Countries are testing Visible light Communications or LiFi for, Internet of Things, Vehicular networks, 5G mobile and Underwater networks

This next-generation network shall provide fast Internet for everyone, smart cities, driverless cars, critical health care, "internet of things" revolution, and reliable and secure communications for critical infrastructures and services. The wireless-fidelity (Wi-Fi) with maximum speed of 150 Mbps, according to standards of 1EEE 802.11n, is not sufficient to fulfill the need of this future network. In order to remove this deficiency of Wi-Fi, a new technology is developed by German physicist, professor Harald Haas is known as Li-Fi. The Li-Fi is a wireless communication system in which light is used as a carrier signal instead of traditional radio frequency as in Wi-Fi. Li-Fi is a technology that utilizes a light emitting diode to transmit data wirelessly.

The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum hence can provide large data rates. Researchers have reached data rates of over 10 Gbit/s, which is more than 250 times faster than superfast broadband. Li-Fi is expected to be ten times cheaper than Wi-Fi. The LED lights require so little energy; they can be powered by a standard ethernet cord. Inventor Harald Haas has also suggested that the smart lights could be powered by solar cells charging batteries.

LiFi works by switching LEDs on and off within nanoseconds to communicate data, which is too quick to be noticed by the human eye. At the receiving end Li-Fi uses a photodetector to receive signals and convert them into streamable content. Li-Fi pioneers pureLiFi already have two products on the market: Li-Flame Ceiling Unit to connect to an LED light fixture and Li-Flame Desktop Unit which connects to a device via USB, both aiming to provide light and connectivity in one device.

It is predicted that LEDs will be the ultimate light source in the near future powering indoor illumination, outdoor lamps, traffic signs, advertising displays, car headlights/taillights, etc. Li-Fi, or light fidelity, promises to double the utility of light-emitting diodes (LEDs) by using their light as a medium to deliver networked, mobile, and high-speed communication in a similar manner as Wi-Fi. Li-Fi has already achieved blistering speeds in the lab. Researchers at the University of Oxford have reached a new milestone in networking by using light fidelity (Li-Fi) to achieve bi-directional speeds of 224 gigabits per second (Gbps).

LiFi has started entering into mainstream. Dubai plans soon be the first city to fit its street lights with Li-Fi. The lamps are said to have cost Dubai $1000 each. Li-Fi is reportedly being tested in Dubai, by UAE-based telecommunications provider, du and Zero1. Du claims to have successfully provided internet, audio and video streaming over a Li-Fi connection. Scientists are trialling it in offices and industrial environments in Tallinn, Estonia, reporting that they can achieve data transmission at 1 GB per second – that’s 100 times faster than current average Wi-Fi speeds.

Indian government is also testing this revolutionary technology to bring internet connectivity to the masses. The successful pilot project was carried out by autonomous scientific society ERNET (Education and Research Network) in association with IIT Madras and Philips lighting company. What’s more, reports suggest that Apple may build future iPhones with Li-Fi capabilities.

The dual use of LEDs for illumination and communication purposes is a sustainable and energy-efficient approach and has the potential to revolutionize how we use light. Haas said. “In the future we will not only have 14 billion light bulbs, we may have 14 billion Li-Fis deployed worldwide for a cleaner, greener, and even brighter future.”

In future LiFi would make possible the extensive deployment of visible light communication for a wide range of short and medium-range communication applications including wireless, local, personal, and body area networks (WLAN, WPAN, and WBANs), vehicular networks, underwater networks and machine-to-machine (M2M) communication among others.

Li-Fi can provide the military with high speed, non-detectable communications that cannot be identified through current direction-finding technology. The high-speed, multi-frequency communication capability inherent in Li-Fi can free up bandwidths used in critical legacy applications that haven’t converted to newer technology. With Li-Fi, inter-soldier, inter-vehicle, and inter-ship line-of-sight communications can render mobile units ubiquitous relays of information and orders without any verbal communication, while remaining totally invisible in the battlespace.

The Navy is interested in using Li-Fi to improve submarine communications, since radio waves travel poorly under water and current acoustic communications are slow. The underwater VLC in the blue/green spectral range (450 nm-550 nm) is able to achieve data speeds of hundreds of Mbps for short ranges (less than a hundred meter) complementing long range acoustic communication.

