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RESEARCH ARTICLE

Vision of IoUT: advances and future trends in optical wireless communication

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Abstract Oceans cover about 72 percent of the Earth's atmosphere. Owing to distinct incredible aquatic activities the Oceans remain unclear and deep-seated to investigate. "Underwater wireless communication" (UWC) plays an important role in sea species tracking, water contamination, oil and gas production, natural hazard control, maritime security, naval military activities, and in detecting improvements in the aquatic environment. To achieve these applications in an efficient way, a new era name Internet of Underwater Things (IoUT) is introduced. IoUT is a scientific development that could bring a new phase for research, business, and underwater military applications. It also severs as an important feature of 5G and 6G networking systems. The up-coming fifth (5G)- and sixth (6G)-generation connectivity networks are supposed to make tremendous improvement relative to the current fourth-generation systems with some essential and general problems about 5G coverage performance, 6G and high-ability networking networks, huge coverage, low latency, high protection, low power usage, strong knowledge, and stable networking. To encounter the obstacles in 5G networks, innovations like optical (OWC) communication by means of wireless means is utilized. Innovations such as optical wireless communication (OWC) are used to tackle the obstacles in 5G networks. OWC is a better employee for operation in 5G network specifications than other wireless technologies. This paper explains how the OWC strategy would be the best and most effective approach to effectively implement 5G, 6G, and IoUT networks.

Keywords Artificial intelligence · Internet of underwater things · Heterogeneous network · Optical wireless communications

Introduction

OCEANS occupy about 72 percent of the surface of the earth and offer essential benefits to society, such as climate management, transport, food supply, entertainment, natural resources, and medicine [1]. Oceanic environmental practices, the analysis of oceanographic data, water sampling, and water contamination, therefore, need to be monitored. In recent decades, the value of research, improvements in the global climate, discovering of the oceanic monitoring environment, and analysis of the unguided water network has been greatly acquired. The research technique "Underwater wireless communication" (UWC) is a point of interest to study the ocean eco system, referring to the data transfer mechanism in the undiscovered water medium [2]. Just to secure the oceans and at the same time their full benefits time, transport, inventory, organize and the process is crucial to the surge in data collected from underwater sensors and fixed / mobile marine terminals. For that reason, the "Internet of underwater things" (IoUT) is a technical development in integrating the physical and digital worlds by interconnecting smart subjects in underwater [3]. So IoUT marks a new age for the underwater sciences,

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manufacturing and military applications, offshore exploration, environmental monitoring, and situational monitoring.

Evolving IoUT technologies need a high-quality standard of service requiring high-speed, ultra-reliable, and underwater networking systems with low latency. Owing to powerful channel barriers in the aquatic climate, these aims place daunting challenges on certain electromagnetic frequencies. The basic feature of the future IoUT would be customized Internet. It will allow real-time, underwater communications systems. To imagine the concept of IoUT, there is a rapid rise in the amount of physical devices connecting to the Network by end-users [4]. The optical wireless communication (OWC) plays an essential role in the sensing, monitoring, and distribution of data in IoUT's massive system connectivity [4, 5].

UWC is an innovative underwater communication approach in the modern age chosen to investigate and observed data in the underwater environment. Wireless networking systems have now become a part of the everyday life of humans and are an important area of study to be investigated in recent years. Wireless mediums like underwater acoustic communication (UWAC), underwater optical communication (UWOC), and RF electromagnetic communication are used to predict wireless communication in underwater technologies. Despite the omni-directional transmittance and long connectivity range, low acoustic wave propagation speed (1500 m/s) yields a high latency, which interferes with proper functioning broad range applications, in particular for real-time operations and the functions of synchronization. Ships sail over the ocean and the divers communicate with ships by utilizing the acoustic technique. Acoustic techniques possess low data rates due to frequency attenuation [6, 7]. Lately, optical wireless communication in underwater got recognition because of its higher advantages like bandwidth, lower latency, and greater protection. Due to some remarkable features "Optical wireless communication" technologies (OWC) have gained considerable attention in recent years [8]. Wireless networks with the aid of "OWC" means the optical spectrum. OWC has been a suitable addition to radio technology. OWC technologies hold several important characteristics such as broad range, high-data-rate, low delay, high security, low price, low energy usage, meeting highly challenging 5G and 6G. The comparative architecture of 4G, 5G and 6G is explained in Fig. 1.

