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LIGHT FIDELITY (Li Fi) : A SURVEY

Suriya Begum*, Siddharth Konar, Ashhar

* Professor,Department of Computer Science and Engineering,New Horizon College of Engineering, Bangalore, India

Student,Department of Computer Science and Engineering,New Horizon College of Engineering, Bangalore, India

Student, Department of Computer Science and Engineering, Bangalore, India

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ABSTRACT

There are a plethora of possibilities to be gouged upon in this field of technology. If this technology becomes justifiably marketed then every bulb can be used analogous to a Wi-Fi hotspot to transmit data wirelessly. The possibilities are numerous and can be explored further. If this technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future[2]. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn‘t allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

KEYWORDS: Li FI

INTRODUCTION

Li-Fi stands for ‘LIGHT FIDELITY’ (Li-Fi) is transmission of data through illumination by taking the fibre optics by sending data through a LED light bulb that varies in intensity faster than the human eye can follow Li-Fi is the term some have used to label the fast and cheap wireless-communication system, which is the optical version of Wi-Fi[1].

Li-Fi is a branch of optical wireless communication which is an emerging technology. By using visible light as transmission medium, Li-Fi provides wireless indoor communication.

The Chair of Mobile Communication at the University of Edinburgh [2] , is recognized as the founder of Li-Fi.He coined the term Li-Fi and is the co-founder of pure Li-Fi. He gave a demonstration of a Li-Fi prototype at the TED Global conference in Edinburgh o 12th July 2011.He used a table lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen. During the talk, he periodically blocked the light from lamp with his hand to show that Li-Fi can be regarded as light-based WiFi. Li-Fi can be better than Wi-Fi because there are some limitations in Wi Fi. Wi-Fi uses 2.4-5GHz radio frequencies to deliver wireless internet access and its bandwidth is limited to 50-100Mbps.With the increase in the number of Wi-Fi hotspots and volumes of Wi-Fi traffic, the reliability of signals is bound to suffer.

Li-Fi is a new technology which uses visible light for communication instead of radio waves .It refers to 5G Visible Light Communication systems using [3]. Light Emitting Diodes as a medium to high speed communication in a similar manner as Wi-Fi. It can help to conserve a large amount of electricity by transmitting data through light bulbs and other such lighting equipments. It can be used in aircrafts without causing any kind of interference. Li-Fi uses light

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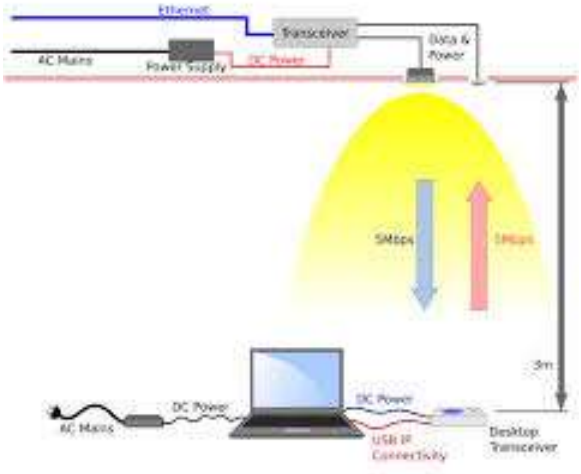
carrier opposed to traditional use of radio waves as in Wi-Fi and this means that it cannot penetrate walls, which the radio waves are able to. It is typically implemented using white LED bulbs at the downlink transmitter. By varying the current through the LED at a very high speed, we can vary the output at very high speeds. This is the principle of the Li-Fi. The working of the Li-Fi is itself very simple – if the LED is ON, the signals transmitted are a digital 1 whereas if it is OFF, the signal transmitted is a digital 0.

