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Feasibility of LiFi in the Contemporary World – A Survey on the Dichotomy of its Production and Distribution Mechanisms

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Abstract

LiFi is expected to garner a market share of US $14.91 Billion by 2022. Our research is an endeavor to finding out whether the dichotomy of production and distribution of LiFi systems would bring positive change in the future of this nascent technology. To undertake it, we analyze the standardization efforts, the consumer market acceptance and the trends in the production of the components of LiFi. Partly, because the technology forwards the Green Communication Goal, and eradicates the Radio Frequency Bottleneck.

Keywords: Consumer Market, Feasibility, Light Fidelity, LiFi, Market Trends, Optical Wireless Communication, Visible Light Communication

1. Introduction

Light has been vital to humankind ever since the first fire was kindled. Recently however, light's importance has been reiterated by its use in communications more than anything; as in the earlier times light from fire was used for signaling danger, now it is used to transmit the bits and bytes of our communication systems using Fiber Optics. Light, being a fast carrier of information, has since propped the backbone networks around the world[1,2]. Much to an extent, that there is no viable alternative to it thus far.

The fiber optical communication systems operate on subtle changes in the light traversing a fiber optical cable. The changes are recorded and translated to digital equivalents and then deciphered to information on the receiver. If an insulated pure glass is used as transmission medium, great data rates can be achieved[3]. In practice, it can be observed in the SEA-ME-WE-3 link, each core in the cable can support up to 480Gbps of data rate[1]. But an individual cannot afford a SEA-ME-WE-3 grade fiber optic cable nor does he need that great of a speed. Moreover, let us not forget that high speed is a requirement of a contemporary system while mobility is an even bigger concern to an end user.

Nevertheless, the conventional Laser dependent light has one limitation, one that has not been overcome at least until the recent past: it does not support mobility. While the world enjoys mobile communication using radio waves, light suffers its years for being limited to rigid fiber optical cables.

Light's profound importance is now reiterated with yet another utility that uses LEDs for the transfer of data in Air[4,5-9]. While the global market is looking up to implementing LED lights at home, the proposition of using those LEDs for communication is becoming the upcoming paradigm of this age. Establishing itself from the need of human beings to stay connected in the modern era, this disruptive technology aims to solve the problems that hinder us to do so. Using it, binary data can be translated

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to pulses of light directly by encoding 1s and 0s to the switching of light source. When light source is visible to the human eye i.e. lies in the visible spectrum of electromagnetic radiation, the system is called a "Visible Light Communication" system (VLC). VLC systems can be used to transmit light signals in pulses. The systems can use a single color for information transmission, or can also use multiple colors for parallel data streams, hence multiplying the data rate with the trade-off of increased system complexity[10-15]. If the visible light is emitted using LEDs, the system is then dubbed as a "LiFi System". The name LiFi was coined by Harald Haas, a german scientist in his TED Talk in 2011[16-18].

In fact, it can be used for mobile connectivity to the internet. More to the awe, it can be implemented using existing deployments of Light Emitting Diodes (LEDs) rejecting the notion of implementing bulky and unsafe LASER systems out in the open air. It has therefore, most aptly been dubbed Light Fidelity (LiFi) after its radio counterpart, WiFi.

In the experiments performed by Herald Haas and his team, LEDs exhibited a potential to work even when the receivers were partially shadowed. The experiments hint the viability of such systems in practical deployment and that they can be used for communication at great speeds peaking to 1Gbps under clear conditions and more than 100 Mpbs in fog[18].

It is not an alien idea to us now, that the LEDs have become a de facto for our illumination needs. On the other hand, it is an indispensable fact that the Wireless Spectrum that we currently use is moving towards saturation, which is why, primarily, we are moving to higher frequencies and coming up with interesting and disparate domains of communication media[15].

Amidst the quest for finding a better usable spectrum, LiFi places itself conveniently on the scope of the highest band and the greatest frequency: frequency of light. With the blazing frequency of 400 – 789 THz[19], and a multifold greater bandwidth than any other Radio Frequency (RF) mechanism, LiFi boasts greater speeds and more security than its predecessor technologies.

Identifying ways to eradicate the radio-frequency crunch; LiFi boasts applications inside an aircraft or hospitals, places where radio frequency signals aren't preferred[20]. It supports Greener Environment with a radio-frequency free environment allowing the ubiquitous internet connection. LiFi categorizes itself as a disruptive technology that utilizes the household LEDs to meet the target speeds. It is this ready integration with the household that makes the nascent technology implementable right off the bat, in a matter of few years, with market share capping to almost 14.91 billion dollars by in a meager ten years after its birth according to a report by MarketsandMarkets[18] and almost US $80 Billion by a stat from Mordor Intelligence[21]. Moreover, this market share is expected to rise ten-fold by the next five years of reaching the 14.91 billion goal[22].

