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

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Abstract: The LiFi, Wi-Fi, 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.

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 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 |

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, therefore 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 |
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 (GHz) | Bandwidth (MHz) | Stream Data Rate | Allowable MIMO streams | Modulation Antenna Tech. | Approx. range In (m) | Approx. range Out (m) |
|-------------------------------|----------------|-------------|----------------|----------------|---------------------|--------------------------|--------------------------|---------------------|---------------------|
| 802.11                        | Jun 1997       | 2.4         | 22             | 1-2            | 1                   | DSSS, FHSS              | 20                       | 100                 |
| a                             | Sep 1999       | 5           | 20             | 6-54           | 1                   | OFDM (SISO)             | 35                       | 120                 |
| 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)       | 35                       | 140                 |
| n                             | Oct 2009       | 2.4/5       | 20             | 7.2-72.2 (6.5-65) | 4                   | OFDM (MIMO)             | 70                       | 250                 |
| ac                            | Oct 2013       | 5           | 20             | 7.2-96.3 (6.5-86.7) | 8                   | OFDM (MU-MIMO)          | 35                       | 35                  |
|                               |                |             | 40             | 15-150 (13.5-135) |                     |                          | 70                       | 250                 |
|                               |                |             | 80             | 32.5-433.3 (29.2-390) |                     |                          | 35                       | 35                  |
|                               |                |             | 160            | 65-866.7 (58.5-780) |                     |                          | 35                       | 35                  |

C. LiFi

The LiFi considered as a WiFi with light being use 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                  | WiFi                  | Ethernet              |
|-----------------------------|------------------------|-----------------------|-----------------------|
| IEEE Standards              | 802.15.17              | 802.11b               | 802.3                 |
| Frequency Band              | 100 X Tera HZ          | 2.4 GHZ               |                       |
| Costs                       | 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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