Communication, the most emerging part in everybody's life is through exchanging information either on wired or wireless devices,[4] .In 2011[2] creating an 800mbps capable wireless network by using nothing more than normal red, blue, green and white LED light bulbs, thus the idea has been around for a while and various other global teams are also exploring the advancement possibilities. 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 uses light emitting diodes to transmit data wisely that cannot be detected by human eye. The paper will focus on Li-Fi technology over Wi-Fi technology and challenges for the new era VLC technology [5].

Hence , all that is required is some LEDs and a controller that code data into those LEDs. All one has to do is to vary the rate at which the LED's flicker [2] depending upon the data we want to encode. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data Channel. Such advancements promise a theoretical speed of 10 Gbps – meaning one can download a full high-definition film in just 30 seconds.
The working of Li-Fi is based on VLC, which uses visible light for data transmission [6]. The visible light spectrum has wider range of hundreds of THz of free bandwidth, which is 10,000 times more than RF spectrum up to 30GHz. It uses LED to generate data stream which is connected to the internet or cellular system. As per the data stream the LED flickers at high rate which is not recognized by human eye.



CONSTRUCTION

The main components of Li-Fi system are as follows[4]:

- A high brightness white LED which acts as transmission source.
- A silicon photodiode with good response to visible light as the receiving element. LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The Li-Fi System consists of 4 primary sub-assemblies:
- Bulb
- RF Power Amplifier circuit (PA)
- Printed Circuit Board(PCB)
- Enclosure

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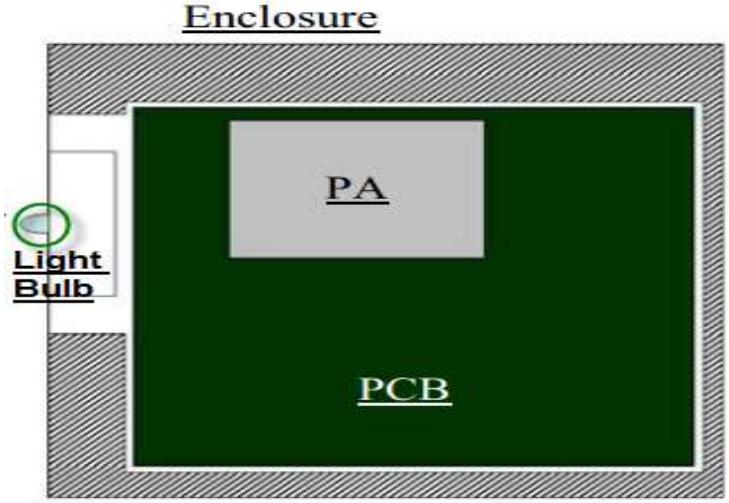
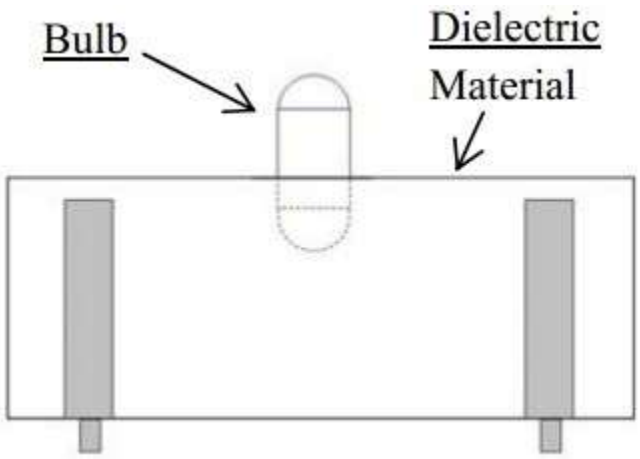
The PCB controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. A RF (radio-frequency) signal is generated by the solid-state PA and is guided into an electric field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb's centre; this controlled plasma generates an intense source of light. All of these subassemblies are contained in an aluminium enclosure.



The bulb sub-assembly is the heart of the Li-Fi emitter[3]. It consists of a sealed bulb which is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb. The dielectric material serves two purposes. It acts as a waveguide for the RF energy transmitted by the PA. It also acts as an electric field concentrator that focuses energy in the bulb. The energy from the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity and full spectrum.