With most applications in the Internet Connectivity domain, LiFi also promises a variety of applications in broadcast medium. For example, a LiFi transceiver could connect to your internet using a table lamp, or a ceiling mounted LED[23]. Contrariwise, it can also receive a broadcast message from a lamp at the corner of a hotel. One that tells you of the number of rooms available on the particular night. Or it can be an LED Light at the corner of a superstore giving away deals inside. LiFi Hotspots can become as common as WiFi originally became in its first few years. Albeit, eradicating the innate limitation of a WiFi receiver that requires one WiFi receiver to connect to no more than 200 devices at a time.

There is another aspect to it that makes LiFi more apt for deployment: the aspect that keeps medical safety and greener technology in check. In some isolated cases, it has also been found that RF waves cause medical hazards[24,25]. The number of cases observed in radio waves are lesser than cases observed in THz waves (some in the visible spectrum of light)[26]. Partly because the penetration power of THz waves is lesser than the radio waves and since they cannot pass the skin tissue, they are likely to cause less damage to the internal organs of human body, mainly the brain[26]. It cannot be concluded however, that THz waves do not pose any dangers to human health, it can be observed that the potential of medical hazards in THz waves is lesser than Radio waves. Hence lending the edge to visible light communication in this case.

It is the scale of its integration of this technology, and the diverse applications otherwise, that carve way through, while also serving as a source of concerns with some scientists. The primary concern that is there is whether LiFi will penetrate in the market enough to garner attention from investors and stake holders. Another concern relates more with the production, that whether the LED market will last long enough for LiFi to make its mark before LEDs morph into another technology for luminescence. Lastly, it is unclear whether the manufacturers from across the world will be able to keep up to the

mantra of forwarding the technology into the hands of the consumer market.

The world as we know it, is heading towards faster communication, better internet data rates, more data security. We feel LiFi can be a solution to these needs; it has already been tested to be 100 times faster than WiFi, with Oxford University testing communication at 224 Gb/s and with the boom of LED light bulbs as a source of illumination[27], LiFi is rapidly becoming a viable option for communication.

Our paper attempts to answer, and establish the relation between the questions asked, and hence, extend a viability study that the community can use to harvest from the growing paradigm. In Section I, we try to articulate efforts that have been put up to standardize the subject. In Section II, we elaborate the consumer trends, thereby indicating the scope and application of the potential market, and in Section III we discuss the mechanisms that naturally push the technological envelope towards LiFi. Lastly, in Section IV, we make conclusion and identify the areas where LiFi could make the most impact.

Later, in the future, we will also try to put an effort to inject this technology into the upcoming 5th Generation of Communication Networks and make suggestions for whether 5G or the yet-not-existent 6G will be able to utilize LiFi and fulfill its standardization requirements.

2. Section I – Standardization Efforts

Any technology on the planet can't survive the masses without ample standardization into place. Similar is true for LiFi. If the technology aims for the masses, standards need to be made for its proper integration. Since the nascent LiFi market is still looking for viable applications, standardization efforts and conferencing has only recently begun. We enumerate below, few of the recent endeavors.

2.1 IEEE Workshop for Optical Wireless Communications

With the evolution of wireless communications, this conference is set up to accelerate the goal of using optical networks to eradicate the frequency crunch that has been faced by the industrial community for long. This workshop focuses on the use of Optical Wireless Communications in mobile phones as an extension to the conventional Wi-Fi and Bluetooth that are rife in this market. Having already conducted first two workshops, the third workshop is scheduled to be conducted in Paris in May, 2017.

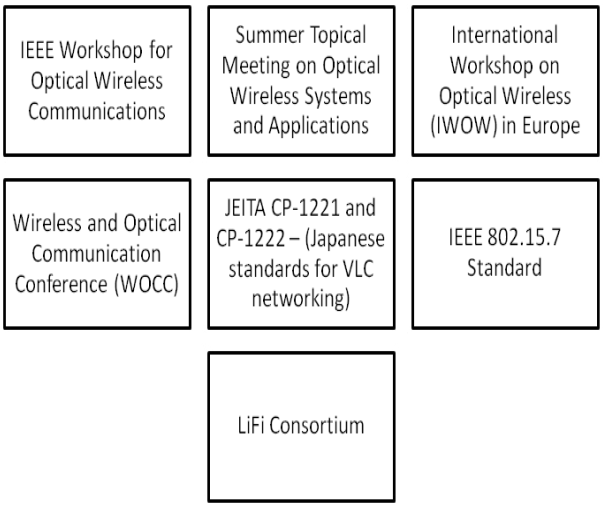

Figure 1. Standardization Efforts for LiFi.

