Li-Fi and its Future

Michael Mozingo

ICTN 6875 Emerging Technology 601

East Carolina University

Dr. Phil Lunsford

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Abstract

Light fidelity (Li-Fi) is a way to transmit data using visible light communications. Since it uses visible light, it has the ability to be much stronger and faster than Wi-Fi which uses radio frequency to transmit data. Li-Fi is an emerging technology that still has a ways to go in order to truly replace Wi-Fi. Currently, it is seen as a way to work alongside Wi-Fi to increase data transmission. There are several limitations, such as, the inability for light to pass through objects, it has a short range, and it is not currently suitable for outdoor transmission. All of these limitations must be addressed in order for it to be a viable option to replace Wi-Fi in the future. This term paper will discuss what light fidelity (Li-Fi) is and how it could be used in the future to either completely replace Wi-Fi or work with it to help increase the way data is transmitted.

What Is Li-Fi?

Light fidelity, also known as Li-Fi, is a wireless communication technology that uses the infrared and visible light spectrum for high speed data communication (Patrizio, 2017). It is a subset of Visible Light Communication which uses a vast unregulated and free light spectrum that can be used to overcome spectrum issues with radio frequencies (Bao, Yu, Dai, & Zhu, 2015). Li-Fi has an extremely brief history as it is still an emerging technology. Professor Harald Haas introduced Li-Fi in 2011 during a TEDGlobal conference (Patrizio, 2017). During this conference Haas mentioned that, due to spectrum crunch caused by the limitations of radio frequencies, he was inspired to create Li-Fi (Patrizio, 2017).

An important question is how does Li-Fi work? In order to transmit the data, Li-Fi uses a system that incorporates both a LED lightbulb and a photodetector. When the lightbulb is turned on, it transmits a binary 1, when the lightbulb is turned off it transmits a 0 (Sathiyanarayanan, Govindraj, & Jahagirdar, 2017). Data can be encoded (binary 0's and 1's) by the rate in which the LED flickers and the flashing are detected by the photodetector (Sathiyanarayanan et al, 2017). Li-Fi systems can be made so that it works with existing light fixtures using LED lightbulbs that support the technology (Frishberg, 2015).

Advantages

Li-Fi presents several advantages over Wi-Fi that could eventually make it an ideal means to transfer data wirelessly in the future as the technology develops further and becomes more commonly used. Both technologies have the ability to transfer data wirelessly at high speeds, however, there a multiple differences between Li-Fi and Wi-Fi in terms of congestion, density, safety, and security and in the amount of speed they are able to transfer the information.

Figure 1 below provides a high level look at some of the differences between the two technologies.

Wi-Fi	**Li-Fi**
Uses radio waves/frequencies	Uses light waves
Suffers from interference	No interference issues
Low-Medium security	High security
Wide range	Low range
Less dense environments	High dense environments

Figure 1: Wi-Fi vs Li-Fi

Wi-Fi uses radio frequencies in order for it to transmit data which are limited and cause devices such as computers, printers, and mobile phones to compete with one another for bandwidth (pureLiFi, 2017). The use of radio frequencies is one reason Wi-Fi struggles with congestion. This competing of bandwidth can cause unexpected disconnections along with a decrease in speed and signal strength. Since Li-Fi uses light to transmit data, it does not suffer from the same issues as Wi-Fi. Light waves are around 1,000 times more ample then those of radio frequencies and they do not have issues with interference with radio frequencies (pureLiFi, 2017).

Along the same lines as congestion, Li-Fi also has the ability to work much better than that of Wi-Fi in high density environments. Li-Fi is able to achieve around 1,000 times the data density of Wi-Fi (Bandela, Nimmagadda, & Mutchu, 2014). The reason behind this is that light can be contained to tight illuminations areas unlike radio frequencies which are more adapt to spread out causing interferences (Bandela et al., 2014).

The speed offered by the two technologies vary greatly as Li-Fi offers faster speed than that of Wi-Fi. The Wi-Fi standard 801.11ac has a maximum speed of 867 Mbps while Li-Fi has recently been tested to have speeds of up to 224 Gbps which would allow for 18 good quality movies to be downloaded in a second (Soni, Mohta, & Choudhury, 2016). Although the speed was accomplished during testing, it showcases the possibility of the technology and speeds for which it could potentially reach in everyday use.