There are various inherent advantages of this approach which includes high brightness, excellent colour quality and high luminous efficacy of the emitter- in the range of 150 lumens per watt or greater. The structure is mechanically robust without typical degradation and failure mechanisms associated with tungsten electrodes and glass to metal seals, resulting in useful lamp life of 30,000+ hours. In addition, the unique combination of high temperature plasma and digitally controlled solid state electronics results in an economically produced family of lamps scalable in packages from 3,000 to over100, 000 lumens.

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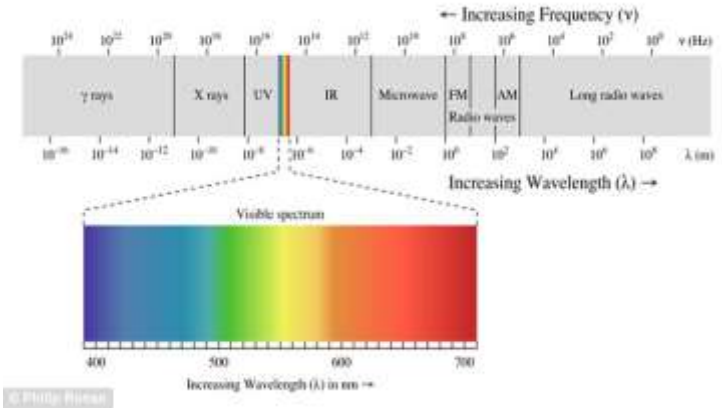
WORKING

Wireless Communication Through Visible Light

On one end all the data on the internet will be streamed to a lamp driver when the led is turned on the microchip converts the digital data in form of light[2] .

A light sensitive device (photo detector) receives the signal and converts it back into original data. This method of using rapid pulses of light to transmit information wirelessly is technically referred as Visible Light Communication.



Li-Fi Technology:Data Transmission Through Visible Light

Light emitting diodes (LEDs) can be switched on and off faster than the human eye can detect since the operating speed of LEDs is less than 1 μs, thereby causing the light source to appear to be continuously on. This invisible on-off activity enables data transmission using binary codes. Switching on an LED is binary '1', switching it off is binary '0'. It is possible to encode data in light by varying the rate at which LEDs flicker on and off to give different strings of 1s and 0s. Modulation is so rapid that humans cannot notice it. A light sensitive device (photo detector) then receives the signal and converts it back into original data.

This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC).The term Li-Fi has been inspired due to its potential to compete with conventional Wi-Fi. The VLC uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as the optical carrier for data transmission and for illumination.

Data rates of greater than 100 Mbps can be achieved by using high speed LEDs with adequate multiplexing. Parallel data transmission using arrays of LEDs where each LED transmits a separate stream of data can be used to increase the VLC data rate. Though the lights have to be kept on in order to transmit data, they can be dimmed to the point that they are not visible to humans but still be capable of transmitting data.

