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Suggestive Solution to Security and Short range problems using RF/OWC Hybridization

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ABSTRACT

As the knowledge of wireless technology keeps growing exponentially in the field of telecommunication, new ideas spring up over time to address and proffer solutions to generational wireless communication issues. In this term paper, the reasons for wireless technology growth was explained, and a detailed information on emerging wireless technology was highlighted. The paper highlights the idealistic of heterogeneous networks, how security and short range within the network can be solved through a suggested solution of hybridizing RF and OW.

Keywords: Hybrid Network, RF, OWC, FSO, WiFi, ZigBee.

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INTRODUCTION

Over the years, wireless technology propagations have been used in many aspects of human activities and interactions with the immediate environment. An ample number of insensitive users of wireless technology tools tolerably make use of these tools without taking notice of the trade-offs which are often times inconsequential when in use. Sensitive IT (Internet Telecommunication) users/organizations are perceived to be sceptical about whether there will ever be a wireless technology that would be panacea to wireless technology issues; especially in a trade-off between long-range communication network and secured network. However, the internet still constitutes the largest heterogeneous network and infrastructure in existence.

Literature has it that over 3 billion people had access to the Internet in 2014. Also, there are as many mobile subscriptions (6.8 billion) as there are people on earth [1]. Global mobile data traffic was estimated at 2.5 Exabyte per month in 2014. This value is estimated to rise to 24.3 Exabyte per month at an annual growth rate of 57% in 2019 [2]. This can be attributed to a number of technological factors including the rapid growth of smartphones, tablets, and other devices of their kinds; and, significantly, the evolvement and technological advancement of wireless and mobile technologies. On the other hand, heterogeneous network of connected sensors and actuators attached to a wide variety of everyday objects [3].

There is a need to manage a number of wireless technology tools connected to the Internet generating a large amount of traffic across heterogeneous networks, particularly those technology tools with low-power capabilities e.g. Bluetooth, BLE, Zigbee, 802.11ah, 6LowPan, Zwave, Lora etc. This paper suggests a possible way to address the security challenge in supporting a secured communication between various technology tools in an ecosystem of coexisting devices and at the same time retain a long range propagation.

EMERGING WIRELESS TECHNOLOGY

The first thing an IT investor needs to know is what an emerging technology is and the state-of-the-art. For the investor, an emerging technology is one that offers a relatively undiscovered method to solve a discouraging wireless problem in a secured and cost-effective ways. The methods or technology itself may be non-conventional, but emerging technologies that become mainstream are typically more evolutionary than revolutionary. This is because a technology cannot succeed by itself.

Over the years, there has been rapid increment in the evolution of wireless technologies, with each evolution aimed at addressing their immediate communication problems.

Security is a big concern in wireless networking, especially in m-commerce and e-commerce applications. Mobility of users increases the security concerns in a wireless network. Current wireless networks employ authentication and data encryption techniques on the air interface to provide security to its users. The IEEE 801.11 standard describes wired equivalent privacy (WEP) that defines a method to authenticate users and encrypt data between the PC card and the wireless LAN access point. In large enterprises, an IP network level security solution could ensure safety of corporate network and proprietary data. Virtual Private Network (VPN) is an option to make access to fixed access networks reliable. Since hackers are getting smarter, it is imperative that wireless security features must be updated constantly [4].

The most important shortcoming in Wi-Fi is the range. There may be difficulties in making a connection with a receiver which is 50-75 m away (inside the buildings). The signal should be stronger to provide larger connectable spaces. Additionally, some of the wireless adapters work on the frequencies that are currently used by many other wireless devices. It can cause serious interference, so the connection performance can be quite poor [4].

EMERGING WIRELESS COMMUNICATION TECHNOLOGY TYPES

Currently, wireless communication system has become an essential part of various types of wireless communication devices that permits user to communicate even from remote operated areas. There are many devices used for wireless communication like mobiles. Cordless telephones, ZigBee wireless technology, GPS, Wi-Fi, satellite television and wireless computer parts. Current wireless phones include 3 and 4G networks, Bluetooth and Wi-Fi technologies.

Satellite Communication: Satellite communication is one type of self-contained wireless communication technology, it is widely spread all over the world to allow users to stay connected almost anywhere on the earth. When the signal (a beam of modulated microwave) is sent near the satellite then, satellite amplifies the signal and sent it back to the antenna receiver which is located on the surface of the earth. Satellite communication contains two main components like the space segment and the ground segment. The ground segment consists of fixed or mobile transmission, reception and ancillary equipment and the space segment, which mainly is the satellite itself.