2.2 Summer Topical Meeting on Optical Wireless Systems and Applications

Sponsored by the IEEE Photonics Society, this conference aims to gather groups of researchers and industry experts to address the emerging areas of photonic science and its applications. In 2017, the theme of this conference is to work with Integrated Photonics and hence the meeting puts efforts to hold annual meetings for the standardization of Visible Spectral Range, THz wave communication systems. It also focuses on the technologies that complement Visible Light Communication such as Low Energy Nanophotonics, Optical Switching, Photonics Research for 5G and beyond and Quantum Networks.

2.3 International Workshop on Optical Wireless (IWOW) in Europe

This workshop addresses issues relating to the Electromagnetic Spectrum for Wireless Communications, particularly in the direction of Optical Networks that embody LiFi and in general, all the Visible Light Communication Paradigms. This meeting is an effort to probe into the applications of Free Space Optics and Visible Light Communication as a complementary technology. Having already conducted three workshops, it hosted its fourth workshop in September 2015.

2.4 Wireless and Optical Communication Conference (WOCC)

Wireless and Optical Communications Conference is probably the oldest of all the Wireless Optical Conferences in the world. It made its first conference in 1992 with a title of Optical Communications Conference and was renamed to Optical Wireless Communications Conference in the following years. This conference invites debate of mavericks from industry and academia. Recently, this conference has been working with Wireless, Networks, Optical and IoT areas. It also welcomes papers and discussions with regards to LiFi.

2.5 JEITA CP-1221 and CP-1222 – (Japanese standards for VLC networking)

Recently, Japan spearheaded the standardization efforts with its CP-1222 and CP-1223 Visible Light Communication Standards that are to be followed by the entire country. The communication standard encompasses applications like LiFi and other Visible Light Communication Domains.

2.6 IEEE 802.15.7 Standard

IEEE, the forerunner in most communication standardization efforts has also started putting up efforts to standardize visible light communications with its 802.15.7 personal area network standard. It is a wireless personal area network (PAN) standard for VLC at data rates ranging from 11 kb/s to 96 Mb/s, also suggesting modulation schemes as standards. With authors from Samsung, Intel and ETRI, the effort leads to another peek into the viability of this technology.

2.7 LiFi Consortium

Alongside international endeavors, LiFi consortium is another efforts to standardize communication efforts particularly for LiFi communications, making it a platform that focuses on optical wireless technologies in general as well[28,29]. It was founded by Fraunhofer IPMS, Germany, IBSEN telecom, Norway and Supreme Architecture, USA, Israel. It aims to prop the development of LiFi systems and support the nascent applications that bud.

Overall, the research community is working hand-in-hand with the standardization experts to expend in standardization efforts of this technology. Like any other successful endeavor, it is true for LiFi too that the world's leading organizations such as Intel, IEEE, Samsung and the likes are actively participating in its growth. With the standardization in place, and books being published[2], this technology is not far from commercialization.

3. Section II: Consumer Market

According to a survey by MarketsandMarkets, Visible Light Communication is to have a market of $6,138 million by 2018.

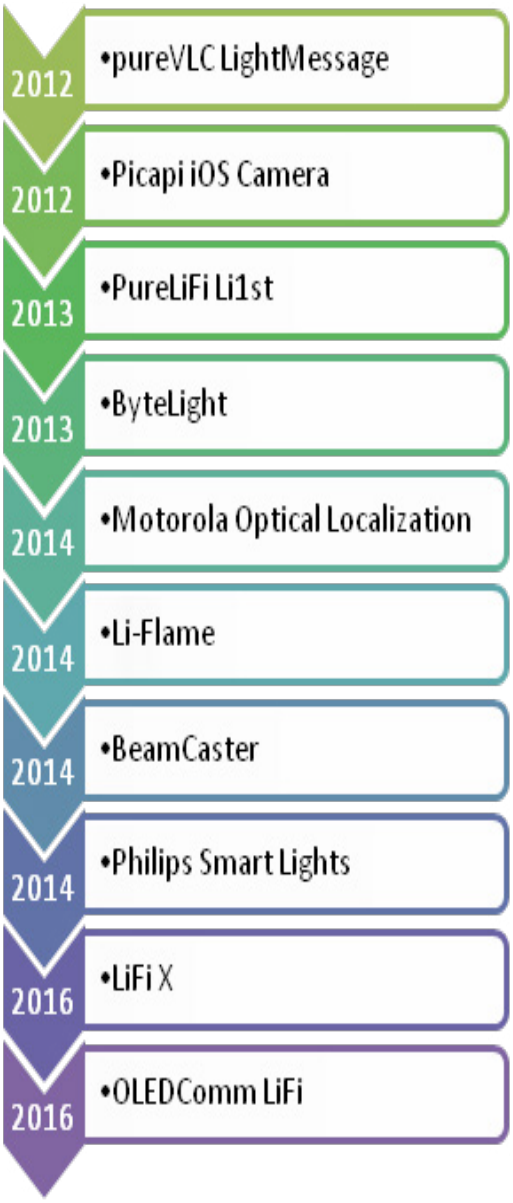

Figure 2. Consumer Trends.