HOW Li-Fi **WORKS ?**

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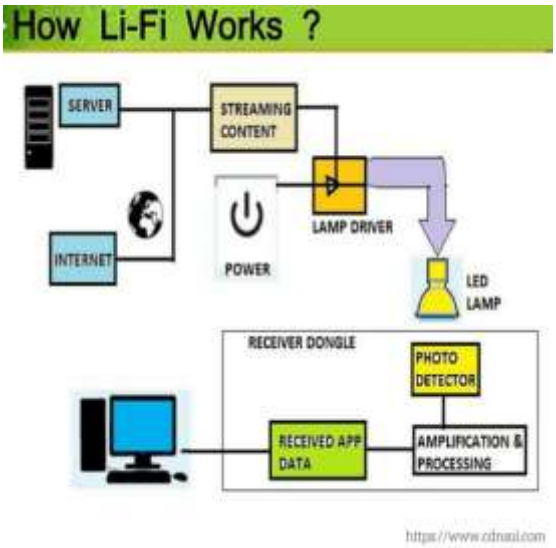
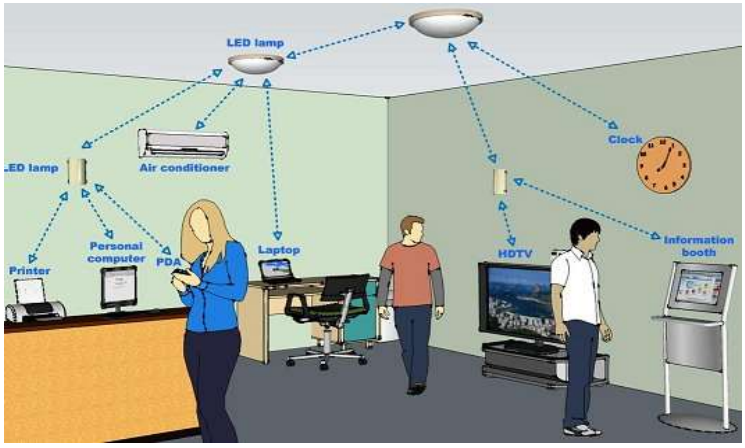


The new generation of high brightness light-emitting diodes (LED) forms the core part of light fidelity technology. These high brightness LEDs can be switched on and off very quickly felicitating for transmitting of data through light. In order to transmit a message, the mechanism must consist of a light emitter on one end, for example, an LED and a photo detector (light sensor) on the other. The photo detector which converts this light into electrical signals registers a binary 1 when the LED is on and 0 if off flash, times to acquire data rates in the range of 100 Mbps device connected to it. Voltage regulator and level shifter circuits are used on both the sides to convert a voltage level between transmitter and receiver. The modulation of LED couldn't be noticed by human eyes, causing the light source appeared to be continuous .It's likely to be applicable for traffic and street lights, car brake lights, remote control units and countless other applications. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC), though it is popularly called as Li-Fi because it can compete with its radio-based rival Wi-Fi. Figure shows a Li-Fi connecting devices in a room. Many other sophisticated techniques can be used to dramatically increase VLC data rate. Teams at the University of Oxford and the University of Edinburgh are focusing on parallel data transmission using array of LEDs, where each LED transmits a different data stream. Other groups are using mixtures of red, green and blue LEDs to alter the light frequency encoding a different data channel[3].

Li-Fi is a superset of different optical wireless technologies involving communication, positioning, natural user interfaces and many more.



WORKING PRINCIPLE

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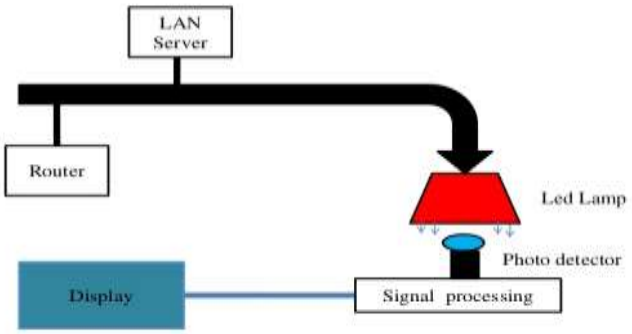
WORKING PRINCIPLE



Energy Efficiency Light Bulbs	 INCANDESCENT	 CFL	 INCANDESCENT
Life Span	1,200 hours	8,00 hours	50,00 hours
Watts of Electricity Consumed	60 watts (or more)	15 watts	8 watts
Operating Cost (per bulb)	$11/year	$2.50/year	$1.10/year
GHG Emmissions (per bulb)	150 pounds CO_2/year	35 pounds CO_2/year	15 pounds CO_2/year

CHALLENGES

Data Transimission Through Visible Light

Apart from many advantages over Wi-Fi, Li-Fi technology is facing some problems such as[1]:

- Li-Fi requires line of sight.
- Receiving device would not be shift in indoors.
- A major challenge is how the receiving device will transmit data back to transmitter[2].
- Other disadvantage is visible light can't penetrate through brick walls as radio waves and is easily blocked by somebody[2].
- If the apparatus is set up outdoors, it would need to deal with changing weather conditions[5].
- If the apparatus is set up indoors, one would not be able to shift the receiver.
- Light waves can easily be blocked and cannot penetrate thick walls like the radio waves can.
- We become dependent on the light source for internet access. If the light source malfunctions, we lose access to the internet[3].

