LI-FI: THE FUTURE OF HIGH SPEED INTERNET ACCESS

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Abstract

The future of data transmissions are up in the air. Wi-Fi is nearing its bandwidth capacity, so what will replace it? We will dive into the world of using light bulbs, more specifically LED lights, to provide data transmissions, otherwise known as Li-Fi. This data transmission can reach speeds that are faster than Wi-Fi, at costs that are cheaper than Wi-Fi. Li-Fi is safer when it comes to protecting against hacking, although it has a shorter range and opaque items can affect its range. Professor Harald Haas' spoke about Li-Fi at his TED Talk in 2011, where he introduced Li-Fi. His company and a couple of others are working to bring Li-Fi to the world and make it widely available as a solution for the diminishing capacity of Wi-Fi.

1. Introduction

The world is moving around at an incredible pace. Everywhere people want things fast and on the go. There are more people than ever leaving their home phone service in favor of cellular service. As of January 2014, ninety percent of all American adults own a cell phone, and of those 90, sixty-four percent own a smartphone, as shown in **Figure 1** (Mobile Technology Fact Sheet, 2014). After all, why have a phone that ties you down and could cause you to miss important calls when you can carry a small electronic device in your pocket or purse and make sure you get those important calls? It just makes sense that the world is wireless.

Now there's a new entry into the world of wireless called Li-Fi. Everybody has heard of Wi-Fi, most people have it in their homes. Li-Fi is similar to Wi-Fi. It provides access to high-speed Internet to be able to surf the web, access Facebook and other social media sites, and check email. Wi-Fi uses radio waves to transfer data at high speeds, whereas Li-Fi uses light to transfer data at high speeds. Before we go into great detail about the differences between Wi-Fi and Li-Fi, let's take a look at the origins of Li-Fi. After we find out exactly what Li-Fi is, then we'll take a look at how it works, its advantages and disadvantages, how it affects the lives of consumers, the applications of Li-Fi, what advancements have already been made and what is being made.

2. What Li-Fi Is, Where It Came From, and How It Works

The term "Li-Fi" may be complete new to those who are not avid followers of TED or who do not keep up with technology news. Others, however, are very aware of the term and are intrigued by anything having to do with Li-Fi. The term was first coined in 2011 from a TED talk by German physicist Professor Harald Haas. The 13 minutes talk demonstrated Haas' "vision for the future of wireless communications, using little more than LED bulbs" (Sawers, 2014). The term Li-Fi is now the commonly used name for "bi-directional, networked wireless communications using visible light, as opposed to traditional radio frequencies" (Sawers, 2014).

PureLiFi is the name of Haas' company that is continuing to perform research on Li-Fi and its uses. The company's mission statement reads: "PureLiFi seeks to resolve the global struggle for diminishing wireless capacity by developing technology for secure, reliable, high-speed communication networks that seamlessly integrate data and lighting utility infrastructures and significantly reduce energy consumption" (Sawers, 2014). The company was founded in 2012 and is a spin-off of the University of Edinburgh, where most of the research, dating back to 2008, was done. Haas has big plans for PureLiFi. "Li-Fi is creating a

new industry. It's something we believe is big and the reason for that is we see a variety of different applications" (Sawers, 2014).

Cell owners in 2014

Among adults, the % who have a cell phone

		Have a cell phone
	All adults	90%
	Sex	
a	Men	93[b]
b	Women	88
	Race/ethnicity*	
a	White	90
b	African-American	90
c	Hispanic	92
	Age group	
a	18-29	98[cd]
b	30-49	97[cd]
c	50-64	88[d]
d	65+	74
	Education level	
a	High school grad or less	87
b	Some college	93[a]
c	College+	93[a]
	Household income	
a	Less than $30,000/yr	84
b	$30,000-$49,999	90
c	$50,000-$74,999	99[ab]
d	$75,000+	98[ab]
	Community type	
a	Urban	88
b	Suburban	92
c	Rural	88

Figure 1. Cell Owners in 2014. Pew Research Center Internet Project Survey (Mobile Technology Fact Sheet).