Infrared Communication: Infrared wireless communication communicates information in a device or systems through IR radiation. IR is electromagnetic energy at a wavelength that is longer than that of red light. It is used for security control, TV remote control and short-range communications. In the electromagnetic spectrum, IR radiation lies between microwaves and visible light. So, they can be used as a source of communication for a successful infrared communication, a photo LED transmitter and a photo diode receptor are required. The LED transmitter transmits the IR signal in the form of non-visible light that is captured and saved by the photoreceptor. So the information between the source and the target is transferred in this way. The source and destination can be mobile phones, TVs, security systems, laptops etc. supports wireless communication.

Broadcast Radio: The first wireless communication technology is the open radio communication to seek out widespread use, and it still serves a purpose nowadays. Handy multichannel radios permit a user to speak over short distances, whereas citizen's band and maritime radios offer communication services for sailors. Mostly an audio broadcasting service, radio broadcasts sound through the air as radio waves. Radio uses a transmitter which is used to transmit the data in the form of radio waves to a receiving antenna (Different Types of Antennas). Radio broadcasting may be done via cable FM, the net and satellites. A broadcast sends information over long distances at up to two megabits/Sec (AM/FM Radio). Radio waves are electromagnetic signals that are transmitted by an antenna. These waves have completely different frequency segments, and you will be ready to obtain an audio signal by changing into a frequency segment.

The frequency spectrum of RF lies in the range of 30 kilo Hertz (KHz) to 300 Giga Hertz (GHz). This spectrum has been widely used largely due to restricted interference and wide area coverage. The spectrum is divided into sub-bands and is either exclusively licensed to the operators or un-licensed. The most commonly used unlicensed frequency bands are 2.4-2.4835 GHz for low power equipment. Low power equipment supports maximum transmitter output power of 1 Watt. The operating range is 5.150-5.350 GHz, 5.725 – 5875 for low power equipment for cellular telecom systems including radio local area networks and indoor applications (maximum mean effective isotropic radiated power of 200mW). The important features of the various wireless technologies presented in this section is easily and widely available [5].

Microwave Communication: Microwave wireless communication is an effective type of communication, mainly this transmission uses radio waves, and the wavelengths of radio

waves are measured in centimeters. In this communication, the data or information can be transferred using two methods. One is satellite method and another one is terrestrial method. Wherein satellite method, the data can be transmitted through a satellite that orbit 22,300 miles above the earth. Stations on the earth send and receive data signals from the satellite with a frequency ranging from 11GHz-14GHz and with a transmission speed of 1Mbps to 10Mbps. In terrestrial method, in which two microwave towers with a clear line of sight between them are used, ensuring no obstacles to disrupt the line of sight. So it is used often for the purpose of privacy. The frequency range of the terrestrial system is typically 4GHz-6GHz and with a transmission speed is usually 1Mbps to 10Mbps. The main disadvantage of microwave signals is, they can be affected by bad weather, especially rain.

Wi-Fi: Wi-Fi is a low power wireless communication that is used by various electronic devices like smart phones, laptops, etc. In this setup, a router works as a communication hub wirelessly. These networks allow users to connect only within close proximity to a router. Wi-Fi is very common in networking applications which affords portability wirelessly. These networks need to be protected with passwords for the purpose of security, otherwise it will be accessed by others.

Bluetooth Technology: The main function of the Bluetooth technology is that it permits you to connect a various electronic devices wirelessly to a system for the transferring of data. Cell phones are connected to hands free earphones, mouse, and wireless keyboard. By using Bluetooth device the information from one device can be transferred to another device. This technology has various functions and it is used commonly in the wireless communication market.

ZigBee: ZigBee is a wireless communication standard designed to address the unique needs of low-power, low-cost wireless sensor, and controlled networks. ZigBee can be used almost anywhere, as it is easy to implement and requires little power to operate. ZigBee has been developed looking into the needs of the communication of data with a simple structure like the data from the sensors.

Wireless Low-Power Technologies

Energy consumption has always been a limiting factor in many wireless network applications. This limiting factor continued as a major challenge facing the development of many applications in the realms of wireless applications, especially in wireless sensor networks and Internet of things (IoT). The invention of technologies such as Bluetooth Low-Energy (BLE), Low Range (LoRa), ZigBee, IEEE 802.11ah, 6LowPan, etc., birthed the solution to energy consumption limitation, making low-power consumption an essential requirement to the success of wireless sensor networks [6]

Wireless Long-Range Technologies

The focus of successful communication technology is on long ranges, reliable communication, and low power consumption for extended battery life.

