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# Review Paper: Advantages and Limitations of Li-Fi over Wi-Fi and iBeacon Technologies By

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**Abstract:** Li-Fi can be thought of as a light-based Wi-Fi. That is, it uses light instead of radio waves to transmit information. And instead of Wi-Fi modems, Li-Fi would use transceiver-fitted LED lamps that can light a room as well as transmit and receive information. Light is inherently safe and can be used in places where radio frequency communication is often deemed problematic, such as in aircraft cabins or hospitals. So visible light communication not only has the potential to solve the problem of lack of spectrum space, but can also enable novel application. The visible light spectrum is unused; it's not regulated, and can be used for communication at very high speeds. This paper compares the Li-Fi technology with Wi-Fi and iBeacon technologies.

**Keywords:** Li-fi, Wi-Fi, iBeacon, visible light communication, BLE communication

## I. INTRODUCTION

In recent trends, wireless communication Wi-Fi is gaining tremendous importance. CISCO reported that the compound annual growth rate (CAGR) of mobile data usage per month is around 80% which has led to the saturation of the network spectrum consequently bringing down its efficiency. It is unlikely that a significant new spectrum may be made available for mobile communications; the only option is to increase the spectrum efficiency of wireless systems. To resolve this the following problems need to be addressed which are (a) the elimination of interference, (b) a massively improved reuse of the available frequency resources, and (c) utilisation of the free, vast and unlicensed infrared and visible light spectrum leading to hybrid radio frequency (RF) and optical wireless systems. These drawbacks may be overcome with the use of Li fi technology. Section II gives the overview of Li-Fi technology, Section III gives the overview of Wi-Fi technology, Section IV gives the overview of iBeacon technology, and Section V gives the brief comparison of the three technologies applications and future scope of Li-Fi technology.

**Origin of the three terminologies-**

**Li-Fi:** Light Fidelity (Li-Fi) is a bidirectional, high-speed and fully networked wireless communication technology similar to Wi-Fi. The term was coined by Harald Has and is a form of visible light communication and a subset of optical wireless communications (OWC) and could be a complement to RF communication (Wi-Fi or cellular networks), or even a replacement in contexts of data broadcasting. This technology has been proposed as a solution to the RF-bandwidth limitations.

**Wi-Fi:** Introduced by the visionary ruling by Federal Communications Commission (FCC) in 1985 allowing the use of bands of wireless spectrum without the need for a government licence. This new Ethernet standard was compatible with devices and technology working on radio waves and came to be known as "Wi-Fi" only in 1999.

**iBeacon:** The technology was first introduced by Apple at the Apple Worldwide Developers Conference in 2013. It uses beacons which are low-cost, low-powered transmitters equipped with Bluetooth Low Energy or BLE that can be used to deliver proximity-based, context-aware messages.

**Technology details of Li-Fi**

**A. Core Technology-**

**Li-Fi:** Li-Fi is a form of Visible Light Communication (VLC) technology. VLC technology is an optical wireless data communications medium which uses visible light between 400 and 800 THz (780–375 nm) to transmit binary data in the form of light pulses.This Optical Wireless Communication technology uses light from light-emitting diodes (LEDs) as a medium to deliver networked, mobile, high-speed communication in a similar manner to Wi-Fi.

Visible Light Communications (VLC) works by switching the current to the LEDs off and on at a very high rate, which is too quick to be noticed by the human eye. Although Li-Fi LEDs would have to be kept on to transmit data, they could be dimmed to below human visibility while still emitting enough light to carry data. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi. Direct line of sight is not necessary for Li-Fi to transmit a signal; light reflected off the walls can achieve 70 Mbit/s. It uses common household LED (light emitting diodes) light bulbs to enable data transfer, boasting speeds of up to 224 gigabits per second.

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**B. How it works-**

**Li-Fi:** Li-Fi consists of four primary sub-assemblies as shown in figure 1:

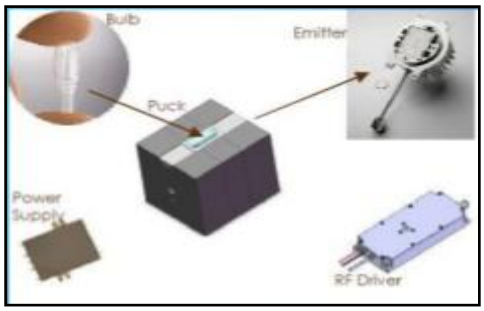


**Fig 1: Sub-assemblies of Li-Fi**

- Bulb
- RF power amplifier circuit (PA)
- Printed Circuit Board(PCB)
- Enclosure
- Power supply.