Figure 2. Professor Harald Haas giving his TED talk in 2011 (Snolowe, 2010-2015).

Figure 3. Logo for PureLiFi, a company co-founded by Harald Haas (PureLiFi.com).

Earlier, we gave a bit of the how in telling that Li-Fi uses lights to transfer data at high speeds. Let's dive a bit deeper into how. According to Wikipedia, "Li-Fi is a subset of Optical Wireless Communications (OWC) and can be a complement to RF communications (Wi-Fi or Cellular networks), or a replacement in contexts of data broadcasting" (2015). Unlike Wi-Fi, Li-Fi uses Visible Light Communication (VLC) to transfer data. OWC technology carries more information than radio waves. The OWC technology used by Li-Fi uses "light from Light-Emitting Diodes (LEDs) as a medium to deliver networked, mobile, high-speed communication in a similar manner as Wi-Fi" (Sherman, 2013). Since VLC has much larger bandwidth than radio waves, Li-Fi has been offered as a solution to the RF-bandwidth limitations. In addition, "Li-Fi could lead to the Internet of Things (IoT), which is everything electronic being connected to the Internet, with the LED lights on electronics being used as Li-Fi internet access points" (Ranscombe, 2013). VLC works by switching bulbs on and off within nanoseconds (Coetzee, 2013). This is done much too quickly for the human eye to see. Contrary to popular belief, "direct line of sight isn't necessary for Li-Fi to transmit a signal; light reflected off the walls can achieve 70 Mbits/s" (Williams, 2013). **Figure 4** shows how Li-Fi works. An Internet connection is connected to the lamp driver; a switch is connected with the lamp driver and a LED lamp is also connected to this lamp driver through a fiber optics cable. A receiving device called a photo detector is used to receive signals and to process this device, which is connected to a PC or Laptop's LAN port. On one end all the data on the Internet will be streamed to the lamp driver when the LED is switched on the microchip converts the digital data in the form of light. The light sensitive photo detector receives the signal and converts it back into original data (Mazumder, 2014).

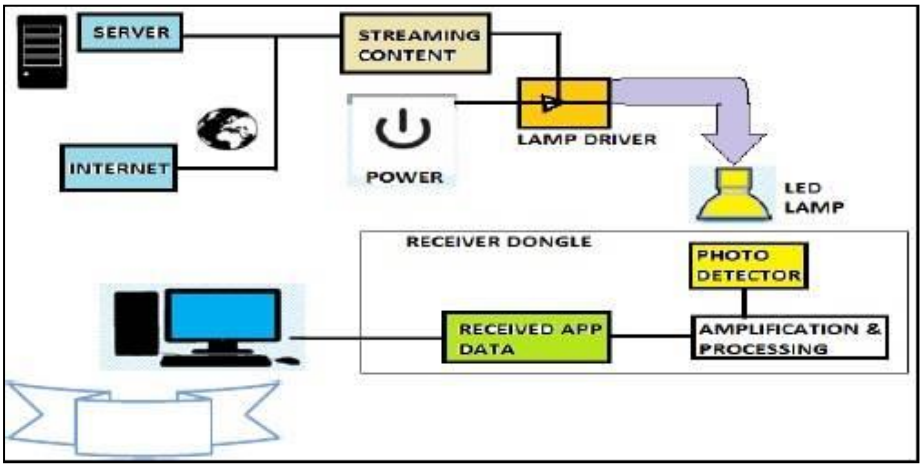

Figure 4. How Li-Fi Works (Mazumder, 2014).