With these goals in mind, the Third Generation Partnership Project (3GPP) has created the LTE machine-type communications (LTE-M) standard. LTE-M transmits in the licensed sub-GHz band at between 700 MHz and 900 MHz. The downlink and uplink data rates are roughly 1 Mbps. The low power consumption approach could help to extend the life of battery-powered end devices up to between 10 and 20 years. LTE-M also uses the existing cellular wireless infrastructure, providing excellent coverage, and operates on the well-known licensed spectrum, making it more safe and robust – ideal for services with high quality requirements.

LoRa is very similar to the SigFox technology, as LoRa also uses the sub-GHz band (868 MHz in Europe), achieves similar ranges (up to approx.15 km), and is economical due to low data rates ranging from 0.3 to 22 kbps. In contrast to SigFox, LoRa utilises chip spread

spectrum technology to set the ratio between bandwidth and bitrate.

HETEROGENEOUS/HYBRID NETWORK

Heterogeneous network (HetNet) is an architecture with concurrent operation of different technologies, as well as various base stations (BSs) classes (i.e., macro, pico, and femto) [7]. This architecture can provide a flexible coverage and improved spectral and energy efficiency. Overlaying different classes of BSs can also potentially provide a solution for the growing data traffic, especially when the transmission is optimised to take advantage of the HetNets characteristics. It is obvious that HetNet is different paradigm from conventional macrocell-only wireless networks [8].

Consider the heterogeneous cellular system depicted in Figure 1. This cellular system consists of regular (planned) placement of macro base stations that typically transmit at high power level (~5W - 40W), overlaid with several pico base stations, femto base stations and relay base stations, which transmit at substantially lower power levels (~100mW - 2W) and are typically deployed in a relatively unplanned manner.

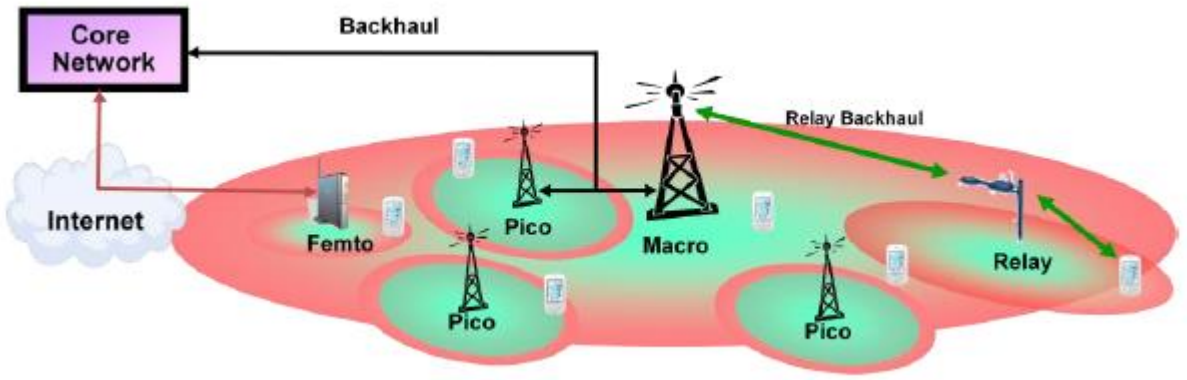

Figure 1: Heterogeneous Network utilizing mix of macro, pico, femto and relay base stations [9].

In a homogeneous network, each mobile terminal is served by the base stations with the strongest signal strength, while the unwanted signals received from other base stations are usually treated as interference. In a heterogeneous network, such principles can lead to significantly suboptimal performance. In such systems, smarter resource coordination among base stations, better server selection strategies and more advanced techniques for efficient interference management can provide substantial gains in throughput and user experience as compared to a conventional approach of deploying cellular network infrastructure.

RF WIRELESS COMMUNICATION

Radio-frequency (RF) wireless communication systems have been around for many years with applications ranging from garage-door openers to satellite communication [10].

In RF wireless communication systems, radio waves are used to transfer information between a transmitter (Tx) and a receiver (Rx). RF systems can be classified as either terrestrial-based or space-based systems. Terrestrial-based systems include microwave point-to-point, WLANs, and cellular mobile radio, to mention only a few. Terrestrial microwave systems are limited in distance and line-of-sight (LOS) propagation is the limiting factor. Relay towers with carefully aligned directional antennas are often used to provide an unobstructed path over an extended distance. The data signal is processed, up- or down-

converted, modulated or demodulated, filtered, and amplified at the transceivers. The transmitted signal propagates through the air and is attenuated by several propagation mechanisms [10].