LiFi Technology

The system functions in the following way: a regular light-emitting diode acts as the signal source. It flashes at a high frequency and radiates light impulses. A photodetector receives the impulses and decodes them into an electrical signal. The signal is further deciphered and digital data is extracted. Altogether the light-emitting diode and the photodetector resemble a transmitter: light on is binary 1, light off is binary 0. This mode of data transmission cannot be detected by the human eye: the frequency with which the diodes flash is extremely high.

The Li-Fi technology is being developed into an omnipresent systems technology. They consist of application specific combinations of light transmitters, light receivers including solar cells, efficient computational algorithms and networking potential that can be deployed in an extensive range of communication scenarios and in a diversity of device platforms.

Since August 2013, data rates of over 1.6 Gbit/s were demonstrated over a single color LED. In October 2013, it was announced Chinese manufacturers were working with Li-Fi development kits. Again in April 2014, the Russian company Stins Coman declare the development of a 4 Li-Fi wireless local network called BeamCaster. Their current module transfers data at 1.25 gigabytes per second, but they predict the boosting speeds up to 5 GB/second in the near future. In 2014 a new record was established by Sisoft (a Mexican company) that was capable of transferring data at speeds of up to 10 Gbit/s across a light spectrum emitted by LED lamps.

Short range, low reliability and high installation costs are the potential downsides of LiFi. Researchers are now making efforts towards developing heterogeneous networks incorporating both WiFi and LiFi to make the best of the pros of both VLC and WiFi. Operators say that 80% of the mobile traffic occurs indoors; therefore, the combination of LiFi and WiFi has great potential to be breakthrough technologies in future HetNets including the next generation (5G) mobile telecommunications systems

Light Fidelity or Li Fi entering mainstream

This system would be an innovative technology when it comes to a reduction in interference, increase in security, speed, and potentially be an innovation that will receive support from many companies. Unlike Wi-Fi, which presents a high potential for EMI, the proposed system will be permitted in electromagnetically sensitive locations where radio waves are not, such as around medical equipment in hospitals.

Li-Fi will be especially valuable in commercial applications, such as communication between cars and other vehicles requiring integrated high-speed motion detection; in hospitals, where radio waves interfere with delicate instrumentation; in airplane environments, where radio frequencies (RF) can interfere with navigation equipment; and in construction, where heavy explosives are currently detonated through radio signals.

Li-Fi emits no electromagnetic interference and so does not interfere with medical instruments, nor is it interfered with by MRI scanners. Thus, they can be used in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing electromagnetic interference.

Li-Fi could lead to the Internet of Things, which is everything electronic being connected to the internet, with the LED lights on the electronics being used as Li-Fi internet access points.

LEDs are also being widely used in outdoor lighting, traffic signs, advertising displays, car headlights/taillights, etc. Vehicles fitted with LED-based front and back lights can communicate with each other and with the road side infrastructure (RSI), i.e., street lamps, traffic lights, through the VLC technology.

Furthermore, LED-based RSI can be used for both signaling and broadcasting safety-related information to vehicles on the road. VLC is well positioned to address both the low latency required in safety functionalities (i.e., emergency electronic brake lights, intersection collision warning, in-vehicle signage, platooning) and high speeds required in so-called infotainment applications (i.e., map downloads and updates, media downloading, point of interest notification, high-speed internet access, multiplayer gaming, and cooperative downloading), according to Murat Uysal and Hatef Nouri, Ozyegin University, Turkey

LiFi internet breakthrough: 224 Gbps connection broadcast with an LED bulb

Li-Fi has already achieved blistering speeds in the lab. Researchers at the University of Oxford have reached a new milestone in networking by using light fidelity (Li-Fi) to achieve bi-directional speeds of 224 gigabits per second (Gbps). The 224Gbps speed would technically allow for 18 movies of 1.5GB each to be downloaded in a single second.

“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,” the report states.

Although Li-Fi has faster speeds than Wi-Fi, it has a very short range. Over longer distances, using LEDs originally intended for lighting, and in otherwise more realistic conditions, Li-Fi is slower than the speeds achieved in the lab. Anagnostis Paraskevopoulos and colleagues at the Heinrich Hertz Institute in Germany, for instance, managed to achieve data transmission ratesup to 500 megabits per second over distances of one to two meters and transmission rates up to 100 megabits per second over 20 meters.