3. Advantages

With every new technology that emerges, there are a list of advantages and disadvantages. The same goes for Li-Fi. We'll start with the advantages. According to a study by the International Air Transport Association, there were 75 instances of suspected electronic device interference, including 20 involving mobile phones from 2003 to 2009 (Ahlers and Marsh, 2013). Li-Fi is useful in electromagnetic sensitive areas. This is one advantage that could make Li-Fi desirable to airlines and aircraft manufacturers. Aircraft cabins, hospitals, and nuclear power plants are electromagnetic sensitive areas where radio waves cause interference. Because it transfers data via visible light, Li-Fi does not cause the same interference. Another advantage is Li-Fi "has almost no limitations on capacity" (The future's bright—the future's Li-Fi, 2013). The U.S. Federal Communications Commission (FCC) has been giving warnings on a potential spectrum crisis as Wi-Fi is close to full capacity. With little to no limitations on capacity, Li-Fi seems like a viable candidate for replacement for when Wi-Fi does reach its capacity.

Figure 5. Aircrafts are an example of electromagnetic sensitive areas that Li-Fi would be beneficial in (Bombardier, 2003-2015).

Another advantage Li-Fi has over Wi-Fi is speed. According to an article posted to Miz News by Gregory Smith, "researchers from the University of Oxford have made an amazing breakthrough in network speeds by using 'light fidelity' and achieving upload and download speeds of up to 224Gbps" (2015). The most recent method of data transfer that even comes close to speeds that high is fiber optics, which runs at approximately 100Gbps. Fiber optics have only recently begun being used worldwide by companies. To put it more in layman's terms, Li-Fi could allow for 30 movies at 1.5GB each to be downloaded in a single second. This would revolutionize the speed of the Internet. Video gamers (like myself) would revel in speeds this fast. Massively multiplayer online role playing games (also known as MMORPGs) such as World of Warcraft would run a lot smoother with speeds this fast. Research was published in the journal Photonics Technology Letter tells how specialized broadcast LEDs and receivers operate with different fields of view and bands that affect data transmission speeds: "The link operates over ~3 m range at 224 Gb/s (6 x 37.4 Gb/s) and 112 Gb/s (3 x 37.4 Gb/s) with a wide Field of View (FOV) of 60° and 36°, respectively. To the best of our knowledge, this is the first demonstration of a wireless link of this type

with a FOV that offers practical room-scale coverage" (Smith, 2015). Along with speed comes another advantage: price. "Li-Fi is expected to be ten times cheaper than Wi-Fi" (Condliffe, 2011).

4. Disadvantages

This leads us to our disadvantages. Price is also a disadvantage for Li-Fi. While it may be cheaper than Wi-Fi in respect to monthly access, high installation costs could be the difference between whether a family gets Li-Fi or Wi-Fi installed. Wi-Fi is relatively inexpensive to install as most homes today already have some form of data transfer installed, like coaxial cable for cable television access. Cable companies split the signal from this cable, one to the receiver box for television and another to a modem or gateway (router/modem combination). With Li-Fi, new installations would have to be done in order to install the Li-Fi. In addition to installation pricing, short range is a major downside to Li-Fi. Wi-Fi can cover areas as small as a single room or as large a college campus. Li-Fi, however, cannot travel through walls. This means that Li-Fi connections would be needed in each room or a home, a business, or a college campus. On the plus side, this makes Li-Fi more secure than Wi-Fi when it comes to hacking (Lim, 2011). Another downside to Li-Fi is its low reliability.

5. What Li-Fi Means For Consumers

So what does this mean for consumers? Li-Fi is still in its beginning development stages. This means that widespread adaptation of Li-Fi use in businesses and homes could be a while off, maybe even as much as five years or more. Dmitris Katsianis at the University of Athens, believes Li-Fi might be in use within the next five years (Savage, 2014). Li-Fi isn't really a Wi-Fi killer, however. Wi-Fi has many benefits over Li-Fi, including its ability to cover large areas and not having to need lights to operate. Haas expects Li-Fi to take off on a much larger scale. "In 25 years, every lightbulb in your house will have the processing power of your cell phone today. It will in the future serve illumination as just one of many purposes" (Savage, 2014).