Another difference between the two technologies is security. Radio frequencies are able to pass through objects such as walls, ceilings, and floors, however, light waves do not (pureLiFi, 2017). This difference means a great deal when it comes to security. For example, imagine a hacker sitting outside a hotel or apartment building. They would be able to pick up the Wi-Fi signal from outside of these buildings and could potentially get access to an individual's network since radio frequencies are able to penetrate through walls, therefore, outside of these buildings. If an individual inside the hotel or apartment building were using Li-Fi, however, they could simply ensure their doors were closed, blinds were shut, and take other actions to make sure the light transmitting data was not illuminating outside of their desired location. This would prevent a hacker outside of the defined area from being able to access their network as they would have no way of connecting due to not being able to get the signal.

Disadvantages

Although there are many advantages of Li-Fi, there are also some disadvantages that must be understood and worked on in order for the technology to truly have the future it is capable of achieving. Some of the current disadvantages are being worked on with the hopes of a resolution soon. Others will take more time, research, and testing in order for them to be corrected.

One of the main disadvantages when it comes to Li-Fi is that it cannot work in the dark. This goes back to the fact that it uses light in order to transmit data, therefore, it cannot work if light illumination is not present. The good news about this particular disadvantage is that it is one of the ones that should be rectified fairly soon. There is already work underway to make is to that lightbulbs can be dimmed so low that the room would appear to be dark, however, still be able to transmit data (pureLiFi, 2017). Once this piece has been completed, it would eliminate a key disadvantage to the technology.

Another disadvantage is that it has a limited range for which it can transmit data. When compared to Wi-Fi the range of Li-Fi is much shorter due to radio frequencies having a much larger range than that of light waves. Ultimately, the range of Li-Fi is limited to the range of the lightbulb that is being used as the source of light (Patrizio, A. (2017). Another cause for Li-Fi's short range is the fact that it cannot penetrate through walls. Of course the range can be extended by increasing the amount of lightbulbs to ensure the light illuminate is extended to where it is needed, however, that increases the cost of the technology as more lightbulbs would need to be purchased and more lightbulbs would need to be turned on at any given time to ensure desired connectivity is obtained.

Li-Fi is not ideal for the outdoors which clearly is a major hurdle that will limit its use. According to pureLiFi (2017), Li-Fi is capable of operating in daylight and in direct sunlight conditions due to the fact that modulated lights can still be detected. However, the issue is when there are weather conditions such as fog, rain, snow, etc. that will impact the visibility and illumination of the lightbulb proving the transmission. That is where Li-Fi outdoors become a major problem.

Potential Usage

With Li-Fi being so new, there are currently no true areas for which it is being used. The more time spent developing and researching the technology, this will eventually change. There are several potential usage for Li-Fi and ways for these areas and applications to greatly benefit from this technology.

Home usage is a major area that could see considerable benefits from Li-Fi as it is well suited for video and audio downloads along with live streaming (Bandela et al., 2014). With many users turning away from traditional cable/satellite TV and going to live stream services such as Netflix, Hulu, Sling TV, etc. having a technology that is well suited for live streaming helps tremendously. Computers, smart phones, tablets and other mobile devices will all be able to connect using Li-Fi to further enhancing the home usage.

Another application is in hospitals and healthcare. Unlike Wi-Fi, Li-Fi does not emit electromagnetic interference, thus, it does not interfere with medical instruments or MRI scanners (pureLiFi, 2017). The same also goes for aviation. Since Li-Fi does not emit electromagnetic interference, it can also be used on airplanes, instead of Wi-Fi, without the worry of possibly interfering with the planes mechanics.

The Internet of Things (IoT) is quickly becoming a hot topic in technology and Li-Fi has the potential to further increase the expansion that it has experienced in the past few years. IoT can be described as an attempt to connect items to the Internet in order to provide a seamless integrated system used to enhance the transmission of information (Tsai, Lai, & Vasilakos, 2014). It is estimated that there will be around 26 billion connected devices apart of the IoT by 2020 and they will need the ability to properly communicate with one another (Tsai et al., 2014). The IoT will need multiple access points which is one area where Li-Fi can assist greatly due to

the fact that lightbulbs can be easily installed and used as access points to allow for the communication of these connected devices (Pottoo, Wani, Dar, & Mir, 2018). There are multiple other advantages of using Li-Fi in IoT systems including the following:

- LED's both consume less energy and are highly efficient
- High data transmission rates can be achieved
- It can be implemented in practically any location
- Low implementation and operation costs
- Low environmental impact

  (Sathiyanarayanan et al, 2017).

Although there are clearly major advantages of potentially using Li-Fi as a means to advance the IoT, there are also some limitations to the technology in regards to the IoT. These include the following:

- Currently not commercially ready for deployment
- Can only work on devices that are equipped with a Li-Fi receptor
- Transmission can be obstructed by objects as light cannot penetrate through objects.
- Constant light source would be needed
- A completely new infrastructure would need to be built to support Li-Fi

  (Sathiyanarayanan et al, 2017).