ADVANTAGES:-

- Li-Fi uses light rather than radio frequency signals so are intolerant to disturbance[1].

- Under water in sea Wi-Fi does not work at all but light can be used and hence undersea explorations are good to go now with much ease[2].
- Security is side benefit of using light for data transfer as it does not penetrate through walls.
- The issue of the shortage of radio frequency bandwidth may be sorted out by Li-Fi [3].
- It can be used on highways for traffic control applications[2].
- It can be used safely in aircrafts without affecting airline signals unlike Wi-Fi.
- Every street lamp can be converted into free data access point.
- High data transmission rates of up to 10Gbps can be archived[5].

DISADVANTAGES:-

- The main problem is that light cannot pass through objects, so if the receiver is inadvertently blocked in any way, then the signal will immediately be cut out. If the light signal is blocked one could switch back over to radio waves.
- High installation cost of the systems can be complemented by large-scale implementation of VLC though adopting this technology will reduce further operating costs like electricity charges, maintenance charges etc.

We still need Wi-Fi and we still need radio frequency cellular system. You can't have a light bulb that provides data to high-speed moving object or to provide data in a remote area where there are trees, walls and obstacles[3].

Lights cannot be dimmed: The experiments with a various dimmed intensities are observed at Li-Fi R&D centre and they have found that there no effect of deemed light[4].

The lights flickers: The Li-Fi light flickers at higher rates which is not recognizable and hazardous to the human eye. The human eye can sense flickering of lower rates that is below 120-150Hz. This is for downlink only: As discussed earlier the Li-Fi system uses IR light for uplink completing the full duplex communication[5].

COMPARISION BETWEEN LI-FI AND WI-FI

Comparison Chart of Li-Fi and Wi-Fi

List of Parameter	Li-Fi	Wi-Fi
Speed	Very High	Moderate
Data Density	Very High	Low
Security	Very High	Moderate
Availability	Very High	Low
Transmission power	Very High	Moderate
Reliability	Moderate	Moderate
Range	Low	Moderate
Eco-Impact	Low	Moderate
Device Connectivity	Very High	High
Obstacle Interference	Very High	Low
Familiarity	Low	Very High

APPLICATION OF LIFI

Educational Systems

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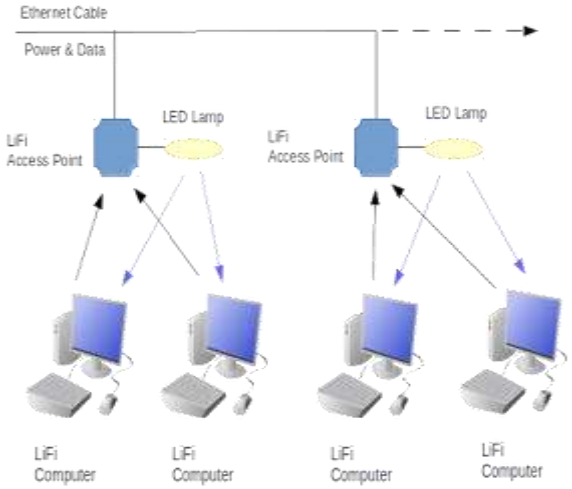