The functions of the individual sub-assemblies are enlisted below

**Function of the Bulb Assembly:**

The heart of the Li-Fi is the bulb sub-assembly where a sealed bulb is embedded into a dielectric material which serves as a waveguide and electric field as shown in figure 2.

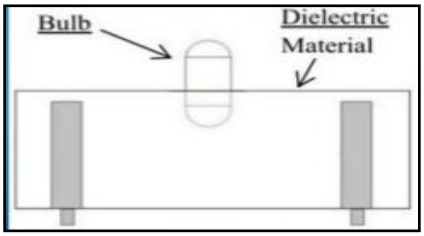


**Fig 2: Bulb sub assembly**

**Function of the RF driver:**

As shown in figure 3, the power amplifier (PA) assembly uses an LDMOS device which converts electrical energy to RF power. This assembly is designed for ruggedness and efficiency. The RF driver also controls circuit for digital and analog lighting controls.

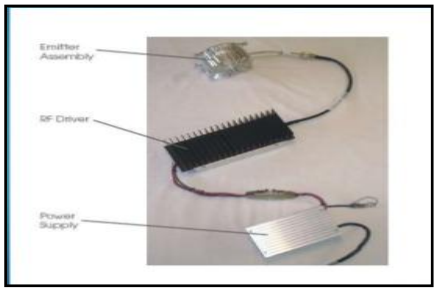


**Fig3: RF driver sub assembly**

**Steps involved in the working:**

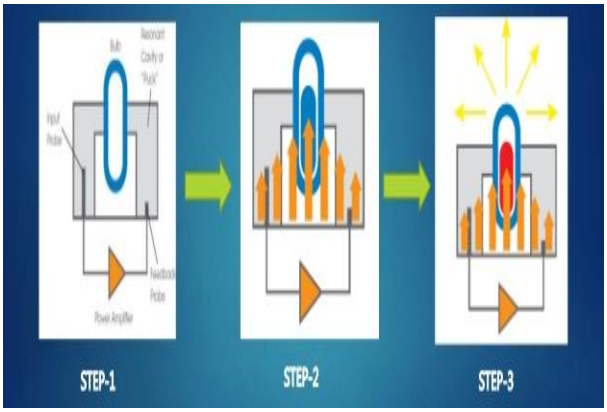


**Fig 4: Working Principle of Li-Fi**

As shown in figure 4 the working principle of Li-Fi technology can be explained in three steps:

**Step-1:** A radio frequency signal is generated by the solid state Power Amplifier is guided into an electric field about the bulb.

**Step-2:**The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb's centre.

**Step-3:** This controlled plasma generates an intense source of light.

All of these sub- assemblies are enclosed in an aluminium enclosure.

Li-Fi and Wi-Fi are quite similar as both transmit data electromagnetically. However, Wi-Fi uses radio waves while Li-Fi is a Visible Light Communications (VLC) system a medium that uses visible light between 400 and 800 terahertz (THz).It accommodates a photo-detector to receive light signals and a signal processing element to convert the data into 'stream-able' content.

An LED light bulb is a semi-conductor light source meaning that the constant current of electricity supplied to an LED light bulb can be dipped and dimmed, similar to switching a torch on and off according to a certain pattern to relay a secret message. Flicking an LED on and off at extreme speeds can be used to write and transmit things in binary code. up and down at extremely high speeds, without being visible to the human eye to write and transmit things in binary code.

For example, as shown in figure 5, data is fed into an LED light bulb (with signal processing technology), it then sends data (embedded in its beam) at rapid speeds to the photo-detector (photodiode).The tiny changes in the rapid dimming of LED bulbs is then converted by the 'receiver' into electrical signal. The signal is then converted back into a binary data stream that we would recognise as web, video and audio applications that run on internet enables devices [2].

