PERFORMANCE OF LI-FI TECHNOLOGY WITH COGNITIVE RADIO NETWORK IN 5G TECHNOLOGIES- A SURVEY

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Abstract- The 5G wireless mobile network addresses the evolution beyond mobile internet to massive IoT (Internet of Things) from 2019/2020 onwards. The most evolution compared with today's 4G and 4.5G (LTE advanced) is that data speed enhancements. Past simply speed enhancements, 5G is relied upon to release a tremendous IoT ecosystem any place systems will serve communication for billions of associated gadgets, with the best possible trade-offs between speed, latency and cost. Like all wireless transmission system, 5G network also require to use frequency spectrum to transmit data. So as to support higher bandwidth, 5G require high frequency range, presently upto a couple of tens of GHz and millimetre waves, however that the new network generates radio frequency radiation will injury deoxyribonucleic acid and result in cancer and it will increase the path loss. So, one various to attain these objectives with reducing impact of radiation on health risks is to use different accessing techniques in outdoor and indoor environments. The light fidelity (Li-Fi) with the cognitive radio (CR) technology is one of the promising solutions to extend the transmission capacity in the indoor scenario. It is based on light emitting diodes (LEDs) to enable high speed communication and secure data transmission in communications with fully networking capabilities. This paper administers recent advances in analysis associated with Li-Fi technology with cognitive radio technology in 5G technology, diversifying the wireless communication with hiking spectrum utilization and immense capacity.

Keywords- 5G Networks, IoT (Internet of Things), Cognitive Radio (CR), Light Emitting Diode (LED), Light Fidelity (Li-Fi) Communication, Visible Light Communication (VLC).

I. INTRODUCTION

Nowadays, we tend to area unit witnessing a proliferation within the usage of mobile devices as well as smart phones, tablets, laptops and Internet of Things (IoT). This has elicited a vital growth of the mobile traffic. The rise within the range of mobile devices that use wireless property is anticipated to continue within the future. With the fast development in communication applications the requirement for data rate inflated. To beat this issue, the analysis and industrial communities had begun engaged on the event of the new generation of mobile technology named as the 5G mobile networks. The most target of the new customary is to boost the capacitance and transmission performance compared to the present technologies. Higher data speeds are currently bonded for applications like streaming video, video conferencing, and virtual reality. To realize this kind of performance, the network can probably want a lot of small cell coverage and can take profit of higher bandwidth spectrum. At the same time, 5G is additionally designed to be the network for the Internet of Things (IoT).

One rising side of the 5G vision is that the conception of heterogeneous networks [1], wherever macrocells base stations co exist with low price and reduced coverage tiny cells operational on the authorised and unauthorised bands to satisfy the increasing demands on mobile data rates. This had been formed on the observation that using higher frequencies to satisfy the data rate demand can increase the path loss and shadowing becomes harder to beat and it additionally cause health risks.

One promising solution is to separate the indoor and the outdoor connectivity, which can want subtle backhauling infrastructure to support the necessary range for ever smaller cells that may compose the mobile 5G network architecture. Significantly, Light Fidelity (Li-Fi) could be a promising technology, which can enable efficient indoor cellular deployment solution built on existing lighting infrastructures [2]. The Li-Fi technology exploits light emitting diodes (LEDs) that are being wide deployed in homes, offices, and streetlights lighting systems to produce high speed wireless communication. Light Fidelity uses flickering LED light bulbs with intensity faster than human eyes to follow yet with

constant outputs for the optical data transmission [3]. To beat the path loss drawback in 5G technology, solution is to use cognitive radio (CR) technology with Li-Fi technology.

Surging advancement within the technology is needed to fulfill the escalating demand over the generations to access wireless spectra for data transmission. To alleviate the matter of spectrum scarcity crisis, many innovative techniques have been developed over the times. Propounded by Dr. Joseph Mitola [4], Cognitive Radios service to produce best spectrum utilization by ways of Spectrum Sensing by instant identification of the unoccupied authorised band of the Primary User, draw to the channel by the Secondary User (unlicensed user) with none hindrance to Primary user's operation and vacating once the authorised user grips to it explicit channel.

Prime benefits offered by cognitive radio with Li-Fi technology are

1) Improved efficiency by permitting unauthorised users to exploit spectrum while not cause any interference to authorised users.
2) Highly reliable communication as and once needed.
3) Li-Fi provides larger bandwidth than Wi-Fi and it provides a more secure atmosphere.

The rest of the paper is organized as follows: Section II of the paper describes about cognitive radio networks and Li-Fi technology. Section III gives the comparison between Wi-Fi and Li-Fi. Section IV describes review on integration of Li-Fi technology with CR. Section V concludes the paper.

