

Technical and Market Trend Analysis of Li-Fi Lan System

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Abstract: Within 10 m WLAN and within 10 cm from the two-way data communication possible close contact/contactless data communications technology is applied very widely spread. In this study, the visible light wavelength using optical wireless communication technology in ultra wideband characteristics of LED-VLC systems technology trends, seems to have promise, Li-Fi technology characteristics and indoor navigation/ITS/cultural content delivery/u-home construction, etc. Li-Fi a wide variety of applications in the system such as building, posed an obstacle between the chip and smart appliances the beacon light wave transmission characteristics of problems/strong external light due to the communication failure is due to a century of telecommunications/light such as the limits of the problem to be solved due to the improving the performance of high-value industries, LED by noted LED-VLC and standardizes the marketability of technology about the prospect. Wi-Fi >100 times over high-speed bidirectional wireless transmission system, possible Li-Fi network powered by the next generation of growth emerging. Li-Fi technology Wi-Fi high efficiency lighting technology and internet shares LED the technology combines LED-VLC technology. LED lighting technology-based Li-Fi system for indoor navigation, ITS, content delivery and u-home construction was the application in a variety of industries are going to spread those values. Indoor navigation GPS systems that are difficult to operate in the field of Interior of barriers will be able to solve. Li-Fi technology is applied very widely spread that WLAN (10 cm~10 m) from the two-way data communication possible close contact/contactless.

Key words: Li-Fi, LED-VLC, Wi-Fi, WLAN, high-efficiency LED, ITS, u-home, backbone network, GPS system, M2M/D2D, mobile media, visible light, intelligent network, e-Commerce

INTRODUCTION

Li-Fi (Light Fidelity) technology is sharing that LED (Light Emitting Diode) technology for high efficiency lighting technology and fused with Wi-Fi (Wireless Fidelity) internet technology. Mobile media consumption needs and quickly spread as a result of the wireless data traffic rapidly increases the frequency for the transmission of large amounts of multimedia resource shortage is serious. In these situations, Li-Fi technology Wi-Fi 100 times more quickly and safely than the network high speed bidirectional wireless transmissions can be made possible by the next generation of emerging growth. Li-Fi technology Wi-Fi high efficiency lighting technology and internet shares LED the technology convergence. Wi-Fi network is sending and receiving information using technology. In comparison, Li-Fi technology uses visible

light to high-speed next-generation wireless network that can transfer information into. LED-VLC(LED-Visible Light Communication; LED-based wireless communication) technology features briefly summarized as follows (Kyu, 2014; Dong, 2014): LED lights on the wireless communication chips, digital signal to send and receive data between a smart device LED bulbs and loaded onto the light-induced optical wireless communication technology.

LED lighting system fitted with the Beacon chip load the digital signal LED bulb light, using the radio to transmit and receive data between a smart appliance technology. Arising from the visible light of semiconductor LED semiconductor flicker (60 times per sec blink) to send and receive data using the phenomenon of light. The wavelength of light 1 Gbps high speed transmission and very high energy efficiency more RF

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that information and communication standard of new generation will be the spread. Therefore, Li-Fi network will be the spread that the wavelength of, light 1 Gbps high speed rate and very high energy efficiency more RF that information and communication standard of new generation.

MATERIALS AND METHODS

Li-Fi wireless technology

Basic concepts: Mobile media consumption needs and quickly spread as a result of the wireless data traffic rapidly increases the frequency for the transmission of large amounts of multimedia resource shortage is serious. In these situations, Li-Fi technology is 100 times more quickly and safely than the Wi-Fi high-speed bi-directional wireless transmissions can be made possible by the next generation of emerging growth. Current Li-Fi technologies can connect to the internet PC using 1 W LED bulb, 150 Mbps enough technology that can be transferred. Li-Fi technology using visible light (infrared/visible/UV/X-ray/a-ray) is compared a non-visible light using electromagnetic waves 380~750 THz of high frequency because it uses 1 million times higher than the full-frequency wireless broadband has an attribute (Cisco, 2015) (Fig. 1).