With every disruptive technology that contributes this much to the market in its nascence, there comes the chal-

lenge of commissioning applications anew to the market. Optical Fiber, in its first iterations must have been difficult concept to handle altogether because of its nonexistent infrastructure, and limited applications. With the passage of time, the scope application widened up and so did the consumer acceptability towards it. We have Fiber To The Premises (FTTP) nearly 3 Million new FTTP homes in the US in 2015[30]. The growth of Optical Network Equipment expected an annual growth rate of 35.7% by the year 2014[31] and transformed the international backbone of the internet with its underwater cables.

Similarly, LiFi is a budding technology and its consumer market is limited. However, its integration with the preexistent infrastructure makes it a candidate for faster growth when compared to its competing Optical Fiber Networks. Another reason for its sharp acclivity could be its innate use of higher frequencies resulting in greater bandwidth. The propinquity of saturation in the unlicensed and licensed Wireless bands makes it even more favorable to the consumer market for adaptation at an early stage.

The applications of LiFi for the consumers may reach out as far as industrial and military grade[32,33], but for the sake of eliciting consumer market, we highlight only ones with implementation for the masses.

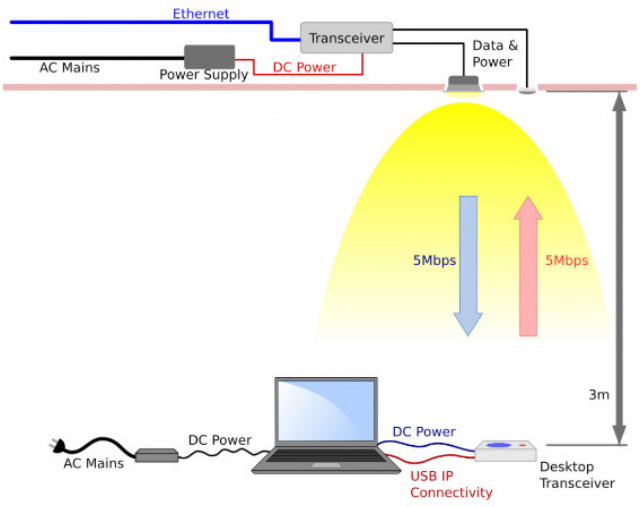

Figure 3. Li-1st[34].

3.1 pureVLC LightMessage

Commercially, the first efforts to establish a viable LiFi connection were made in May 2012 by pureLiFi in a public demonstration called pureVLC LightMessage that rendered data rate of about 2.5Kbps and achieved it using reflected light[35].

3.2 Picapi iOS Camera

By the time pureVLC entered into the market, there already existed efforts to put Visible Light Communication into action by Casio in 2012 when it showcased Picapi iOS Application that used a cellphone camera to send messages using encryption on a colored paper[36]. At that point in time, global LiFi efforts weren't put up to make use of household lighting to connect to the internet.

3.3 PureLiFi Li-1st

Previously, In August 2013, pureVLC hinted towards the commissioning of the first commercial application and announced achieving 1.67Gbps of data rate using LEDs. Later, using multiple LEDs they announced attaining 6Gbps of data rates, a target that was met by the company a year later. And the streak of has been on the incline ever since. More consumer shows are now exhibiting LiFi as a technology for implementation than ever.

By the end of October 2013, pureLiFi announced to have attained 10Gbps using multiple colors of light and 3.5Gbps using one color alone. Ultra-parallel visible light communications, as it was known, was a joint-project that was conducted in University of Cambridge, Oxford, Edinburgh and St Andrews. The research aimed at improving the waveguides. IT was funded by Engineering and Physical Sciences Research Council[37].

Consequently, Li-1st in 2014 became the first LiFi dubbed transceiver offering data rates of 11.5 Mbps in Full Duplex that used visible light for downlink and infrared for uplink[34]. The product was made using LEDs that worked with a dongle that connected to two computers, each one of them acted as a transceiver. With the said speed, the device was able to live-stream a High Definition video to each one of the connected laptops. The introduction of this product received quite an audience at the Mobile World Congress 2014. In January 2014, pureLiFi put a light sensor on top of a smartphone to receive LiFi signals[38]. Ever since, Apple and Samsung have also been on the run to put patent efforts to make such devices[39,40].