Future of Li-Fi

As the technology current sits, it is not likely to truly ever replace Wi-Fi. Li-Fi has limitations that must be worked out in order for that day to ever arrive. The immediate future for Li-Fi is to work in conjunction with Wi-Fi so that each technology can complement one another and fix the limitations that each of these technologies suffer from.

Currently, there are over 4 billion people in the world who do not have access to the Internet (Luxton, 2016). These numbers are shockingly high especially in today's times where technology seems to be everywhere and so many are dependent upon it. Some of the reasons behind the lack of Internet access include the infrastructure lacks the ability to support it. According to Luxton (2016), 31% of the population does not have 3G coverage and around 15% does not have electricity. Another issue is that the cost of devices to be able to obtain Internet access is too expensive (Luxton, 2016). There are more reasons, however, these two in particular are areas in which Li-Fi can assist in expanding Internet access throughout the world. Being able to transmit data using a lightbulb will assist in both the issues with infrastructure along with the cost as installing lightbulbs is both easy and cheap to accomplish.

Conclusion

Li-Fi is a fascinating new emerging technology that has the capability of revolutionizing the way wireless data is transmitted. It has numerous advantages over Wi-Fi, however, it also has many disadvantages. By using light waves instead of radio, the technology has the ability to be more secure and faster than Wi-Fi. Due to the disadvantages Li-Fi is currently facing, the technology is unable to achieve its true potential. If the issues currently facing the technology are corrected, Li-Fi will provide a faster, safer, greener, better and healthier future that what is currently provided by Wi-Fi (Leba, Riurean, & Lonica, 2017).

References

Bandela, P., Nimmagadda, P., & Mutchu, S. (2014). Li-Fi (Light Fidelity): The Next Generation of Wireless Network. Retrieved from http://www.warse.org/pdfs/2014/icetetssp25.pdf

Bao, X., Yu, G., Dai, J., & Zhu, X. (2015). Li-fi: Light fidelity-a survey. *Wireless Networks, 21*(6), 1879-1889. doi:http://dx.doi.org.jproxy.lib.ecu.edu/10.1007/s11276-015-0889-0

Frishberg, M. (2015). Li-fi lighting the way. *Research Technology Management, 58*(1), 7-8. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/1658215386?accountid=10639

Leba, M., Riurean, S., & Lonica, A. (2017). "LiFi — The path to a new way of communication," *2017 12th Iberian Conference on Information Systems and Technologies (CISTI)*, Lisbon, 2017, pp. 1-6.Retrieved from http://ieeexplore.ieee.org.jproxy.lib.ecu.edu/stamp/stamp.jsp?tp=&arnumber=7975997&isnumber=7975671

Luxton, E. (2016). 4 billion people still don't have internet access. Here's how to connect them. Retrieved from https://www.weforum.org/agenda/2016/05/4-billion-people-still-don-t-have-internet-access-here-s-how-to-connect-them/

Patrizio, A. (2017). How wi-fi could get a boost from li-fi. *Network World (Online)*, Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/1927301469?accountid=10639

Pottoo, S. N., Wani, T. M., Dar, M. A., & Mir, S. A. (2018). IoT Enabled by Li-Fi Technology. Retrieved from http://ijsrcseit.com/paper/CSEIT411817.pdf

pureLiFi. (2017). Shedding Light on LiFi. Retrieved from https://purelifi.com/wp-content/uploads/2017/06/Shedding-Light-On-LiFi-webv2.pdf

Sathiyanarayanan, M., Govindraj, V., & Jahagirdar, N. (2017) Challenges and opportunities of integrating Internet of Things (IoT) and Light Fidelity (LiFi), *2017 3rd International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT)*, Tumkur, 2017, pp. 137-142. Retrieved from http://ieeexplore.ieee.org.jproxy.lib.ecu.edu/stamp/stamp.jsp?tp=&arnumber=8389121&isnumber=8389095

Soni, N., Mohta, M., & Choudhury, T. (2016). "The looming visible light communication Li-Fi: An edge over Wi-Fi," *2016 International Conference System Modeling & Advancement in Research Trends (SMART)*, Moradabad, 2016, pp. 201-205. Retrieved from http://ieeexplore.ieee.org.jproxy.lib.ecu.edu/stamp/stamp.jsp?tp=&arnumber=7894519&isnumber=7894471

Tsai, C., Lai, C., & Vasilakos, A. V. (2014). Future internet of things: Open issues and challenges. *Wireless Networks, 20*(8), 2201-2217. doi:http://dx.doi.org.jproxy.lib.ecu.edu/10.1007/s11276-014-0731-0