Characteristics of Li-Fi system: Li-Fi system using a frequency of 1.25~20 MHz is frequency characteristics that 4G mobile communication system with 300~30 GHz and using broadband frequency of WLAN systems because it uses visible light compared with the frequency band 1 million times more than the entire wireless frequency 380~750 THz's ultra-wideband. Because of over 100 times faster than Wi-Fi or WLAN system can be implemented to speed up the transfer. LED visible light communication light gets blocked signal outdoor seeped into the leaves. Therefore, the Bluetooth/ZigBee/UWB/NFC/PSC/Z-Wave such as compared to the existing contact/contactless WLAN security-enhanced technologies. Li-Fi a brief summary of the benefits of the network as follows:

- Can help the shortage frequency problem that do not use the frequency band limitation in preparation for Wi-Fi frequency
- Data transmit/receive efficiency is very high and anywhere it is possible with light
- Interference or no conflict because broadband frequency characteristics communication
- Security efficiency is very high because external network intrusions can block the finest source
- Very high efficiency LED the sending or receiving the data light is possible anywhere



Fig. 1: Li-Fi wireless service concept (Cisco, 2015)

Table 1: Applications of Li-Fi technology

Applications	Detailed contents
Indoor navigation	10 Gbps bit rate offer using LED visible lights Wide coverage than the wireless routers In difficult of GPS signal reception area to spread seamlessly
ITS	LED light individually of each work, high speed location information is possible to receive Traffic lights in the vehicle with video/voice traffic information Autonomous driving systems support using car-to-car communication Lighthouse-to-ships and ship-to-ship collision avoidance systems that utilize available
Cultural contents delivery	Description of the museum exhibits Store guide and product information offer Multi-language service offer
U-home construction	Indoor navigation, cleaning robot etc Short-haul home networks and sensor networks M2M devices and smart phone file sharing Wireless environment offer using combine the power line communications

Korea communications commission (Hee-Suk, 2016; Kwon, 2017; Kim *et al.*, 2015)

- Broadband frequency characteristics of signal interference or no conflict
- External network intrusions can block the very finest security source
- LED light bulbs use visible light wavelengths that occur in the data transfer and the receiving side receives the light and restore your data
- Transmitter Li-Fi for data transfer as well as fluorescent light bulbs and light-emitting device capable of the same general connection
- WiGig (Wireless Gigabit Alliance: 2.4/5/60 GHz frequency using the bit rate of the multi-Gigabit wireless communications with a 7 Gbps technology) with the next generation communication technology

We do not have a problem with frequency allocation than what Li-Fi technology is internationally compatible and use the visible light spectrum, not regulation for free wireless communication has the advantage that you can implement. In addition, go to the digital signal transmission system in a digital so a separate converter is required. Also do not use radio waves can be applied effectively in sensitive places promising technologies such as aircraft or vessels, nuclear power plant propagation and interferences (Kim *et al.*, 2015).

Li-Fi system applications: Li-Fi system is being applied to a variety of industries such as indoor navigation based on the LBS using high accuracy, ITS (Intelligent Transportation Systems) various cultural contents delivery (music or movie, etc.) u-home construction for ubiquitous network. Furthermore, high definition video (HD, 4K, etc.) transmission, backbone network configuration, wireless communication environment improvement in the area of traffic congestion, etc.,

Table 2: Patent trends of Li-Fi technology

Variables	Patent applications	Patent share (%)
VLC-PHY	221	45
App service	136	28
Others	133	27
Total	490	100

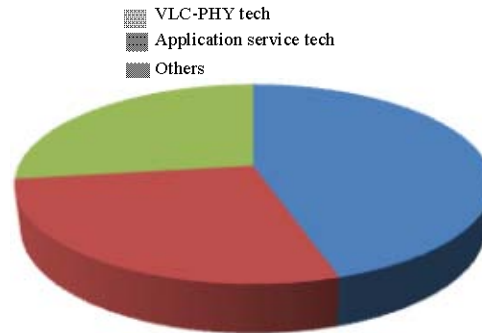


Fig. 2: Number of patent application (Anonymous, 2015a, b)

high speed telecommunications services is expected (Hee-Suk, 2016; Kwon, 2017; Kim *et al.*, 2015, 2016) (Table 1).

