Li-Fi

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Li-Fi (short for *light fidelity*) is wireless communication technology which utilizes light to transmit data and position between devices. The term was first introduced by Harald Haas during a 2011 TEDGlobal talk in Edinburgh.[1]

Li-Fi

Introduced	March 2011; 9 years ago
Industry	Digital Communication
Connector type	Visible light communication
Physical range	visible light spectrum, ultraviolet and infrared radiation

In technical terms, Li-Fi is a light communication system that is capable of transmitting data at high speeds over the visible light, ultraviolet, and infrared spectrums. In its present state, only LED lamps can be used for the transmission of visible light.[2]

In terms of its end use, the technology is similar to Wi-Fi -- the key technical difference being that Wi-Fi uses radio frequency to induce a voltage in an antenna to transmit data. Whereas Li-Fi uses the modulation of light intensity to transmit data. Li-Fi can theoretically transmit at speeds of up to 100 Gbit/s. Li-Fi's ability to safely function in areas otherwise susceptible to electromagnetic interference (e.g. aircraft cabins, hospitals, military) is an advantage.[3] The technology is being developed by several organizations across the globe.

Contents []

Technology details [edit]

Li-Fi is a derivative of optical wireless communications


li-fi modules

(OWC) technology, which uses light from light-emitting diodes (LEDs) as a medium to deliver network, mobile, high-speed communication in a similar manner to Wi-Fi.[4] The Li-Fi market was projected to have a compound annual growth rate of 82% from 2013 to 2018 and to be worth over $6 billion per year by 2018.[5] However, the market has not developed as such and Li-Fi remains with a niche market, mainly for technology evaluation.

Visible light communications (VLC) works by switching the current to the LEDs off and on at a very high speed,[6] too quick to be noticed by the human eye, thus, it does not present any flickering. 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.[7] This is also a major bottleneck of the technology when based on the visible spectrum, as it is restricted to the illumination purpose and not ideally adjusted to a mobile communication purpose. Technologies that allows as roaming between various Li-Fi cells, also known as handover, may allow to seamless transition between Li-Fi. The light waves cannot penetrate walls which translates to a much shorter range, and a lower hacking potential, relative to Wi-Fi.[8][9] Direct line of sight is not necessary for Li-Fi to transmit a signal; light reflected off walls can achieve 70 Mbit/s.[10][11]

Li-Fi has the advantage of being useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing electromagnetic interference.[8][12][9] Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible, ultraviolet, and infrared light. While the US Federal Communications Commission has warned of a potential spectrum crisis because Wi-Fi is close to full capacity, Li-Fi has almost no limitations on capacity.[13] The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum.[14] Researchers have reached data rates of over 224 Gbit/s,[15] which was much faster than typical fast broadband in 2013.[16][17] Li-Fi is expected to be ten times cheaper than Wi-Fi.[7] Short range, low reliability and high installation costs are the potential downsides.[5][6]

PureLiFi demonstrated the first commercially available Li-Fi system, the Li-1st, at the 2014 Mobile World Congress in Barcelona.[18]

Bg-Fi is a Li-Fi system consisting of an application for a mobile device, and a simple consumer product, like an IoT (Internet of Things) device, with color sensor, microcontroller, and embedded software. Light from the mobile device display communicates to the color sensor on the consumer product, which converts the light into digital information. Light emitting diodes enable the consumer product to communicate synchronously with the mobile device.[19][20]

History [edit]

Professor Harald Haas coined the term "Li-Fi" at his 2011 TED Global Talk where he introduced the idea of "wireless data from every light".[21] He is Professor of Mobile Communications at the University of Edinburgh, and the co-founder of pureLiFi along with Dr Mostafa Afgani.[22]

The general term "visible light communication" (VLC), whose history dates back to the 1880s, includes any use of the visible light portion of the electromagnetic spectrum to transmit information. The D-Light project at Edinburgh's Institute for Digital Communications was funded from January 2010 to January 2012.[23] Haas promoted this technology in his 2011 TED Global talk and helped start a company to market it.[24] PureLiFi, formerly pureVLC, is an original equipment manufacturer (OEM) firm set up to commercialize Li-Fi products for integration with existing LED-lighting systems.[25][26]