II. COGNITIVE RADIO NETWORKS AND LI-FI TECHNOLOGY

A. Cognitive Radio Networks:

Cognitive radio could be a radio that alters its transmission parameters according to the setting within which it operates. Cognitive radio is dynamic in nature. The most objective of CR is to decide the best spectrum. The CR user senses the spectrum so as to search out the vacant one. The vacant spectrum is named as the spectrum holes or white space. CR user continues its transmission till the PU reappears otherwise it leaves the spectrum [5].The CR user ought to bear in mind regarding the interference level with the PU. For seamless transmission it moves to new vacant spectrum. Cognitive radio networks spectrum hole idea will perceive through Fig.1.

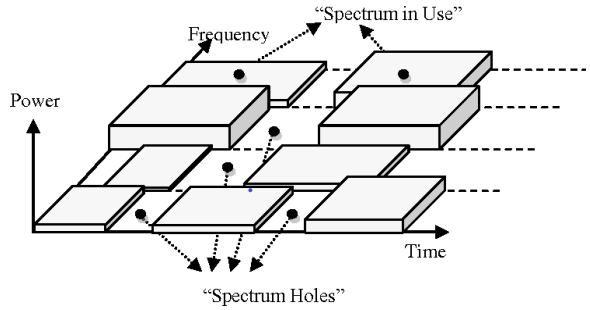

Figure 1: Cognitive radio networks idea

The main characteristics of cognitive radio are:

1) *Cognitive capability*: It refers to the flexibility of CR node to sense and gather the knowledge like transmission frequency, bandwidth, power, modulation, etc from its setting. By acceptable sensing the SU will opt for the best spectrum by adjusting the parameters.

2) *Reconfigurability*: It adjusts the parameters like operative frequency, modulation, transmission power, etc. Supported the gathered data with none modification in hardware elements [6].

The main functions of CR are illustrated in Fig.2. The CR senses the setting and collects the knowledge. Supported this it make a decision and change the parameters. These functions are named as spectrum sensing, spectrum decision, spectrum sharing and spectrum mobility.

1) Spectrum sensing: CR senses the spectrum and determines the spectrum holes. Additionally it captures their data.
2) Spectrum decision: Out of the perceived spectrum the CR selects the best spectrum and determines the transmission parameters.
3) Spectrum sharing: It coordinates the spectrum access with alternative users.
4) Spectrum mobility: SU vacate the channel once the commissioned user reappears. For continuous transmission the CR user moves to a different spectrum hole.

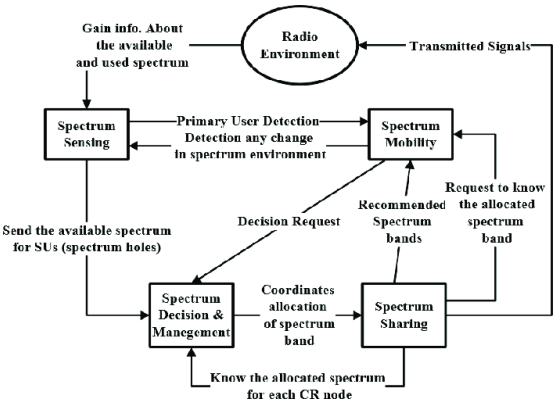

Figure 2: Cognitive Radio Cycle

B. Li-Fi Technology:

Li-Fi involves LED bulb at transmitting end, mobile devices and photo-detectors at receiving end to access the binary information via light as shown in Fig.3. Digital 1 is transmitted when LED is in ON state and vice-versa when it is OFF. By altering the brightness of light through LED bulbs unsteady in manner that is imperceptible to human eye, data can be communicated at totally different rates. The photo detector receives the data from an infrared transmitter which allows high speed full-duplex data communication [3].

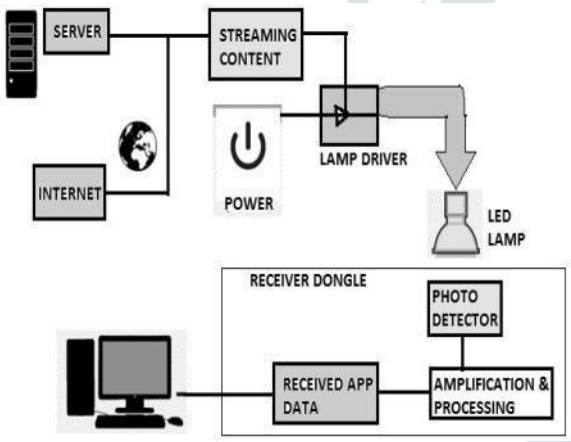

Figure 3: Li-Fi technology block diagram

A block construction of the Li-Fi system is shown in Fig.3. Power supply produces constant power for lamp driver. Lamp driver hook up with the internet connection. Switch and LED lamp is connected lamp driver with fibre optic cables. LED lamp acts as a communication source. Microchip that is found in LED lamp converts the data into light. Rapid information is transmitted utilizing light beam from LED light to photograph indicator. Receiver detects dynamic in intensity of the light beam and converts the data into electrical signal [10]. This converted information is transmitted to the technological devices [9].