Patent trends of Li-Fi system: LED-VLC (380~780 nm wavelength) technology using optical wireless communication takes place in a way that a short distance from the current technology adoption stage. Gradually, the indoor location-based services including a wide variety of products and services are being developed and that the scope of use and usage continues to increase. Increases the efficiency of LED lighting equipment prices lower recently, a trend was used in a variety of fields to an existing tradition's lights as the next-generation light source that can replace culled. A wide range of digital devices in the near future this LED-VLC wireless technology is expected to be spread. Li-Fi technology, SAMSUNG Electronics, ETRI, SIEMENS, France Telecom, Oxford University, SONY, VLCC, etc. The 802.15 IEEE WNG VLC IG by participating international standardization. If you look at the status of the PCT patent related to VLC-PHY technology 221 (45%), application service technology 136 (28%) and is follows (Table 2) (Fig. 2).

RESULTS AND DISCUSSION

Li-Fi system commercialization trends

Overview and strategy: The Ministry of Trade and Industry of Korea is promoting the 'LED lighting 2060 project'. In addition, TTA in VLC service level 1 (WG4021) founded by an expert such as ETRI and SAMSUNG electronics since 2006 and is active in research and development in progress (Cisco, 2015).

Table 3: Li-Fi system commercialization trends

Countries	System trends
Korea	International standard adoption (IEEE 802.15.7)
France	Important beachhead of ICT convergence VLC technology
	In 2014, development of technology/application/solutions
	June 2014, Thompson lighting, product launching
United Kingdom	Thorn, Li-Fi-based LED lighting test
	EDF optimus solutions, Li-Fi experience installation
	SNCF, service test in train station
United Kingdom	Implementation of the existing Germany institute (3G bps)
China	High rate implementation of 10 Gbps
China	1W LED: 150 Mbps realization

VLC Tech-related data/re-composition

- Li-Fi system standards of Korea are research and development of VLC-PHY technology, VLC-MAC technology and VLC application protocol
- In 2011, ETRI has completed the development of a visible light wireless PHY, LED driver and visible light radio PHY modulation techniques are driving modules rolled into one
- These findings, IEEE 802.15 meeting held July 2014, the radio PHY/MAC technology visible in Korea proposed adopted by international standards

Li-Fi system is an early stage commercialization currently a trend yet but the not so exciting reasons to pay attention to this technique is by far the most of short distance wireless communications technology known as the fast WLAN (802.11ac, 6.93 Gbps) than about 1.4 times faster transfer rate (10 Gbps) because you can implement (Dong, 2016; Jeon and Lee, 2016). This around the world, focusing on the development of technology for the commercialization of LED-VLC (Jang, 2016). In particular, France and the United Kingdom and other European and central asian people's China and Korea are relatively active in the technical development of this Table 3.

Marketability of Li-Fi system: LED-VLC technical market as well as improving the performance of wireless communications technology, high value-added industries with the growth of interest in visible light collected. LED lights and lower manufacturing costs by reducing communications costs have market growth potential, competitive price are endless is expected to do. LED-VLC industry at home and abroad over a brief summary follows (Patcharaprakiti *et al.*, 2015): Korean Government (Ministry of industry) is planning to replace 60% of lighting by 2020 through the 'LED 1530 Project'. This LED lighting market to domestic annual is expected to reach ten trillion. LED-VLC front and back related global market size in 2011 is 12 trillion and 5,000 hundred million dollars from an average of CAGR 84.98% high-speed growth sustained by 88 trillion and 9,000 hundred million dollars and is expected to from karge market in the begning of. 5G mobile communication ssystem and to pepare for at the present time