The 5G network should have new functionality and enhanced quality of service (QoS) relative to communications in fourth-generation (4G) [4–8]. Other applications, such as virtual reality (VR) systems, would go further than 5G, because they need a data rate of at least 10 Gbps [1, 9–11]. Thus, with 5G reaching its limits in 2030, A cellular sixth-generation (6G) networks need to be developed with additional attractive technologies to overcome the 5G shortcomings in addressing modern challenges. The integration of all past features such as high performance, high efficiency, low power consumption, and wide coverage will be the key drivers of 6G. The 6G communication network is set to begin between 2027 and 2030 specification of 6G not fully comprehended yet, but several researchers are focusing on it [12–15]. Issues like capability enhancement, improved accessibility, latency reduction, and improvement of protection, improvement of energy and resource use, improvement of user QoE [16], and reliability enhancement are to be discussed in both 5G and 6G communication networks.

Figure 2 shows the evolution of different generations of communication and their improvement towards the efficiency. The 6G information network is supposed to be a regional means of communication with a high service level compared to 5G. The 6G network will also continue innovations of past decades that require advanced technology with the implementation of new technologies.

The new technologies include AI, smart wearables, injections, driverless cars, internet reality tools, detecting and 3D surveying. For 6G wireless networks, the most significant prerequisite is the capacity to accommodate large data volumes and high-speed access per device. A very high optical band is declared as an effective alternative to build high-density and reliable 5G IoUT networks. Unlike RF networks, OWC-based network systems uses other special benefits such as fast connection speeds, reduced latency, security systems and lower power [1–3, 6]. The period of transmission ranges from a few nanometers to more than 10,000 km of OWC Networks [2]: visible light communication (VLC) [17–19], light fidelity (LiFi) [20–22], OCC (Connectivity of Optical Camera) [23–27], and free space optics (FSO) [28, 29]. Deployment using OWC is a challenging which may be affected by means of its channel characteristics like salt accumulation in soil, strain in deep sea, fluctuations in temperatures, light, winds, and their impacts on underwater wave propagation.

Related survey articles

Wireless communications networks become underwater profitable in research and technological direction. These technologies involve necessarily in ocean exploration for minerals, gasoline, offensive military operations, monitoring the air, and water pollution [30]. The electromagnetic reaction is not very efficient communication technology because of great water channel attenuation and losses. The authors [31–34] discussed how UWC is implemented. These articles in the survey provide additional forum to