Li-Fi has a variety of applications because of providing quick speed Internet access and using visible light. Wi-Fi uses radio waves for communication. However, Wi-Fi connection cannot permit in some places (hospitals, airplanes, etc.) due to radiation issues and interfering with alternative radio signals [8]. Unlike Wi-Fi, signals of checking equipment can't be blocked utilizing visible light.Thus, Li-Fi is often employed in hospitals to access Internet and management the medical equipment. In addition, it may be used for robotic surgery in close to future [12].

C. Operation Principle of Li-Fi:

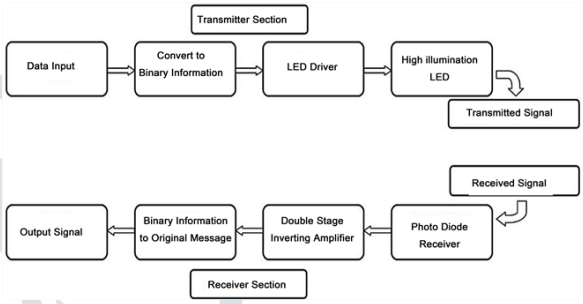

Figure 4: Design of Li-Fi Transceiver

In data transmission (design of Li-Fi Transceiver shown in Fig.4), Li-Fi utilizes light waves rather than radio waves so visible light spectrum is employed Li-Fi technology. Visible light spectrum is 10,000 times greater than radio frequency spectrum. Therefore, Li-Fi technology offers unlimited capacity in wireless network system [9]. Although the transmission speed of fluorescents light source is 10Mb/s, LED (light emitter diode) light transmission speed is 500Mb/s. Therefore, LED light source is most well liked in Li-Fi systems [10]. Essentially, Li-Fi is a Visible Light Communication system (VLC) that uses high brightness white LED lights to transmit data without wires. In alternative words, not only Li-Fi transfers information wirelessly but it also receives information wirelessly [8], [10].

In principle, LED lamps can be turn on and off very quickly and this situation cannot be realized in human eye. If light is on state, a digital 1 is transmitted. If light is off state, a digital 0 is transmitted. LED can be switched on and off within nanoseconds, which provides smart chance for transmitting information [10]. A photo detector, which is p-i-n photodiode or avalanche photodiode, receives transmitted data from the light source and decodes the information [11], [10]. Parallel data transmission can be produced using LED arrays so data transmission speed is augmented.

III. COMPARISON BETWEEN WI-FI AND LI-FI

Current wireless innovation, which is called Wi-Fi, has different issues. These problems can be divided into three main groups that are capacity, efficiency and security [9]. Radiofrequency range is narrow so Wi-Fi technology offers constrained bandwidth. In addition, 3G and 4G technologies run out of this limited radio spectrum [13]. In any case, visible light spectrum is multiple times more extensive than radio frequency spectrum so Li-Fi innovation offers unlimited capacity for communication systems.Accordingly, Li-Fi technology is ready for IoT and 5G [13].

From one viewpoint, Wi-Fi technology utilizes base station or cellular radio poles to transmit informationutilizing radio waves. 1.4 million Base stations consume remarkable energy particularly to cooling stations. The efficiency of these stations is only at about 5% [13]. Then again, Li-Fi utilizes light waves to transmit information utilizing LEDs. LEDs consume less energy as compared base stations. It tends to be seen clearly, wireless communication can be less expensive and more effective utilizing Li-Fi technology.

Energy efficiency of Wi-Fi network declines quickly while clients increasing. In any case, the energy efficiency of Li-Fi network stays constant along aenormous number of clients.Radio waves can pass through walls and any objects in environment so private networks can be used by someone else [8]. This situation increases security problem in Wi-Fi communication. Light cannot pass through any articles and walls so private network can't be utilizedby another person for any negative purpose. Therefore, Li-Fi provides secure and private environment. Radio frequencies penetrate human body and can cause cell mutation but light are not harmful for human body. Unlike Wi-Fi, Li-Fi offers safe and green communication environment [8].

