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LI-FI TECHNOLOGY: DATA TRANSMISSION REDEFINED

Gp Capt Ashok chordia
Senior Fellow, CAPS

Communication Today

"There are almost as many cell-phone subscriptions (6.8 billion) as there are people on this earth (seven billion) ... Shouting is the likely next-most widespread communications technique."

~ Tim Fernholz[1]

As per the United Nations' telecommunications agency, in 2013, there were about 96 cell-phone service subscriptions for every 100 people in the world. That data took into account the fact that low subscription (89.4 per 100) in the poor or developing countries is offset by people in affluent countries where many people have two or more mobile phones. Even in Africa––where development lags in all spheres of life, there are 63.5 cell-phone subscriptions per 100 people as against 1.4 fixed-line subscriptions every 100.[2]

Voice and data transmission relies almost entirely on radio waves.

Transmission Woes of Radio Waves

Transmission of data using radio waves suffers from some drawbacks. It is done mostly through transmission towers and relay stations erected at geographically separated locations. The towers and relay stations consume energy which is supplied either by miles of electrical cables and––in difficult terrain or in remote locations where it is difficult or uneconomical to lay cables––by means of generator sets. The generator sets guzzle diesel to produce electricity, most of which is used for cooling the equipment, which gets heated due to transfer of huge amount of data. Supply of diesel to run the generators is an exercise in itself. As of now, only about 0.11% towers run on some form of green energy; with more efforts this figure could rise to 5%.[3]

Data transmitted using radio waves is insecure because radio waves can penetrate walls and can be intercepted. The transmitted data is susceptible to jamming and

eavesdropping. Tapped data can be used to disrupt commercial activity and it can compromise security.

There is the problem of congestion, too. In 2011, nearly 600 terabytes of data was being exchanged, in the US alone, through radio waves every month between nearly five billion mobile phones and 1.4 million cellular masts. India is not far behind. The amount has increased tremendously over the last five years leading to the problem of capacity. Today, a lot of the data, both secure and unsecure, is transmitted using electromagnetic waves. [4] An ever-increasing number of users and limited spectrum cause *congestion*, which slows down transfer of data considerably. In 2011, in the US, there were 1.4 million radio cellular base stations, which were expensive and inefficient.[5]

Visible Light: A Ray of Hope

A comparison of the size of the spectrum of visible light with that of the radio waves shows that the former is 10,000 times larger than the latter; yet less exploited (read explored).According to Dr Harald Haas, this visible light can be used effectively and efficiently for data transmission. The simplest example where it is in use is that of a commonly used infrared remote control device. It has an LED, which when operated, creates a simple, low-speed data stream of 10,000 to 20,000 bits per second.[6]

The intensity of light emitted by an LED can be modulated and switched off at very high speeds. This basic property is made use of thus: thousands of data streams are transmitted in parallel, at much higher speeds than that of an infrared ray emitted from remote control device.[7] This new technology enables conversion of little, subtle changes in the amplitude of light emitted by the LEDs into electrical signals which are converted into a high-speed data stream.

So when a light (an LED light) is switched *on* it not only illuminates the surface it falls on––say the page of a book, enabling someone to read it––but also conveys data in the form of fluctuations which are not perceptible to the human eye. The subtle changes in the amplitude that are impressed onto the LED bulb go unnoticed. These fluctuations can *convey* data say, a high-definition video. Other *steady* lights in the proximity do not affect this data transfer. Besides, the intensity of the *signal-carrying beam* of light is not all that important. Thus, it is possible to transmit data even in conditions of poor visibility, to an extent though. Suffice to say that even a dimmed beam can transmit data.