Space-based systems (e.g., satellites) are similar to terrestrial microwave systems except that signals travel from earth-based ground stations to a satellite (uplink), and a signal is sent back from the satellite to another earth-based ground station (downlink). This achieves a far wider coverage area than the earth-based systems. The satellite system could be in geostationary earth orbit, medium earth orbit, or low earth orbit [10].

Figure 2 shows the various forms of RF-based wireless communication systems, which is classified into six groups: microwave RF systems, fixed and mobile satellite systems, wireless networks and protocols, personal communication systems, remote sensing systems, and emerging wireless technologies. No distinction is made between the communication layers and protocols in this classification. These systems transmit and receive radio waves tuned to specific bands of frequencies.

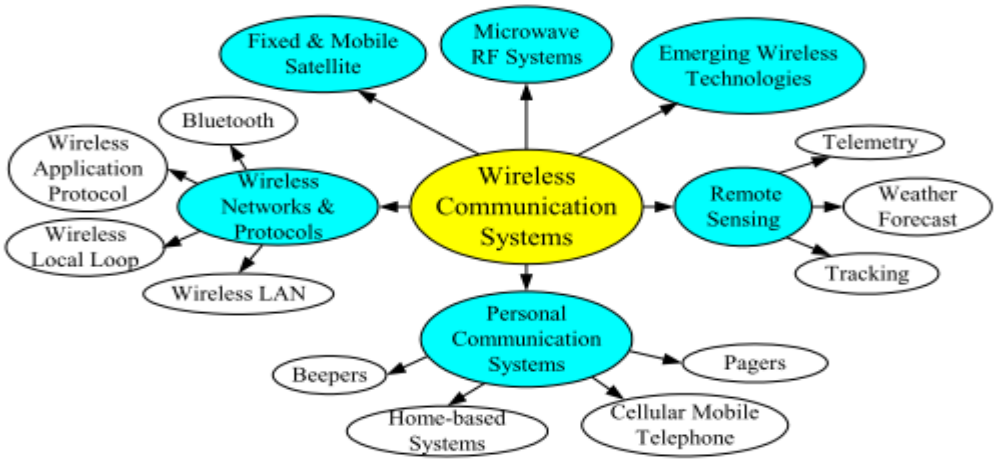

Figure 2: Different forms of radio-frequency (RF)-based wireless communication systems [11].

In wireless communication, radio waves are used to transfer information, and because radio waves propagate in space, they are susceptible to some security risks. An intruder can intercept the signal or gain access to network services, without being an authorised user. The specific risk associated with wireless communication is presented later.

OPTICAL WIRELESS COMMUNICATION

Optical Wireless Communication (OWC) refers to data transmission in unguided propagation media through the use of an optical carrier. OWC are categorised into three main types, which are Free-Space Optical (FSO) communications, Visible Light Communications (VLC), and Ultra-Violet (UV) Communications. FSO communications and UV Communications use the Infra-Red (IR) band (750 nm - 1600 nm) and the UV band (200 nm - 280 nm), respectively, to allow for outdoor long and short ranges data transmission. On the other hand, VLC - also known as Li-Fi for Light-Fidelity - uses the visible light band (380 nm - 780 nm) to allow for indoor short-range data transmission [12].

Free Space Optics (FSO)

An FSO transmission system consists of an optical transmitter and an optical receiver which uses the atmosphere as the transmission media for the optical signal (specially, a laser beam) as shown in Figure 3.

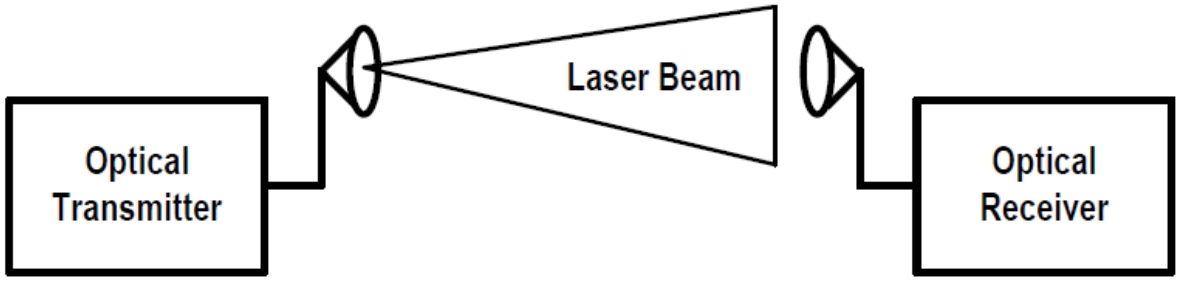

Figure 3: FSO system block diagram [13].