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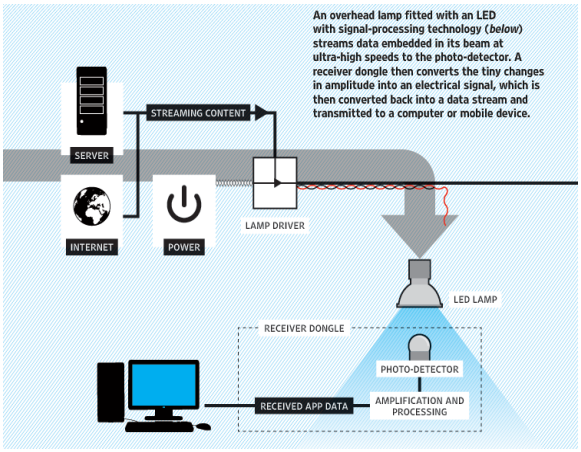


**Fig 5: Overview of the Li-fi technology**

## II. TECHNOLOGY DETAILS OF WI-FI

**Wi-Fi:** Wi-Fi is based on Radio Frequency (RF) technology which uses a frequency within the electromagnetic spectrum associated with radio wave propagation. When a radio frequency current is supplied to an antenna, it creates an electromagnetic field capable of propagating through space. Devices equipped with wireless network adapters detect the wireless signal broadcasted by access points and tune into it.

There are three elements that constitute the Wi-Fi network. They are:

- Access point (AP)-It is a wireless transceiver or "base station" that can connect one or more wireless devices simultaneously to the Internet.
- Wi-Fi cards: They can be external or internal. They accept the wireless signal and relays information.
- Safeguards: Firewalls and anti-virus software protect the networks from uninvited users and keep the information secure.

The building of a Wi-Fi network involves five steps as shown in figure 6:

1. A Wi-Fi hotspot is created by installing an access point to an internet connection.
2. The access point acts like a base station.

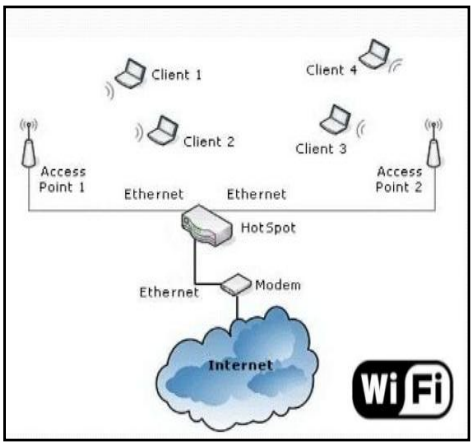


**Figure 6: Building of Wi-Fi network**

3. When the Wi-Fi enabled device encounters a hotspot the device can then connect to that network wirelessly.
4. A single access point can support up to 30 users and can function within a range of 100-150 feet indoors and 300 feet outdoors.
5. Many access points can be connected to each other via Ethernet cables to create a single large network.

Once the network is built the connection works through a transmitting antenna which is connected to a DSL or cable internet connection.The antenna on the router will beam the radio signals through a specific range and another antenna which is on the laptop or computer will recive the signal as shown in figure 7 below.

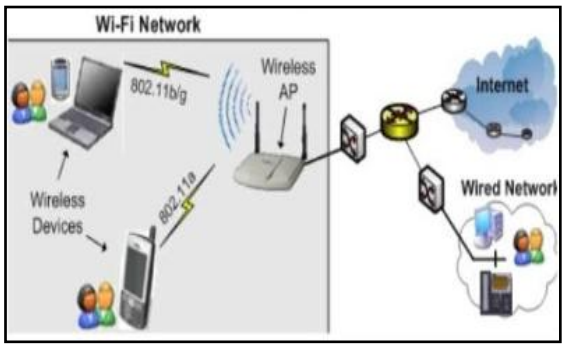


**Figure 7: Practical implementation of Wi-Fi**

Applications include Home, Small Businesses, Large Corporations and Campuses, Health care etc.

## III. TECHNOLOGY DETAILS OF IBEACON TECHNOLOGY

**iBeacon:** In essence, iBeacon technology allows Mobile Apps to understand their position on a micro-local scale, and deliver hyper-contextual content to users based on location. The underlying communication technology used is Bluetooth Low Energy. It uses low-cost, low-powered transmitters called beacons(or ibeacons), equipped with Bluetooth Low Energy also known as Bluetooth 4.0 or Bluetooth Smart, that transmit a signal which allows another device to determine its proximity to the broadcaster.

Bluetooth Low Energy is a wireless personal area network technology used for transmitting data over short distances. As the name implies, it's designed for low energy consumption and cost, while maintaining a communication range similar to that of its predecessor, Classic Bluetooth.

Beacons are the signal transmitters (senders)of a signal which has small bits of data, typically a unique identifier in a BLE location system and not information. They are battery-powered, stick to almost any surface and can be configured from a mobile app, making them scalable and highly portable. And, since they operate on a low energy form of Bluetooth, a single device can last 1-3 years.