6. Applications of Li-Fi

So in what areas can Li-Fi be applied, besides the obvious access to the Internet? PureLiFi, the company co-founded by Harald Haas' has some answers for this. Its website boasts "Li-Fi is particularly suitable for many popular Internet 'content consumption' applications such as video and audio downloads, live streaming, etc. These applications place heavy demands on the downlink bandwidth, but require minimal uplink capacity. In this way, the majority of the Internet traffic is off-loaded from existing RF channels, thus also extending cellular and Wi-Fi capacities" (PureLiFi, 2014). It also offers the following other applications for Li-Fi:

- **RF Spectrum Relief:** Excess capacity demands of cellular networks can be off-loaded to Li-Fi networks where available. This is especially effective on the downlink where bottlenecks tend to occur.
- **Smart Lighting:** Any private or public lighting including street lamps can be used to provide Li-Fi hotspots and the same communications and sensor infrastructure can be used to monitor and control lighting and data.
- **Mobile Connectivity:** Laptops, smartphones, tablets and other mobile devices can interconnect directly using Li-Fi. Short range links give very high data rates and also provides security.
- **Hazardous Environments:** Li-Fi provides a safe alternative to electromagnetic interference from radio frequency communications in environments such as mines and petrochemical plants.
- **Hospital & Healthcare:** Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners.
- **Aviation:** Li-Fi can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins where LED lights are already deployed. In-Flight Entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.
- **Underwater Communications:** Due to strong signal absorption in water, RF use is impractical. Acoustic waves have extremely low bandwidth and disturb marine life. Li-Fi provides a solution for short-range communications.
- **Vehicles & Transportation:** LED headlights and tail-lights are being introduced. Street lamps, signage and traffic signals are also moving to LED. This can be used for vehicle-to-vehicle and vehicle-to-roadside communications. This can be applied for road safety and management.

- **RF Avoidance:** Some people claim they are hypersensitive to radio frequencies and are looking for an alternative. Li-Fi is a good solution to this problem.
- **Location Based Services (LBS):** Highly accurate location-specific information services such as advertising and navigation that enables the recipient to receive appropriate, pertinent information in a timely manner and location.
- **Toys:** Many toys incorporate LED lights and these can be used to enable extremely low-cost communication between interactive toys (PureLiFi, 2014).

7. Advancements and the Future

There have already been some advancements made in the field of Li-Fi and visible light communications. Haas' company PureLiFi isn't the only one working on Li-Fi. A Mexican company, Sisoft, as well as scientists in China are working on getting the same technology up and running. Just like the Space Race, each wants to see who can get Li-Fi into homes and businesses sooner as well as making it reliable as well. PureLiFi launched its first product in early 2014. Called Li-1st, it is the first "publicly-available bi-directional visible light communication device" (Sawers, 2014). While it cannot be purchased off-the-shelf or from places like Amazon or Google, it is on the market. That market being companies from the "security-focused fraternity" (Sawers, 2011). The device lets you "network via a desktop photosensitive unit that works in tandem with an off-the-shelf, unmodified light fixture" (Sawers, 2011). It has a capacity of 5Mbps for both uplink and downlink and covers up to three meters. SunPartner Technologies and 3M announced a new technology called Wysips. Wysips is "a thin layer of crystal glass that can be embedded into small screens like watches, phones, or tablets and turn the screen into a solar panel of sorts" (Van Camp, 2014). In addition to charging the device, it could also aid in getting data access to the mobile device. "The Wysips layer is also capable of Li-Fi data transmission; it can send and receive data through light waves" (Van Camp, 2014).

8. Conclusion

After hearing about all that Li-Fi can provide, we are all for it. Even with its disadvantages, we believe it could revolutionize the future of data transmissions. The overhead light on an airplane could provide Internet access to passengers without interfering with any of the systems on board. Having data networks in every single room could provide better security while surfing the Internet. We believe the best out of everything is the Wysip, which can provide not only data transmissions, but also a way to charge the mobile device without having to plug it into an electrical outlet. That would be amazing to be absolutely wireless! Li-Fi is one piece of technology we need to plan to keep our eyes open for. We expect to put the new technology to use in our homes and businesses.

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