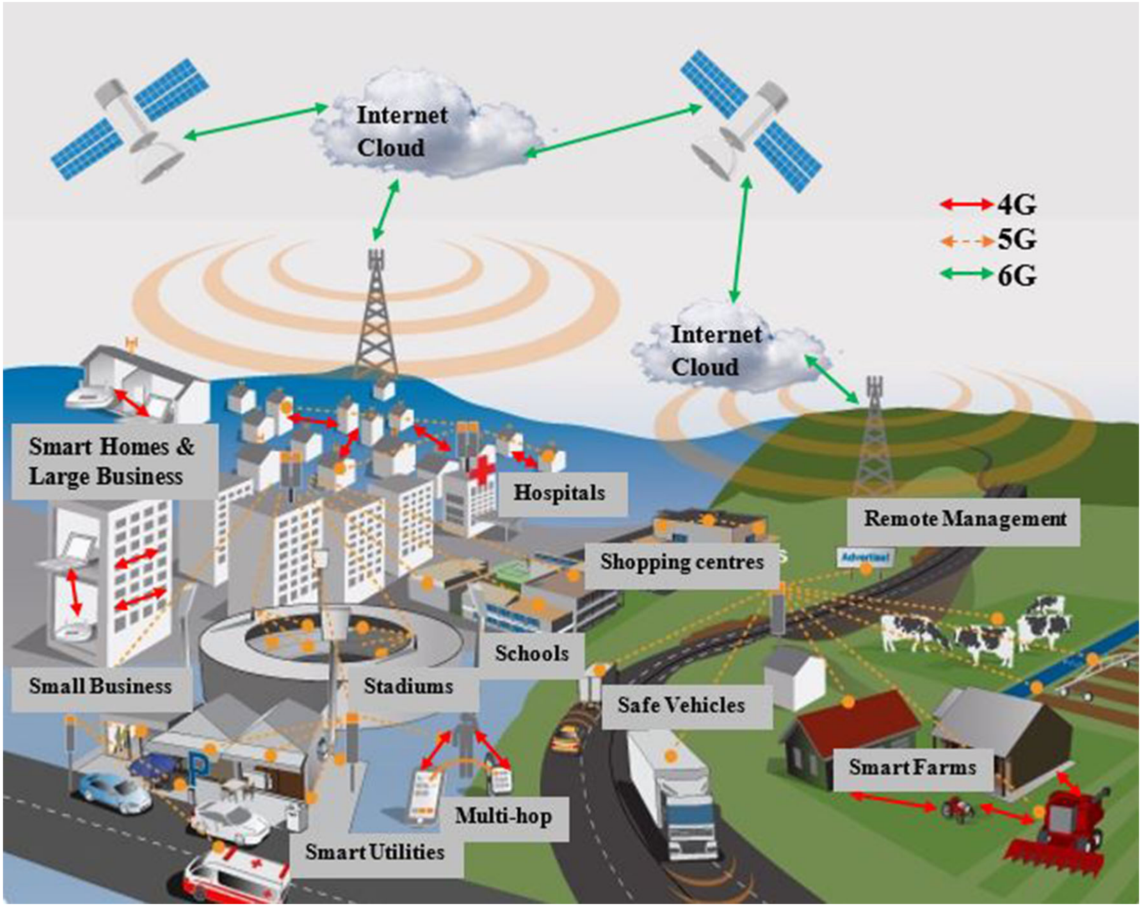

Fig. 1 Architecture of 4G, 5G and 6G

1G (1980s) Analog (NMT,TACS, NMPS) 2 Kbps	2G (1990s) Digital(GSM) 64Kbps	3G (2000s) IMT-2000 (WCDMA, CDMA, Wi-MAX) 2Mbps	4G(2008s) IMT-Advanced (LTE,LTE-A) 1Gbps	5G (2020s) (MIMO, mm-waves) >1Gbps
				

Fig. 2 Evolution of various types of communications

explore current UWC technology. Paper [32] on the UWC network studied the underwater transmission on acoustic, electromagnetic and optical waves and the associated technological problems. Due to significant attenuation and lack of channel control, electromagnetic communication technology is not very successful. The [31–34] writers struggled to implement UWC techniques and their applications. An examined report regarding coordination mechanisms based on the EM motions in seawater. The writers of [35] addressed the drawbacks and advantages of strategic targets for EM waves and undersea uses. The principle of IoUT is examined in [2] and [36] where IoUT are located and its potential applications are similarly presented in the networks of underwater acoustic sensors. A lot more approach is provided in [37] where authors consider software-defined IoUT nodes which can be used with acoustics, optics and magnetic signal induction to overcome the peculiarities of the software-defined opto-acoustic environment. It is also proposed to design a network architecture in [38] where authors explain the long view relationships between functionalities and introduce different layers of network function virtualization (NFV) to realize different cross-layer applications. Recently underwater survey in wireless optical communication (WOC) and related matters widely disseminated in [15]. The authors [17] made reference to UWOC Methods, their similarities, in related research and rapid analysis of different underwater connectivity in laser sources. The writers in [39, 32] studied the absorption of light waves of different wavelengths in the clearest type of ocean water. A comprehensive UWOC survey [17] also suggested the variables affecting, vibration, absorption, a mixed acoustic-optic device, and scattering phenomena.