3.4 ByteLight

With the advent of LiFi in the Visible Light Communication (VLC) paradigm, LiFi and its sister technologies opened the floodgates to some myriad applications. One of them

that being localization. Earlier, indoor localization faced problems with accuracy since locating devices indoor were subject to interferences. However, using the Line of Sight LiFi, the task became a lot easier. The introduction in this commercial sector was made by a company called ByteLight. The application was used for pinpointing exact location within a shopping mart or superstore[41]. The technology made the news in March 2013, soliciting interest towards the new LiFi technology even more so. The technology was furthered into areas such as blind assistance and was used by Shaifur et al. into their application that helped blind people localize[42].

3.5 Motorola Optical Localization

Few patents of Optical Personal Locating Device also appeared as a modification of Indoor Locating determinant Devices,[43,44]. The aim of these devices was to make lights evaluate the location of the receiver in a way similar to the multi-lateration that is commonly used for location in radio frequencies[45].

3.6 Li-Flame

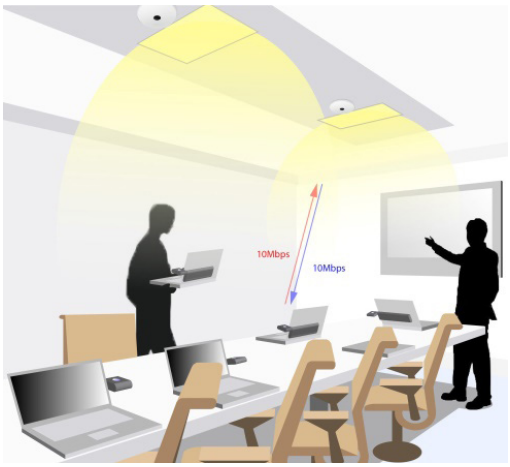

Figure 4. - Li-Flame.

Later, in 2014, as a successor to Li-1st, pureVLC introduced Li-Flame, a 10Mbpstransceiver with uplink using LED and downlink using IR – Demonstrated at Mobile World Congress, Barcelona in March 2014[46]. This was the first time when a bidirectional link was established with internet connectivity on the go. Li-Flame used Infrared instead of light for uplink, for two reasons. 1) An uplink would require a very powerful visible light LED connected to the Laptop which might not be practical and 2) Using a visible light LED would interfere with the downlink signal that was received by the same device. The device had a LiFi Ceiling Unit that connected to a light bulb, and a LiFi Desktop Unit that connected to a laptop, and contained a receiver and an infrared transmitter.

3.7 Stins Coman BeamCaster

Two months after LiFi-Flame, in April 2014, Stins Coman, a Russian company developed a visible light communication network of its own. It demoed the producct with the name of BeamCaster which boasted a data rate of 23 feet and a blazing 1.25Gbps speed. This time, the Russians went one step further and made the product publicly available at less than $100 for the console. However, with the line of sight problem, the devices had to be sharply aligned in order to receive signals[47].

3.8 LiFi X

Figure 5. LiFi-X.

In 2016, pureLiFi came up with with yet another product called LiFi-X was introduced and it offered a speed of 42Mbps with its bidirectional link[48]. The product exhibitedplug-and-play connectivity and offersed a direct alternative to WiFi: an aim that was not projected nearoff in the original LiFi goal. This time, the device shrunk significantly than its predecessors and was much more portable[48].

3.9 Philips Smart Lights – Guided by the Light

The efforts of Philips were also noticed in February 2014, which introduced its own version of Smart Lights. Philips conceived LiFi in a consumer's perspective wherein, it looked up to retail stores for application. With the receiver and a downloadable app, the company wanted its users to stay updated with targeted information inside a

superstore, with each bulb transmitting relevant coupons and recipes to the section they were visiting. On April 24, Philips paired with MediaMarkt and Carrefour to launch this indoor localization app in its Eindhoven, The Netherlands store[49,50].

Figure 6. Philips Smart Light in MediaMarkt Netherlands.

Also, recently, in late 2016, Phillips acquired Luciom, a LiFi internet service company in France in an endeavor to finding out more about the technology[51].

3.10 OLEDComm LiFi

Figure 7. OLEDCOMM LiFi BEACON® For Arts, Culture and Exhibitions (left) and Hospital Management (right)[52].