FSO communication is a line-of-sight (LOS) technology operating at wavelengths of 850 nm, 1300 nm and 1550 nm corresponding to the optical communications 1st, 2nd and 3rd transmission windows, respectively. It can be used in a number of applications ranging from high bit-rate links between buildings, buildings to optical fiber networks, ground to vehicles and trains, vehicle to vehicle, next generation wireless broadband networks, the last-mile access. With rapid development and maturity in the optoelectronic devices, FSO has now witnessed a restore in many applications. Recently, the radio over FSO technology is regarded as a new universal platform for enabling seamless convergence of fiber and FSO communication networks, thus extending broadband connectivity to underserved areas [14].

The fact that FSO is transparent to traffic type and data protocol makes its integration into the existing access network far more rapid, reliable and profitable way in comparison to the traditional fibre communications. Despite these advantages FSO performance is degraded mainly by the atmospheric conditions such as fog, smoke, aerosol, and turbulence; and the presence of pointing errors. Aerosol scattering and absorption due to rain, snow and fog result in significant optical power attenuation, beam spreading and link distance reduction, severely impairing the system performance with an increase in the link error probability. They thus cause the FSO system to fall short of the desired carrier-grade link availability of 99.999 % under heavy, visibility-limiting weather conditions mostly due to the fog [15].

Visible Light Communications (VLC)

Indoor VLC (380 – 780 nm) is a relatively new technology proposed as an alternative to indoor IR (780-950 nm) access technologies offering a number of functionalities. In addition to illumination VLC offers data communication and indoor localization (where current RF based global positioning systems (GPS) offers limited or no coverage in indoor and underground environment) using the existing white light emitting diodes (LED) based lighting fixtures. In VLC systems, both visible light and IR links could be used for the uplink. LEDs are more efficient light source (> 400 lux, which is high enough to transmit data at high speed) than their incandescent and fluorescent counterparts and have a longer lifespan, thus providing both ecological and financial benefits. These features have made the emerging field of indoor short range VLCs very attractive to the worldwide research community, through bodies such as the VLC consortium (more than 20 organizations) in Japan in 2003, the Wireless World Research Forum, the European OMEGA project, IEEE standardization body, and UK research council funded ultra-parallel VLC. The current IEEE VLC standard approved in 2011 supports up to 96 Mbps. A Task Group recently revived the work in IEEE 802.15.7 and is working on an enhanced VLC physical layer based on OFDM to enable peak data rates at Gbps. It is also planned that this standard will support optical camera communication (OCC) where smartphone cameras are used for reception in low data rate applications [16].

COMPARING OPTICAL WIRELESS AND RADIO FREQUENCY

OWC is fast becoming an attractive alternative medium to RF communication and wired optical communication because of the following advantages:

1. **License free spectrum:** The frequencies are license free.
2. **Huge bandwidth (in the range of terahertz):** 200 THz in the 700-1500 nm range.
3. **Energy efficient low power front ends**: The key components for OWC are LED, which is cheap, radiates less heat, has small size and uses one tenth of the total amount of energy of a conventional light source.
4. **Safety**: The skin and eye safety regulations for the visible light spectrum make it safe for usage in the visible spectrum. Also, the light used to transmit the data in OWC does not create Radio-Frequency Interference (RFI), which is known to cause disturbance in electrical circuit due to electromagnetic induction.
5. **Security**: Radio waves have long wavelengths and hence they can easily penetrate walls, hence susceptible to snooping. Optical waves cannot penetrate objects and are more likely to be reflected. This provides enhanced security.
6. **LED Illumination**: Light Emitting Diodes (LED) illumination has wide range of advantages, compared to incandescent lamps. There LEDs are solid-state devices that generate less energy in form of heat and can reduce energy consumption by 80%. If engineered properly, it has long service life and can operate up-to 50,000 hours. They are free from hazardous substances like mercury and have the ability to work under difficult environmental conditions.
7. Minimum absorption effects at 800-890nm and 1550nm.

The above advantages do not however imply that OWC is a universal replacement for RF communication. The applications of OWC systems are limited when considering area coverage and user mobility. Both technologies are complementary in nature and will co-exist.