In October 2011, a research organisation Fraunhofer IPMS and industry Companies formed the Li-Fi Consortium, to promote high-speed optical wireless systems and to overcome the limited amount of radio-based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum.[27]

A number of companies offer uni-directional VLC products, which is not the same as Li-Fi - a term defined by the IEEE 802.15.7r1 standardization committee.[28]

VLC technology was exhibited in 2012 using Li-Fi.[29] By August 2013, data rates of over 1.6 Gbit/s were demonstrated over a single color LED.[30] In September 2013, a press release said that Li-Fi, or VLC systems in general, do not require line-of-sight conditions.[31] In October 2013, it was reported Chinese manufacturers were working on Li-Fi development kits.[32]

In April 2014, the Russian company Stins Coman announced the development of a Li-Fi wireless local network called BeamCaster. Their current module transfers data at 1.25 gigabytes per second (GB/s) but they foresee boosting speeds up to 5 GB/s in the near future.[33] In 2014 a new record was established by Sisoft (a Mexican company) that was able to transfer data at speeds of up to 10 GB/s across a light spectrum emitted by LED lamps.[34]

Recent integrated CMOS optical receivers for Li-Fi systems are implemented with avalanche photodiodes (APDs) which has a low sensitivity.[35] In July 2015, IEEE has operated the APD in Geiger-mode as a single photon avalanche diode (SPAD) to increase the efficiency of energy-usage and makes the receiver more sensitive.[36] This operation could be also performed as quantum-limited sensitivity that makes receivers able to detect weak signals from a far distance.[35]

In June 2018, Li-Fi passed a test by a BMW plant in Munich for operating in an industrial environment.[37] BMW project manager Gerhard Kleinpeter hopes for the miniaturization of Li-Fi transceivers, for Li-Fi to be efficiently used in production plants.[38]

in August 2018, Kyle Academy, a secondary school in Scotland, had pilot the use of Li-Fi within the school. Students are able to receive data through a connection between their laptop computers and a USB device that is able to translate the rapid on-off current from the ceiling LEDs into data.[39]

In June 2019, French company Oledcomm tested their Li-Fi technology at the 2019 Paris Air Show. Oledcomm hopes to collaborate with Air France in the future to test Li-Fi on an aircraft in-flight.[40]

Standards [edit]

Like Wi-Fi, Li-Fi is wireless and similar 802.11 protocols, but it uses ultraviolet, infrared and

visible light communication (instead of radio frequency waves), which has much bigger bandwidth.

One part of VLC is modeled after communication protocols established by the IEEE 802 workgroup. However, the IEEE 802.15.7 standard is out-of-date: it fails to consider the latest technological developments in the field of optical wireless communications, specifically with the introduction of optical orthogonal frequency-division multiplexing (O-OFDM) modulation methods which have been optimized for data rates, multiple-access and energy efficiency.[41] The introduction of O-OFDM means that a new drive for standardization of optical wireless communications is required.

Nonetheless, the IEEE 802.15.7 standard defines the physical layer (PHY) and media access control (MAC) layer. The standard is able to deliver enough data rates to transmit audio, video and multimedia services. It takes into account optical transmission mobility, its compatibility with artificial lighting present in infrastructures, and the interference which may be generated by ambient lighting. The MAC layer permits using the link with the other layers as with the TCP/IP protocol.[*citation needed*]

The standard defines three PHY layers with different rates:

- The PHY 1 was established for outdoor application and works from 11.67 kbit/s to 267.6 kbit/s.
- The PHY 2 layer permits reaching data rates from 1.25 Mbit/s to 96 Mbit/s.
- The PHY 3 is used for many emissions sources with a particular modulation method called color shift keying (CSK). PHY III can deliver rates from 12 Mbit/s to 96 Mbit/s.[42]

The modulation formats recognized for PHY I and PHY II are on-off keying (OOK) and variable pulse position modulation (VPPM). The Manchester coding used for the PHY I and PHY II layers includes the clock inside the transmitted data by representing a logic 0 with an OOK symbol "01" and a logic 1 with an OOK symbol "10", all with a DC component. The DC component avoids light extinction in case of an extended run of logic 0's.[*citation needed*]