Medical Systems

Cheaper Internet in Aircrafts

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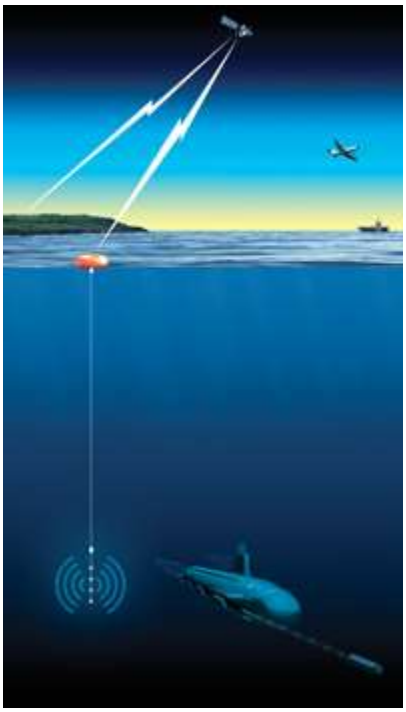
Traffic Management

Used in Underwater Application



CONCLUSION

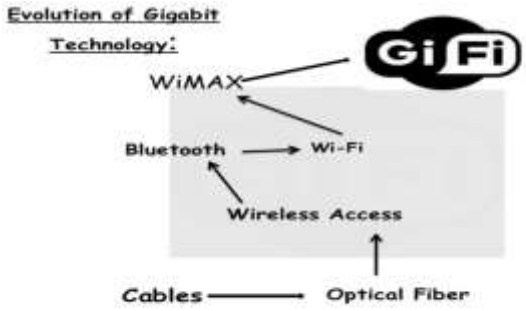
There are a plethora of possibilities to be gouged upon in this field of technology. If this technology becomes justifiably marketed then every bulb can be used analogous to a Wi-Fi hotspot to transmit data wirelessly. The possibilities are numerous and can be explored further. If this technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future[2]. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth

and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

According to changing scenario of wireless communication [5] as the electromagnetic spectrum shrinking continuously the Li-Fi system will going to provide a greener, safer, better and healthier future for communication system. When this system will be developed each light source can be used as a Li-Fi AP means where is a light there is a Internet. Also it will shapes the better future for human kind by reducing the energy consumption, data as well as light at low cost, minimal cellular infrastructure and creating the employments opportunities at large scale. In short the Li-Fi system will be going to change the scenario of wireless communications in many greener ways.

FUTURE SCOPE

The area of Li-Fi is very broad in the manner of Hospitals, Academics, Airlines and more. Can be used in the places where it is difficult to lay the optical fibre like hospitals. In operation theatre Li-Fi can be used for modern medical instruments. In traffic signals Li-Fi can be used which will communicate with the LED lights of the cars and accident numbers can be decreased. Thousand and millions of street lamps can be transferred to LiFi lamps to transfer data. In aircraft Li-Fi can be used for data transmission. It can be used in petroleum or chemical plants [13] where other transmission or frequencies could be Hazardous. Such advancements promise a theoretical speed of 100 Gbps - meaning one can download a full high definition film in just 3 seconds.
The future of LI-FI is GI-FI. GI-FI or gigabit wireless refers to wireless communication at a data rate of more than one billion bits (gigabit) per second. In 2008 researchers at the University of Melbourne demonstrated a transceiver integrated on a single integrated circuit (chip) that operated at 60 GHz on the CMOS process. It will allow wireless transfer of audio and video data at up to 5 gigabits per second, ten times the current maximum wireless transfer rate, at one-tenth the cost. Researchers chose the 57–64 GHz unlicensed frequency band since the millimetre-wave range of the spectrum allowed high component on-chip integration as well as the integration of very small high gain arrays. The available 7 GHz of spectrum results in very high data rates, up to 5 gigabits per second to users within an indoor environment, usually within a range of 10 meters. Some press reports called this "Gi-Fi". It was developed by Melbourne University-based laboratories of NICTA (National ICT Australia Limited), Australia's Information and Communications Technology Research Centre of Excellence.



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