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However, unlike a universal system like GPS, installation of these transmitters is required and maintenance to replace batteries or beacons themselves is necessary.
A big benefit of beacon systems is that they primarily use mobile devices as the receiver system. And because smart devices and cellular networks have become ubiquitous (even in remote areas and developing countries), the receiver network is highly accessible.

Because a mobile app is required, for a beacon system to achieve high penetration, the value proposition to download an app and turn on location services must be high.

**A. Advantages of Bluetooth Low Energy (BLE) when compared to regular Bluetooth:**

- Power Consumption: Bluetooth LE, as the name hints, has low energy requirements. It can last up to 3 years on a single coin cell battery.
- Lower Cost: BLE is 60-80% cheaper than traditional Bluetooth.
- Application: BLE is ideal for simple applications requiring small periodic transfers of data. Classic Bluetooth is preferred for more complex applications requiring consistent communication and more data throughput.

**B. Working of BLE communication**

BLE communication consists primarily of small packets of data, broadcast at a regular interval by Beacons or other BLE enabled devices via radio waves.

BLE Advertising is a one-way communication method. Beacons that want to be "discovered" can broadcast, or "Advertise" self-contained packets of data in set intervals.

These packets are meant to be collected by devices like smartphones, where they can be used for a variety of smartphone applications to trigger things like push messages, app actions, and prompts.

Apple's iBeacon standard calls for an optimal broadcast interval of 100 ms. Broadcasting more frequently uses more battery life but allows for quicker discovery by smartphones and other listening devices.

Standard BLE has a broadcast range of up to 100 meters, which make Beacons ideal for indoor location tracking and awareness.

**C. Steps involved by iBeacon using BLE communication**

With iBeacon, Apple has standardized the format for BLE Advertising. Under this format, an advertising packet consists of four main pieces of information. They are:

1. **UUID:** This is a 16 byte string used to differentiate a large group of related beacons. For example, if Coca-Cola maintained a network of beacons in a chain of grocery stores, all Coca-Cola beacons would share the same UUID. This allows Coca-Cola's dedicated smartphone app to know which beacon advertisements come from Coca-Cola-owned beacons.

2. **Major:** This is a 2 byte string used to distinguish a smaller subset of beacons within the larger group. For example, if Coca-Cola had four beacons in a particular grocery store, all four would have the same Major.

This allows Coca-Cola to know exactly which store its customer is in.

3. **Minor:** This is a 2 byte string meant to identify individual beacons. Keeping with the Coca-Cola example, a beacon at the front of the store would have its own unique Minor. This allows Coca-Cola's dedicated app to know exactly where the customer is in the store.

4. **Tx Power:** This is used to determine proximity (distance) from the beacon. TX power is defined as the strength of the signal exactly 1 meter from the device.

This has to be calibrated and hardcoded in advance. Devices can then use this as a baseline to give a rough distance estimate.

**Example: A beacon broadcasts the following packet**
**UUID: 12345678910245,**
**Major: 22,Minor: 2**

**A device receiving this packet would understand it's from the Coca-Cola Beacon (UUID) in the Target on 1st Street (Major) at the front of the store (Minor).**

**D. Advantage of iBeacon technology**

With an iBeacon network, any brand, retailer, app, or platform will be able to understand the exact location of a customer. This provides an opportunity to send customers highly contextual, hyper-local, meaningful messages and advertisements on their smartphones.

The typical scenario looks like this. A consumer carrying a smartphone walks into a store. Apps installed on a consumer's smartphone listen for iBeacons. When an app hears an iBeacon, it communicates the relevant data (UUID, Major, Minor, Tx) to its server, which then triggers an action.

This could be something as simple as a push message ["Welcome to Target! Check out xxx on Aisle #!"], and could include other things like targeted advertisements, special offers, and helpful reminders ["You're out of xyz!"]. Other potential applications include mobile payments and shopper analytics and implementation outside of retail, at airports, concert venues, theme parks and more.

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## IV. COMPARISON OF LI-FI, WI-FI AND IBEACON TECHNOLOGIES.

