices (laptops, PDAs, desktops) are referred as stations

2. LiFi, WiFi, and Ethernet Technology Details

A. Ethernet

The Ethernet standards is a well-established technology that was released commercially during 1980 as the IEEE802.3. It has been a relatively inexpensive, reasonably fast, and very popular LAN technology for several decades [2]. The most commonly installed Ethernet systems are called 10BASE-T and provide transmission speeds up to 10 Mbps. Ethernet data transfer rates have been increased from the original 2.94(Mbit/s) to the latest 100 (Gbit/s). Jorg Sommer et. al. [3] have investigated fields of Ethernet applications and found them concentrated on three major categories:

- The operated and managed networks of carriers in the core and access part of a public or private network;
- The embedded networks in the manufacturing environment, in aircraft, and in cars;
- The home entertainment (AVB) networks residing between LAN and category two.

Please refer to Table 3. For more relevant details on Ethernet technologies and a comparison with other technologies.

B. WiFi

WiFi - is a short name for Wireless Fidelity, and this system was released during 1990 with standard IEEE 802.11. This technology was designed to provide wireless connectivity to devices that require a quick installation, such as portable computers PDAs or generally mobile devices inside a WLAN network [4]. Table 3 provide more insight to the IEEE802.11 various components specifications.

Table 3: Comparison Between IEEE 802.11 Standards [5]

802.11 network PHY standards								
802.11 protocol	**Release date**	**Frequency**	**Band-width**	**Stream Data Rate**	**Allowable MIMO streams**	**Modulation Antenna Tech.**	**Approx. range**	
							In	**Out**
		(GHz)	**(MHz)**	**Min-Max (Mbit/s)**			**(m)**	**(m)**
802.11	Jun 1997	2.4	22	1-2	1	DSSS, FHSS	20	100
a	Sep 1999	5	20	6-54	1	OFDM	35	120
		3.7				(SISO)	—	5K
b	Sep 1999	2.4	22	1-11	1	DSSS (SISO)	35	140
g	Jun 2003	2.4	20	6-54	1	OFDM, DSSS (SISO)	38	140
n	Oct 2009	2.4/5	20	7.2 -72.2 (6.5- 65)	4	OFDM (MIMO)	70	250
			40	15 - 150 (13.5 - 135)			70	250
ac	**Dec 2013**	**5**	**20**	**7.2 - 96.3 (6.5 - 86.7)**	**8**	**OFDM (MU-MIMO)**	**35**	
			40	**15 - 200 (13.5 - 180)**			**35**	
			80	**32.5 - 433.3 (29.2 - 390)**			**35**	
			160	**65 - 866.7 (58.5 - 780)**			**35**	

C. LiFi

The LiFi considered as a WiFi with light being using light technology instead of Radio waves. It forms a new class of high intensity light source of solid state design bringing clean lighting solutions to general and specialty lighting. With energy efficiency, long useful lifetime, full spectrum and dimming, LiFi lighting applications work better

compared to conventional approaches. The LiFi provide high efficiency communication system within confined spaces when compared to the WiFi, hence the two technologies can be considered complimentary.

The LiFi system uses standard LED light bulbs which are controlled by a driver that turns the LED on and off, or dims and brightens its light intensity. With Li-Fi enabled LED light bulbs, the driver is used to transmit encoded data by controlling the LED light. An optical sensor is used to receive the data, which is then decoded. This is conceptually similar to Morse code – but at rates of many millions of times a second, which is unperceivable to the human eye. The receiver has optics, and is fast enough to ‗see' the light dimming and brightening, smart enough to decode the Li-Fi data, and then deliver it to the attached device such as a laptop computer. Devices can include both a transmitter and receiver to enjoy two-way communications [6].

Table 4: Technology Parameters Comparison Between LiFi, WiFi, and the Ethernet Standards

Parameters	**Li-Fi**	Wi-Fi	Ethernet
IEEE Standards	**802.15.17**	802.11b	802.3
Frequency Band	**100 X Tera HZ**	2.4 GHZ	
Cots	**Cheap**	Expensive	Medium
Data Trans. Medium	**Light**	Radio Spectrum	UTP-STP- O.F.
Network Topology	**Point-to-Point**	Point-to-Point	Bus-Star
Speed	**1-3.5Gbps**	54-250Mbps	10-1000 Mbps
Range	**10 Meters**	20-100 meters	(100-185) meters
Security	**High**	Medium	High
Power Energy	**Available**	less available	Available
QoS			
Data rate		High(low-power models available for battery application	High power over Ethernet
Wireless spectrum reliability		2.4GHZ 5GHZ	None
Reliability	**High**	High	Very High
Release Date	**2011**	1990	1980

3. Discussion

Table 4 illustrates comprehensive comparison between LiFi, WiFi, and the Ethernet technologies. One glaring difference is the operating frequency band for LiFi runs about 100X WiFi range, i.e. in the Tera Hz range. The WiFi technology is characterized by its mobility and flexibility besides its acceptable coverage area. However, WiFi is expensive, prone to interference (noisy), and is characterized with low reliability. On the other hand, the Ethernet is an old technology, characterized by its high reliability, low interference and reasonable cost. Nevertheless, the main disadvantages of Ethernet technology is that it does not offer mobility or flexibility.

The LiFi is a new technology that appeared on 2011 and relies on light transmission as medium of communication. It is characterized by low cost, and is more suitable for a point-to-point schemes of operations. The potential benefit of such technology can be great considering that it uses light sources which are connected in many locations. However, the LiFi suffers from a set of disadvantageous that can be listed as follows:

- Reliability of operation due to interference from other light sources such as sun light, electrical bulbs, etc …
- Opaque interfaces blocks communications
- High installation costs
- Receiving devices inability to respond back through light transmission technique.

4. Conclusions

A comparison of the LiFi, WiFi, and Ethernet technologies is presented. The three technologies are high frequency technologies. A list of network parameters are listed for the technologies to enable tabular comparison format. Wi-Fi facilitate point-to-multiple point connectivity which enable creation of Wi-Fi hotspot zones anywhere. The Li-Fi is solving issues such as shortage of radio frequency bandwidth. Also, the LiFi is more suitable for reliable communication in confined spaces. The Ethernet technology is known to be high reliability technique, but lacks mobility and flexibility. This study highlight reasonable applications for each type of technology were better performance can be achieved.

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