Table 4: Global market growth trend of Li-fi system

Years	Market size (\$ billion)
2011	125,000
2016	514,000
2018	889,000
CAGR (%) (2011~2018)	849

Patcharaprakiti *et al.* (2015)/re-composition

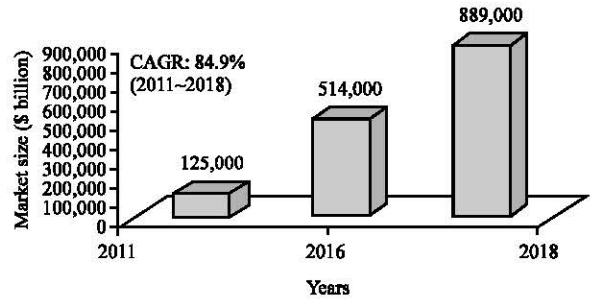


Fig. 3: Market size (\$ billion)

these market growth trends are guessed a big change next-generation wireless LAN global market (Table 4) (Fig. 3).

Future challenges of Li-Fi system

Prospect of Li-Fi system: Current LED-VLC system (1 W LED bulb) is the one that your computer can connect to the internet, four speeds of 150 Mbps has seen much of the technology that can be transferred. Visible light rays (infrared/visible/UV/X-ray/a-ray) are non-visible LED-VLC technology using electromagnetic waves of high frequency, compared to 380~750 THz because it uses 10 thousand times higher than the full-frequency wireless broadband has the characteristics (Cisco, 2015). LED-VLC system is there a limit to the frequency band used in preparation for Wi-Fi do not have free access to a common frequency around the world (Colin, 2010). Therefore, the frequency can help us bridge the shortage problem. We don't have a problem with the above frequency allocation LED-VLC system compatible with visible light spectrum within the global use of no restrictions on free radio has the advantage that you can implement. In addition, go to the digital signal transmission system in a digital so a separate inverter (converter) is required. Also do not use radio waves to the aircraft or vessels including a nuclear power plant propagation and interference can be applied effectively in sensitive areas is a promising technology (Kim *et al.*, 2016; KCC, 2014).

Challenges of Li-Fi system: Technical barriers need to be overcome as the Li-Fi system) light wave because they do not have the permeability characteristics transmission between communication is impossible, due to the light that gets blocked as obstacles) signal can be broken, a strong light from the outside such as PV) depending on

the strength of the light communication distance) subject's telecommunications is limited. If you address these barriers present in the status of a local area wireless next-generation wireless LAN the overload of information and communications technology will be able to pick up a seat. Political, economical, social and technical LED-VLC technology in terms of inhibition factors are summarized as follows (Hwan, 2016):

- Technical aspects: service experienced slowing of core technology
- Economical aspects: components and materials, high-Foreign dependence, that fast-growing developing countries, domestic economic growth and market
- Social aspects: poor infrastructure, lack of skilled workers, installing
- Strategic aspects: ICT industry for promoting policy change is inevitable, LED lights, high price

CONCLUSION

Li-Fi system (visible light LED-based wireless system) does not use electromagnetic waves, electromagnetic interference must be harmless. Due to electromagnetic waves in sensitive areas such as airplanes, hospitals, nuclear power plants, etc., therefor, Li-Fi system is expected to be wireless local area information communication standard of next generation of e-commerce payment systems field. Using VLC-LED lighting technology based Li-Fi systems are going to spread these values that indoor navigation technology, ITS, contents delivery and u-home construction, etc. In indoor navigation division, GPS system's barriers will be able to solve with difficult to operate in the field of indoor. In ITS division will be able to provide service convenience transport facilities, depending on the circumstances by controlling the driver automatically. In cultural contents delivery division will be able to accelerate the popularization with cloud computing technology and IoT and wearable devices (M2M/D2D) communication services. In u-home construction division, intelligent network services will be able to implement through wired and wireless network integration. In the field of building both wired and wireless network u-home intelligent network services through integration, you will be able to implement.

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