A company OLEDComm has ventured off to sharing the development part with the public with its IoT LiFi Platform project. It has also started off with its eccentric applications starting 2016 onwards such as GEOLiFi : Indoor positioning System where it provides positioning information in Mussums, Retail Stores, Warehouses and Smart Cities. and LiFiNet : Internet by Light where it caters to internet and notifications in Galleries, Events, Retail, Offices and Smart Cities. Recently OLEDComm industrialized LiFiNet solution in Perpignan Hospital at south of France[52].

Ever since the first application of LiFi surface, numerous patents have published their way into the global space. Also, many different applications have also appeared on the commercial sector. Though the technology is a little far from commercialization owing to the unavailability of built-in LiFi receivers in smart phones and Laptops. But the cadence of these applications surely reaffirms that it might just be another weekend before LiFi is found in our very own cellphones, tablets and laptops.

4. Section III -Market Trends towards LiFi

With the inception of LiFi, the market has seemed to have grown towards it. The component that is primary to its use, the LED, has shown great promise in the future of luminaire around the world. Similarly, it the competing bulb types have grown obsolete with the passage of time. On the other hand, the size of a transistor will be pushed down to a mm2 form factor of 179 by 2021[53], allowing for more compact devices than ever. Meaning, that there will be more chips inside a single device than before. In this section, we focus on the LED market that is the primary to any LiFi market.

4.1 Global Push for LEDs

We observe with every coming hour; LEDs penetrate into a common household more than ever. As quickly LED bulbs become the de facto lightning source, more chances are created for LiFi to get into the market. With LED being the prime component of a LiFi system, a peek into its market can provide an insight into the potential that comes inherently into its implementation. Only in the United States by 2023 with a Cumulative Annual Growth Rate of 78% every year from 2015-2023[54] and according to another market research, LEDs are expected to garner $42.7 Billion by 2020[55].

Globally, the competing luminaire technologies such as Compact Fluorescent Bulb and HIDs will have dimmed their use in the future. More so, incandescent bulbs have already been declared formally obsolete in many countries since 2012 in countries such as United States, Japan, China, Countries from European Union and South Korea. Growing nations such as India have also opted out of incandescent bulbs as well[56]. The global push for Compact Florescent Light (CFL) bulb has therefore been on the peak since 2012. With the greater efficiency and life expectancy of LEDs, the shift from compact florescent is also imminent in this era. With the 2.8% market share of luminaire already growing towards an incline in the United States, LEDs are already on its way up to replac-

ing CFLs in the near future in the United States, and by a trickle-down effect, in the rest of the world too[57].

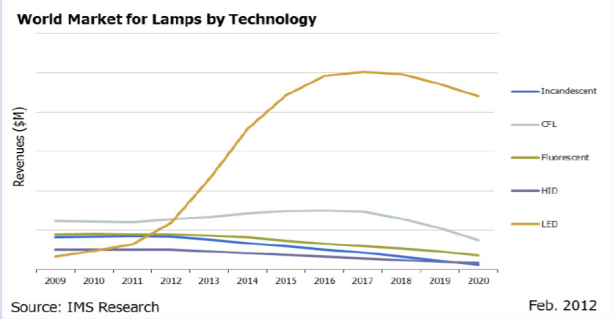

Figure 8. World Market for Lamps by Technology (adapted from[58]).

4.2 Rise in the LED Market

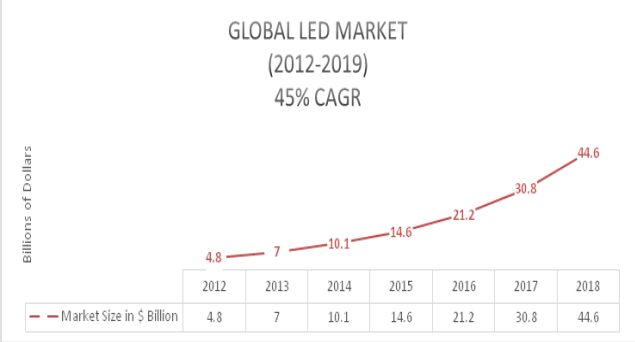

Figure 9. Global LED Market (adapter from[58]).

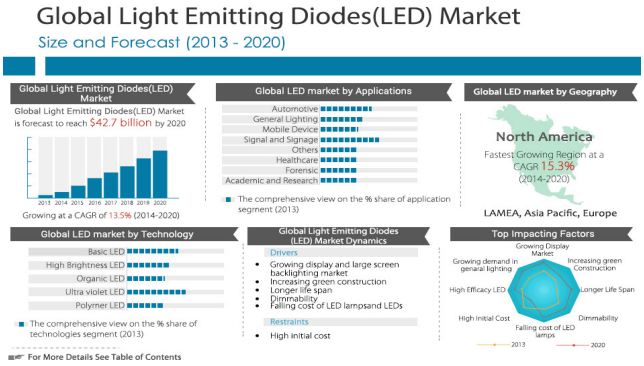

Figure 10. LED Market Size (2013-2020)[55].