Here is a table for a clear understanding of the differences between the three technologies [4]:

| | iBeacon | Li-Fi | Wi-Fi |
|---|---|---|---|
| **Range** | The typical range of Bluetooth low-energy radio module is up to 70 m (230 ft) | In case of Li-Fi, you can receive the data as long as you are in the range of the light being emitted from an LED light source. So, the range depends on the strength of the light which is being emitted | The range of Wi-Fi networks depends on the transmission power, antenna type, and the location they're used in. In an indoor point-to-multipoint arrangement, a router using 802.11b or 802.11g and a stock antenna might have a range of 32 m (105 ft) |
| **Compatibility** | All Bluetooth 4.0-enabled devices are capable of picking up BLE signals | Li-Fi is compatible with IrDa devices | Wi-Fi is compatible with WLAN 802.11 a/b/g/n/ac/ad devices |
| **Cost** | While a beacon would cost anywhere between $10-$70, the cost of beacon system depends on a number of other factors such as app and integration cost, licensing and data service cost | Since Li-Fi can work with the existing LED devices, the installation cost is much less. However, it requires an existing LED lighting system in place | You will need a router for Wi-Fi. While the cost of a router generally varies depending on the manufacturer, getting a high-traffic router can be quite expensive |
| | | | |
| **Energy Efficiency** | Majority of beacons are battery powered and last for up to one year before they need to be replaced | LED bulbs use 85% less energy than incandescent bulbs and last up to 20 times longer | You need to configure and connect routers to a power source for the Wi-Fi to work |
| **Privacy** | Beacons require a consumer's consent to interact with their smartphone | A consumer can choose to receive data by keeping the smartphone in the range of LED light or can simply put away the phone in his/her pocket to avoid it | Wi-Fi technology does not explicitly ask consumers for their permission, as it does not require any user intervention. The only way out of it is to completely disable Wi-Fi on their mobile device |

## V. APPLICATIONS OF LI-FI

1. While Wi-Fi is in place in many hospitals, interference from cell phones and computers can block signals from monitoring equipment. Li-Fi solves both problems: lights are not only allowed in operating rooms, but tend to be the most glaring fixtures in the room.
2. Airlines: In aircraft LiFi can be used for data transmission.
3. It can be used in petroleum or chemical plants where other transmission or frequencies could be hazardous.
4. Smarter Power Plants: Wi-Fi and many other radiation types are bad for sensitive areas. Like those surrounding power plants. But power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. The savings from proper monitoring at a single power plant can add up to hundreds of thousands of dollars. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. Not only would this save money related to currently implemented solutions, but the draw on a power plant‘s own reserves could be lessened if they haven‘t yet converted to LED lighting.
5. Undersea Awesomeness: Underwater ROVs, operate from large cables that supply their power and allow them to receive signals from their pilots above. ROVs work great, except when the tether isn‘t long enough to explore an area, or when it gets stuck on something. If

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their wires were cut and 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 referring findings periodically back to the surface, all the while obtaining their next batch of orders. It could keep one informed regarding an earthquake or a hurricane. Remember, with Li-Fi, if there's light, you're online. Subway stations and tunnels, common dead zones for most emergency communications, pose no obstruction. Plus, in times less stressing cities could opt to provide cheap high-speed Web access to every street corner.

6. Hospitals:Can be used in the places where it is difficult to lay the optical fiber like hospitals. In the operation theatre LiFi can be used for modern medical instruments.
7. Traffic Signals : LiFi can be used which will communicate with the LED lights of the cars and accident numbers can be decreased. Thousand and millions of street lamps can be transferred to LiFi lamps to transfer data.

## VI. CONCLUSION

Li-Fi technology will in future enable faster, more reliable internet connections, even when the demand for data usage has outgrown the available supply from existing technologies such as 4G, LTE and Wi-Fi. It will not replace these technologies, but will work seamlessly alongside them. Using light to deliver wireless internet will also allow connectivity in environments that do not currently readily support Wi-Fi, such as aircraft cabins, hospitals and hazardous environments. Light is already used for data transmission in fibre-optic cables and for point to point links, but Li-Fi is a special and novel combination of technologies that allow it to be universally adopted for mobile ultra-high speed internet communications.

## VII. FUTURE SCOPE

Harold Haas from the University of Edinburgh, who first demonstrated Li-Fi to the world, envisioned turning light bulbs into super-speed broadband wireless Internet systems. As Li-Fi becomes more commercialized, it will usher in an era of incredible business opportunities, such as allowing telecom service providers to reach out to a wider customer base. There will be broader accessibility with Li-Fi Cloud. Smartphones will soon be able to download traffic information from traffic lights or a program guide from a television. In the future, shops will transmit advertisements to our phone as we pass by and bus schedule changes will be transmitted to a screen at the stop. Smarter home appliances that talk machine-to-machine (M2M) are already being extensively researched, where LED lights on electronics function as Li-Fi access points.

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