The first VLC smartphone prototype was presented at the Consumer Electronics Show in Las Vegas from January 7–10 in 2014. The phone uses SunPartner's Wysips CONNECT, a technique that converts light waves into usable energy, making the phone capable of receiving and decoding signals without drawing on its battery.[43][44] A clear thin layer of crystal glass can be added to small screens like watches and smartphones that make them solar powered. Smartphones could gain 15% more battery life during a typical day. The first smartphones using this technology should arrive in 2015. This screen can also receive VLC signals as well as the smartphone camera.[45] The cost of these screens per smartphone is between $2 and $3, much cheaper than most new technology.[46]

Signify lighting company (formerly Philips Lighting) has developed a VLC system for shoppers at stores. They have to download an app on their smartphone and then their smartphone works with the LEDs in the store. The LEDs can pinpoint where they are located in the store and give them corresponding coupons and information based on which aisle they are on and what they are looking at.[47]

[edit]

Home and building automation

It is predicted that future home and building automation will be highly dependent on the Li-Fi technology for being secure and fast. As the light cannot penetrate through walls, the signal cannot be hacked from a remote location.

Applications [edit]

Security waves used by Li-Fi, lights cannot penetrate through walls and doors. This makes it more secure and makes it easier to control access to a network.[48] As long as transparent materials like windows are covered, access to a Li-Fi channel is limited to devices inside the room.[49]

Underwater application [edit]

Most remotely operated underwater vehicles (ROVs) are controlled by wired connections. The length of their cabling places a hard limit on their operational range, and other potential factors such as the cable's weight and fragility may be restrictive. Since light can travel through water, Li-Fi based communications could offer much greater mobility.[50] Li-Fi's utility is limited by the distance light can penetrate water. Significant amounts of light do not penetrate further than 200 meters. Past 1000 meters, no light penetrates.[51]

Aviation [edit]

Efficient communication of data is possible in airborne environments such as a commercial passenger aircraft utilizing Li-Fi. Using this light-based data transmission will not interfere with equipment on the aircraft that relies on radio waves such as its radar.[52]

Hospital [edit]

Many treatments now involve multiple individuals, Li-Fi systems could be a better system to transmit communication about the information of patients.[53] Besides providing a higher speed, light waves also have little effect on medical instruments. Wireless communication can be done during the use of such medical instruments without having to worry about radio interferences hindering the efficiency of the task.[52]

Vehicles [edit]

Vehicles could communicate with one another via front and back lights to increase road safety. Street lights and traffic signals could also provide information about current road situations.[54]

Industrial automation [edit]

Anywhere in industrial areas data has to be transmitted, Li-Fi is capable of replacing slip rings, sliding contacts and short cables, such as Industrial Ethernet. Due to the real time of Li-Fi (which is often required for automation processes) it is also an alternative to common industrial Wireless LAN standards. Fraunhofer IPMS, a research organisation in Germany states that they have developed a component which is very appropriate for industrial applications with time sensitive data transmission.[55]

Advertising [edit]

Street lamps can be used to display advertisements for nearby businesses or attractions on cellular devices as an individual passes through. A customer walking into a store and passing through the store's front lights can show current sales and promotions on the customer's cellular device.[56]

Education [edit]

Students and teachers can be part of a more active educational community in a classroom that is Li-Fi enabled. Students with devices such as smartphones or laptops can communicate with the teacher, or with each other, to create a more efficient learning environment. Teachers can be able to collaborate with students to help better understand class material.[56]

See also [edit]

- Bluetooth
- Free-space optical communication
- Indoor positioning system (IPS)
- Infrared communication
- IrDA
- Near Field Communication (NFC)
- Wi-Fi positioning system
- Spatial light modulator (SLM)
- Super Wi-Fi
- Wi-Fi Direct
- Wi-Fi

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v · t · e	**Optical telecommunication**	[show]
v · t · e	**Internet access**	[show]
v · t · e	**Telecommunications**	[show]

60.Introduction to Li-Fi Technology. : Introduction to Li-Fi Technology.

Categories: Telecommunications-related introductions in 2011 | Wireless networking | Optical communications | University of Edinburgh School of Informatics