Additionally, contemporary lighting industry is controlled by a handful of conglomerates that determine direction of the industry. With fluorescent and incandescent lighting reaching their efficiency and life expectancy limits, these major players in the lighting industry are looking towards LED lights to maintain a competitive edge over one another.

Currently, the adoption of LEDs hasled towards a market share of $4.8 billion as measured in 2012. The share is expected to increase by 45% each year and reach a value of about $42 billion by 2019[58].

Conversely, the market size of LiFi is therefore anticipated to reach USD 75.5 Billion by 2023, U.S with an annual growth rate of 77%. The research was conducted by Global Market Insights Inc[54].

4.3 Market Estimation – by Components of LiFi Transciever

In this part we find out whether the production of individual components of a LiFi System is par with the production needs of a LiFi system. We evaluate therefore, the components needed for a LiFi system. According to a LiFi system patent by Samsung Electronics, the requisite components that make a LiFi transmitter are: 1) LED, 2) Encoder and 3) Controller, whereas on the receiver side, the requisite components are 1) Controller, 2) Decoder and 3) Detector[59].

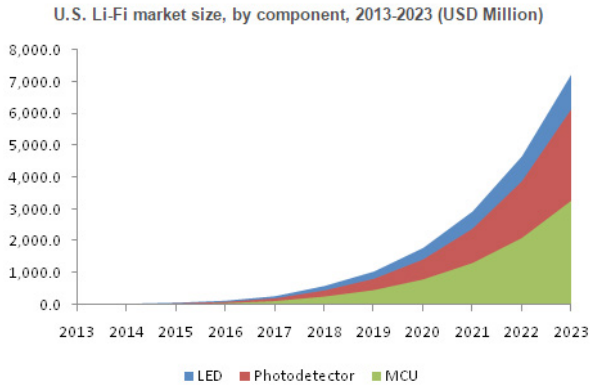

Figure 12. US LiFi Market Size by LiFi Component (adapted from[54]).

It can be observed in Figure 12 that all the three requisite components have seen a greater market in the

Figure 11. LiFi Basic Block Diagram (adapted from[59]).

consecutive years after 2015 and is expected to grow at an almost exponential pace in the coming years of 2018 onwards. Photo detector, the integral part of a receiver is expected to grow to become a US $6,000 Million in 2023 and it accounts a total of 30% of the LiFi market share in 2015[60]. Similarly, the Microcontroller Units have also presented an incline in their market for the upcoming years.

Though the LED, photodetector and MCU market doesn't account for all the LiFi share in the world. Infact, presently they may account only for a fraction of the market. But, since they are an integral part to many other applications around the world, the estimates reasonably predict that the these products are due to become cheaper in the next years because of the higher supply. Which may laterally indicate that the transition to LiFi's will be smoother in future.

5. Section IV - Utility of The Production and Consumer Peaks

In this final section, we discuss and establish the relationship of market trends to the overall propping of the LiFi industry.

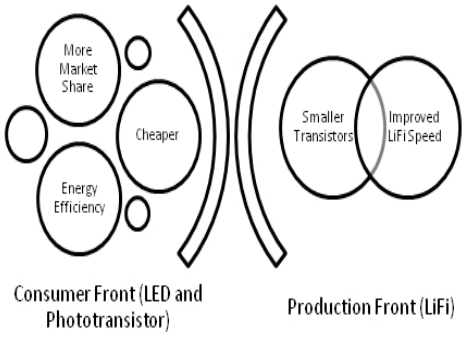

Figure 13. Consumer vs Production Dichotomy.

From the consumer front, owing to the energy savings, LEDs have penetrated into the market by 2.8% in the indoor environment and 10.1% in outdoor environment, a wider increase from the previous years, according to a report by Department of Energy[60]

On the other hand, the average price for an LED bulb has also decreased substantially over the past decade, allowing for more market absorption in the coming future. Overall the supply capability within the LED industry has risen faster than the demand and this has served to drive down LED prices; prices fell by an average of 16% alone in December 2011[61]. Whereas, the bulb obsolescence chart also suggests a blazing future for the LED Market[56], which means less number of consumers are going to use other types of bulbs than before.