First Russian Li-Fi Network Launched at ITMO University

The first light-operated data transmission network in Russia was launched by ITMO University's Department of Light Technologies and Optoelectronics in June 2017. A speed of 50 Mbps was reached in the ITMO University laboratory, which is comparable, and even superior, to a regular Wi-Fi connection. Li-Fi communication channels are considered to provide better security. They may also be used in Wi-Fi "dead-zones": operating rooms, airplanes, and in other conditions requiring minimization of radio interference.

The process involved assembling two modem modules able to both receive and send signals. The first one also included a module with 64 white light-emitting diodes (those used in regular office lamps). The diodes provided transmission of the signal to the second module's photodetector. Modules were linked to two laptops and located within each other's line of sight. The laptops had network folders storing high-quality videos. As a result, the two modems were able to connect – making it possible to use the first laptop to watch videos from the network folder of the second one. For a three-meter distance separating the modules, the transmission rate was 50 Mbps.

The research group conducted control testing of the Li-Fi system in both a dark room and in regular conditions. Sergey Scheglov states that not even sunlight, coming from the windows, is able to disturb signal transmission. Emitted by the transmitter, light radiates in all directions and is mirrored by walls and other surfaces. This creates a kind of “illumination” of the optical signal carrying information – which is enough to maintain efficient data transmission inside a room. Once used in the future, Li-Fi connection will be sustained by the entire lighting system rather than just one bulb or lamp. This way, when moving from one light-source to another, the user will not experience any connection problems.

China makes breakthrough in Li-Fi technology, with speed of 50 Gbps

A test conducted by the Ministry of Industry and Information Technology confirmed that the real-time traffic rate of a Chinese VLC system had reached 50 gigabytes per second (Gbps), as has been reported by Xinhua.IT expert and academic Wu Jiangxing said it will be possible to establish a huge VLC network based on the billions of bulbs and LED lighting facilities already around the globe.

“Every bulb can serve as a high-speed Internet access point (similar to a WIFI hotspot) after VLC technology is widely applied in the future,” said Wu, unable to give a specific time frame. “Imagine downloading several movies while you are waiting for a green light at a crossroad or surfing the Internet on planes and high-speed trains via the lights.”

The VLC system was developed by the People’s Liberation Army (PLA) Information Engineering University and has entered a phase of “integration and micromation in design.” The university succeeded in developing a wireless broadcasting system based on VLC in 2013.

LiFi based networking

But while point-to-point demonstrations have proven LiFi to be a serious alternative to RF-based communications, the technology’s real strength lies in networking. Detector-receiver arrays also house infrared diodes to provide an uplink connection back to the LED-based LiFi access point.

And by combining numerous micro-LED transmitters and receiver assemblies, the researchers can take LiFi beyond a straightforward point-to-point communications system, and create a multiple-input multiple-output (MIMO) transmission network. Transmitters and receivers can even be combined in a single unit to create a single-input, single-output link.

As Haas emphasizes: “The LiFi communications system can serve many users. It allows multi-user access, has an uplink and downlink, and allows handover.”

“The coverage of each LED lamp is up to 10 square meters and when you leave that space, you are illuminated by another lamp, handover takes place, and you don’t lose wireless connectivity,” he adds.

Haas is also confident ambient light will not interfere with transmissions as the receivers are only sensitive to the modulating LED light.

“Even the 100 Hz flicker from an incandescent light bulb is not an issue, as our modulation frequency starts at 1 MHz,” he says. “As long as fluctuations are outside our modulation, these aren’t an issue.”

Future Growth

According to the new market research report by MarketsandMarkets, the VLC market is expected to grow from USD 327.8 Million in 2015 to USD 8.50 Billion by 2020, at a CAGR of 91.8% between 2015 and 2020.

The growth of the VLC market is driven by factors such as faster and safer data transfer than other competing technologies, RF spectrum bandwidth crunch, no bandwidth limitation, less energy consumption, and greener, cleaner, and safer technology.

By 2020, the market share of the photodetector segment is expected to grow very rapidly: At present, only one-way communication is possible with the help of VLC, which requires the installation of LED and installation of some applications on phones and tablets, and a cloud server to maintain the storage platform. However, with the advent of two-way communication by the end of 2020, the market share of the photodetector segment, which includes photodiodes and image sensors, is expected to grow very rapidly.

References and resources also include:

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