Experiments

Light Fidility, li-fi as it is called, can deliver Internet access 100 times faster than traditional wi-fi––offering speeds of up to 1gigabit per second (Gbps).[8] In the experiments carried out in an office by an Estonian start-up, Velmenni in November 2015, a li-fi-enabled light

bulb transmitted data at speeds of 1Gbps. The workers were able to access the Internet and it also provided a smart lighting solution. Laboratory tests have shown theoretical speeds of up to 224Gbps.[9]In the experiments conducted by Dr. Haas in September 2015, he used solar panels as receivers for the li-fi data.[10]

Advantages

Li-fi data transmission has numerous advantages. The spectrum is 10,000 times wider than the one in use at present. Besides, if and when switchover to this spectrum is considered, the existing LED lights would be used––very little extra expenditure.

Consider the energy efficiency of the LED light bulbs. Now imagine, these energy efficient devices being used for the purpose of data transmission while still retaining their primary purpose of illuminating. In a way, data transmission would be a spinoff, literally free of cost.

Artificial lighting is present almost everywhere––hospitals, schools, roads, parks, conference halls, aircraft, trains, ships, cars, mobile phones, … All these, and many more, are potential sources for high-speed data transmission.

Data transmission using light is secure too because light does not penetrate walls; eavesdropping is not possible. Besides, unlike wi-fi, li-fi does not interfere with other signals: use on aircraft and in other places where interference is an issue would be a possibility.

Prof Haas who demonstrated his experiment in 2011, described a future when billions of light bulbs could become wireless hotspots. Because of the size of the spectrum being 10,000 times larger, congestion would not be an issue for some time.

Two drawbacks would, however, have to be overcome. One, that li-fi cannot be deployed outdoors (at this stage) in direct sunlight and two, since it cannot pass through the walls, initial use is likely to be limited to places where it can be used to supplement wi-fi networks, such as in congested urban areas or places where wi-fi is considered unsafe, such as hospitals.

Applications

Here is some food for thought. Remotely operated devices use light, which can be used to transmit data for communication or for command and control. There is enormous scope for use in instruments and gadgets in hospitals and factories. Millions of street-lights can be free access points for data while driving. Light from street-lights can be used to communicate with vehicles; it can be used to control vehicular traffic and prevent accidents. Data transfer between cars or between aircraft may also be a possibility.

Soon, there will be a massive extension of the Internet––tens of billions of devices will be

connected to the Internet. According to Dr Haas, such an extension of the Internet can only work if it is almost energy-neutral.[11] Solar cell and the LED will save the day.

In times to come, a small microchip fitted in every potential illumination device will enable both, illumination and wireless data transmission. Li-fi will solve some of the existing problems of wireless communication. It promises a cleaner, greener, speedier and brighter future. Imagination alone will limit the application of this technology to military use for wherever there is artificial light; there is a potential way to transmit data using this technology. A hundred times improvement in the data transfer speed will give an edge to any force that exploits it.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

[1] Tim Fernholz, "More people around the world have cell phones than ever had land-lines", *Quartz*, February 25, 2014, http://qz.com/179897/more-people-around-the-world-have-cell-phones-than-ever-had-land-lines/ accessed November 29, 2015.

[2]Ibid.

[3] Citation: Kit Eaton, "Greening Up the World's Cell Phone Towers', http://www.fastcompany.com/1667371/greening-worlds-cell-phone-towers accessed November 29, 2015.

[4]Harald Haas: Wireless data from every light bulb Filmed July 2011 at TED Global 2011

[5] Ibid.

[6] Ibid.

[7] The technology is called Subcarrier Index Modulation Orthogonal Frequency-Division Multiplexing(SIM OFDM)

[8]"Li-fi 100 times faster than wi-fi",*BBC News*, November 28, 2015, http://www.bbc.com/news/technology-34942685, accessed November 28, 2015.

[9]"Li-fi 100 times faster than wi-fi",*BBC News*, November 28, 2015, http://www.bbc.com/news/technology-34942685, accessed November 28, 2015.

[10] Harald Haas, "Forget Wi-fi. Meet the New Li-Fi Internet",*TEDGlobal*, filmed September 2015.

[11]Ibid.