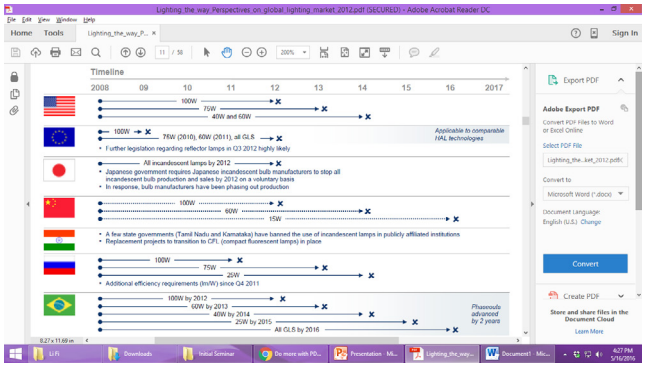

Figure 14. Lamp Obsolescence Chart[56].

On the competition front, the only technology that can provide similar data rates in open air is the Free Space Optics (FSO)[15]. This technology unfortunately suffers it's time for being strictly line of sight and wouldn't support mobility[62,63] due to its narrow beam width and resulting point-to-point links and lags in the Cumulative Annual Growth Rate by 52% and a market capital of $3173 Million.

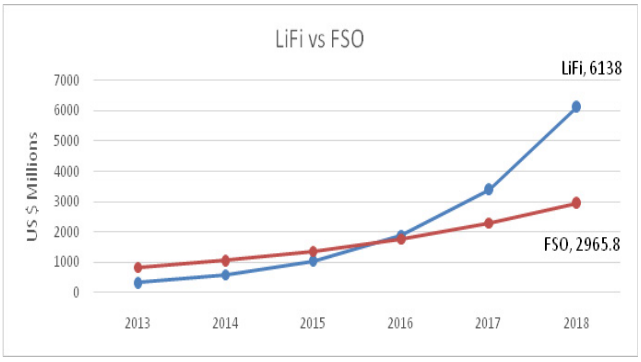

Figure 15. LiFi vs FSO technology Market[22].

From the Production front however, LEDs have garnered more production efforts because of the greater demand and MCUs have become smaller and cheaper too. Also, the speed of LiFi has increased over time, and has the potential to grow even more so in future.

With the consumer market moving towards acceptability and the production achieving greater speeds, LiFi

market is set to gain greater heights and without much competition from the other technologies so far, it can effectively become a leading last 100-meter internet provider throughout the world.

In conclusion, the blazing speeds and the market growth can only be successfully executed once Technology Giants like Apple, Samsung, Intel, Dell and the likes opt for built-in LiFi capabilities in their consumer products. It will be the last mile for LiFi, and will be a window to the breakthrough technology that might just change the way we use communication systems. And before the end of it, here is a link to Apple Inc peeking into ceiling lights that could be used for communication [40] and the news of word "LiFi Compatibility" in iOS[64] and the Samsung Patent for Visible Light Communication[39]

6. Conclusion

This paper discusses LiFi and its uses in serving as the front-end of internet as a complementary technology to WiFi and other internet Access Points. In developing the argument, the standardization efforts were discussed to establish the viability of this technology on a global scale. Highlighting efforts of IEEE, Japanese Standardization Organizations, Conferences and Workshops, it is clear that LiFi has become a global endeavor supported by big industry players such as Samsung, Motorola, Philips and Apple. With applications ranging from a simple message transmission, to video streaming, localization and providing a proper internet connection, this technology has been spearheaded by pureLiFi and other companies away from its nascence to a mainstream internet connectivity source. From 2011 till 2017, LiFi has experienced a gigantic escalation in data rates from 2.5Kbps in 2012 to almost 224Gbps in 2015. The range and mobility has also improved with seamless handoffs demonstrated by pureVLC and BeamCaster in its products. Additionally, the hardware has observed a reduction in its size by more than 50% and increase of connection speeds to many folds of a conventional WiFi connection, resulting in a better system with greater potential of replacing WiFi, or at least adding on to it at the very least.

On the other hand, the manufacturing of individual components of a LiFi system, the LED, Phototransistor and the MCU has also indicated a rise in their markets in the next five years. With the LED market expected to grow to $44.6 billion and the Phototransistor to more than $1 billion and MCU to $0.5 billion by 2018, the LiFi industry will have enough market to sustain its expected $75.5 billion market by 2023. Generally, with the rife LED infrastructure available, the market and the consumer front seems favorable. Albeit, the only hitch that seems to be present is the inclusion of built-in sensors in consumer electronics such as laptops, tablets and phones: number patents of which seem to be on the rise as well, with Samsung and Philips leading this part. We therefore conclude that the consumer market will go hand-in-hand with the production and LiFi might just change the way last 100 meters of internet are delivered to a consumer.

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