TABLE 1:COMPARATIVE STUDY OF RF AND OWC TECHNOLOGIES [5].

Parameters	RF	OWC
Available Spectrum	~300GHz	~400THz in IR region and ~400THz in VLC region
Licencing	licensed	Un licensed
Eye-safety	required	Required for lasers as source
Noise/ Interference	Electromagnetic radiations from other channels, electrical noise	Ambient light
Security	Limited	High
EMI	Wide	Limited

HYBRIDIZING OPTICAL WIRELESS AND RADIO FREQUENCY COMMUNICATIONS

The whole idea is to have both Radio Frequency (RF) and Optical Wireless technologies coexist

in a heterogeneous network, and ensure that each serves a purpose that complement each other for the integrity of such network to be improved.

From the literature examined above, the comparative study of Radio Frequency and Optical Wireless technologies, it is obvious that the coexistence of RF and OWC complements each other. The RF will help to boost the signal to noise ratio (SNR) while the OWC ensures the security of the heterogeneous network.

CONCLUSION

This term paper presents some emerging wireless technologies and the common problem faced in mode of operations. Also, security and short range communication in heterogeneous network was presented with a suggested solution: hybridising a Radio Frequency and Optical Wireless Technologies in hybrid networks.

References:

1. Sanou, B. "The World in 2013: ICT facts and figures," International TelecommunicationsUnion, 2013.
2. Index, C. V. N. "Global mobile data traffic forecast update, 2010-2015," White Paper,February,2011.
3. Index, C. V. N. (2013). “The zettabyte era–trends and analysis," Cisco white paper.
4. Krishnamurthy, M., & Rajashekara, H.M. “Current Trends in Wireless Technologies in Academic Libraries” DESIDOC Journal of Library & Information Technology, Vol. 31, No. 1, January 2011, pp. 41-48.
5. Mukherjee, M. (2016). Wireless Communication-Moving from RF to Optical. *10th INDIAcom-2016*, (March), 1079-1086.
6. Sheng, Z., Yang, S., Yu, Y., Vasilakos, A., Mccann, J., & Leung, K. "A survey on the ietf protocol suite for the internet of things: Standards, challenges, and opportunities," IEEE Wireless Communications, vol. 20, pp. 91-98, 2013.
7. Rao, K. R., Bojkovic, Z. S., Bakmaz, B. Wireless Multimedia Communication Systems: Design Analysis and Implementation, CRC Press, 2014.
8. Yang, N. et al., "Safeguarding 5G Wireless Communication Networks Using Physical LayerSecurity," *IEEE Communications Magazine*, Vol. 53, No. 4, 2015, pp. 20-27.
9. LTE Advanced: Heterogeneous Networks. Qualcomm Incorporated January 2011.
10. Ugweje, O. C. (2004). *Radio Frequency and Wireless Communications*. *The InternetEncyclopedia*. https://doi.org/10.1002/047148296X.tie151.
11. Berlin, I., Cune, W. P., & Greene, J. E. (2016). *U.S. Patent No. 9,240,835*. Washington, DC:U.S. Patent and Trademark Office.
12. Uysal, M., Capsoni, C., Ghassemlooy, Z., Boucouvalas, A., & Udvary, E. (Eds.). (2016).*Optical wireless communications: an emerging technology*. Springer.
13. Khan, M. N., Jamil, M., & Hussain, M. (2016). Adaptation of Hybrid FSO/RF Communication System Using Puncturing Technique. *Radioengineering*, *25*(4), 12-19.
14. Naila, C. B., Wakamori, K., Matsumoto, M., Bekkali, A., & Tsukamoto, K. (2012) "Transmission analysis of digital TV signals over a Radio-on-FSOchannel,"Communications Magazine, IEEE, vol. 50, pp. 137-144.
15. Tsukamoto, K., Hashimoto, A., Aburakawa, Y., & Matsumoto, M. (2009). "The case for Free space," IEEE Microw. Mag., vol. 10, pp. 84-92.
16. Ghassemlooy, Z., Arnon, S., Uysal, M., Xu, Z., & Cheng, J. (2015). Emerging Optical Wireless Communications-Advances and Challenges. *IEEE Journal on Selected Areas in Communications*, *33*(9), 1738–1749. https://doi.org/10.1109/JSAC.2015.2458511.
17. Tamer Rakia. (2016). Performance analysis of hybrid optical wireless and radio frequency communication systems.