Feature	Li-Fi	Wi-Fi
Full Form	Light fidelity	Wireless Fidelity
Operation	Data transmission using light with the help of LED bulbs	Data transmission using radio waves with the help of Wi-Fi Router
Interference	Do not have any interference issues like radio waves	Interference issues from access points
Technology	Present IrDA compliantdevices	WLAN 802.11 standard compliant devices
Applications	Used in airlines, hospitals,undersea, Office and home.	Used for internet browsing with the help of Routers
Merits	Interference is less, can pass through salty sea water, works in densy region	Interference is more, cannot pass through sea water, works in less densy region
Privacy	Light is blocked by the walls and hence will provide more securedata transmission	RF signals can penetrate through walls so security is less for data Transmission
Frequency of operation	10 thousand times of radio frequency spectrum	Upto 5GHz
Coverage distance	Abou 10 meters	About 32 meters

Table 1: Comparison of Li-Fi with Wi-Fi

IV. INTEGRATION OF LI-FI TECHNOLOGY WITH COGNITIVE RADIO

Growing demand of wide spectrum bandwidth to serve multiple wireless applications consistently draws an attention towards a network with multi disciplinary usage capabilities [14]. In order to overcome the below mentioned issues, the concept of Cognitive Radio is used for multi user operation.

Following are the limitations of Li-Fi:

- Relies on Line of Sight and immobile transmitting ends.
- Range limitations due to physical barriers in the transmission path.
- Lamp failures.
- Insignificant transceivers.
- Constricted user service sustainability.

We can consider an indoor environment where both optical Li-Fi and radio frequency Primary Users operate. The predefined users are though using the optical and radio spectrum yet there remains unused optical spectrum which is not fully exploited plus the Radio spectrum also has white spaces. Hence, to use the underutilized spectrum, non-legitimate Cognitive Users are deployed which operate according to the user requirements.

Optical spectra remains underutilized when devices are less so it can be used by placing a cognitive based photo detecting receiving end in the Li-Fi network which enables increased users capacity. Whereas the Cognitive Radio will also search for the TV White Spaces in the existing RF spectra by firstly detecting the primary user (licensed user) using spectrum sensing and transmits data when possible as in Fig.5.

This hybrid methodology to use both the optical as well as radio spectrum can be used during heavy traffic loads resulting in significant capacity build ups. However, once the legitimate user arrives back the cognitive radio user has to step to another available channel via spectrum handoff mechanisms [15].

a) Lamp Failure: Spectrum Mobility is a method by which CR user changes its frequency of operation by transitioning to best available spectrum. Difficulty to maintain sustained connectivity due to lamp failure can be rendered as a poor networking which can be compromised by enabling the secondary user to work on the cognitive RF mode. CR based photo detecting receiver automatically would hook either to most certain RF channel once after the primary users interference or to strongest lamp once on availability for maintaining continuous communication.

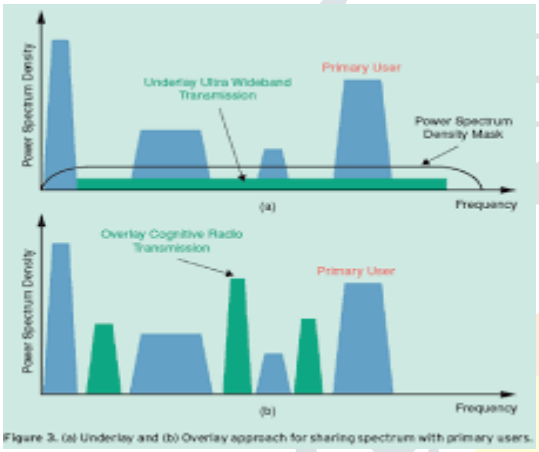

Figure 5: Secondary user access in CR

b) Traffic Priority: The traffic can be divided as either high priority or the low priority traffic based on the data rate, bandwidth, distance from the resource and mobility of the users as. Aggregation of cognitive radio with Li-Fi can be modelled to direct high priority users to use RF spectrum while enabling low priority users to transmit on to the optical spectrum as [16]. Certainly, this will account for better spectrum management and efficient resource utilization.

c) Multi User Sustenance: It's the drawback of Li-Fi that its operation requires sustained Line of Sight and light can't penetrate through walls. This problem can eventually be sorted out by the usage of Cognitive subscribers of the licensed RF spectrum which work using wideband sensing frequency reconfigurable, radiation pattern reconfigurable, polarization reconfigurable antennas as described in [7].

d) Denial of Services: Li-Fi is susceptible to malicious attacks due to interference from sunlight but using a Cognitive Radios sensing the spectrum cooperatively, the properties of the resource head can be known prior thus wasteful transmission over insignificant path can be possibly avoided.

V. CONCLUSION

In this paper, a brief introduction of CR technology presented. A survey is conducted on to different technologies present for data transmission namely Wi-Fi and Li-Fi. In this paper, concluded the advantages of Li-Fi technology over Wi-Fi and gives the comparison here. Further studied implementation of Li-Fi technology with CR Technology because of its advantages. From the extensive review conducted it can be concluded that, every technique has its own merits and demerits. Hence, it is necessary to implement them based on the applications. One issue in implementing Li-Fi is to select the appropriate access technique in the multiuser environment. Many researchers are currently working on developing different algorithms for different methods to improvement in wireless communication technologies.

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