Underwater optical communications has high attenuation, but propagation in flowing water is more effective over a short distance. [29, 30]. Due to the growing demand for UWC, the construction of a UWC infrastructure consisting of sensor networks, hydrophones and base stations for data collection and signaling for signal analysis [12] is mandatory in many areas. Aid for devices and tools to reduce different noise, multitrack propagation, Doppler attenuation, and efficiency [15, 25] is included in the UWC framework. Communication underwater with acoustics, optical, and EM technologies the common path of research is widely debated. UWSNs multihop algorithm is suggested at [40]. Then, three existing technologies were investigated along with major communications problems was addressed via the UWSN's and their deployment. The acoustic frequency and RF communicative hub definition is set out in [29]. Acoustic waves at UWC propagation scatters on a long-distance with water [41, 42]. This paper aims to improve and encourage underwater wireless communication in the given broad variety of UWSN requirements. The most common problem is the power supply in an underwater world. The energy storage UWSN architecture programs namely WPT, SWIPT is also discussed. The scope of OWC innovations to fulfill the standards of 5G/6G and IoUT is explained in more detail. The current work on OWC 5G, 6G, and IoUT applications is studied and developments in testing are addressed. The OWC implementation issues and its future challenges for 5G/6G and IoUT applications are addressed.

A vision of 5G, 6G, and IoUT in OWC

5G will include an enormous amount of improvement to facilitate homogeneous communication technologies with a variety of applications for certain major characteristics as compared with 4G. The key 5G specifications are described as follows:

- A high track volume: At each location, the sum of mobile data is 1000 times 4G. Networks and the number of wireless devices paired would be 100 times higher.
- Strong connectivity: 5G provides seamless connectivity. Ten to 100 times more machines can be interconnected in comparison with 4G connectivity [11]
- High consumer data size linkage: The 5G networks will be able to handle very large usage traffic rate; the system achieves a daily speed of 10 Gbps, 10 to 100 times that of 4G.
- System of correspondence: It will minimize energy consumption by almost 90% (i.e., tenfold less in contrast with 4G networks)[11]
- Very small latency: End-to-end latency is only to a few milliseconds in a semi-millisecond stage. The studies concentrated on optimizing 6G network specifications [44, 13, 45–51]. One feature of 6G is supposed to be the 10 s of Gbps to Tbps [44, 48]. In comparison with 6G is predicted to be 1000 times more than wireless communication is comparable to that of 5G as shown in Table 1.
- Low energy usage: Low power consumption in 5G is an significant requirement.

An ultra-long interaction with the user gets super-low power usage and super-low latency of less than 1 ms is experienced [13]. Other expected 6G capabilities include multiple antennas, increased spectral performance (100 bps / Hz), super-high wireless coverage, super-reliability, super-low power usage, and service offerings. The networks should provide other unique features to meet 5G demands wireless methods of connectivity. A description of the main features of upcoming 5G and 6G network specifications are:

- Super-high-density network: offering reliable QoE, good reliability, and maximum bandwidth specifications, 5G network installations are required to be even more robust and have super deep compared with 4G networks, heterogeneous connections.
- Small cell networks: The concept of high-density small cell networks has been identified as a core aspect of 5G communication networks.
- High spectral efficiency: 5G networks are often required to allow the scientific use of MIMO,

Table 1 Performance comparison of three generation communication systems [43]

Problem	4G	5G	6G
Point-to-point data rate	1Gbps	1 Gbps	1 Tbps
Latency at end-to-end	100 ms	10 ms	1 ms
Spectral efficiency	Max 15bps/HZ	30bps/Hz	100bps/Hz
Support for mobility	35KKm/hr	500 Kms/hr	1000 kms/hr
Integration of satellite	Low	Low	High
Artificial intelligence	Low	Moderate	High
Autonomous vehicle	Low	Moderate	High
XR	Low	Moderate	High
Communication modality	Low	Moderate	High
Frequency	1700MHZ to 2100MHZ	28GHZ to 39GHZ	> 95GHZ
Bandwidth	20Mbits/s	50Mbits/s	95Gbits/s
Modulation/ demodulation	OFDM/MIMO	MIMO	Zero crossing,Continuous phase (CPM), Orthogonal time frequency space (OTFS), MIMO
User experience	2D	2D	3D
Applications	Mobile web, IP telephony, HD tv, HD video conferencing, location based service, telemedicine	BB mobile service, edge computing, AI, gaming, virtual reality, health care, IOT in agriculture, logistics and manufacturing	Terahertz communication, OWC, FSO, Blockchain, 3D n/w, quantum communication, UAV, backhaul n/w, dynamic network slicing, holographic beamforming, big data analysis, communication in space and deep sea

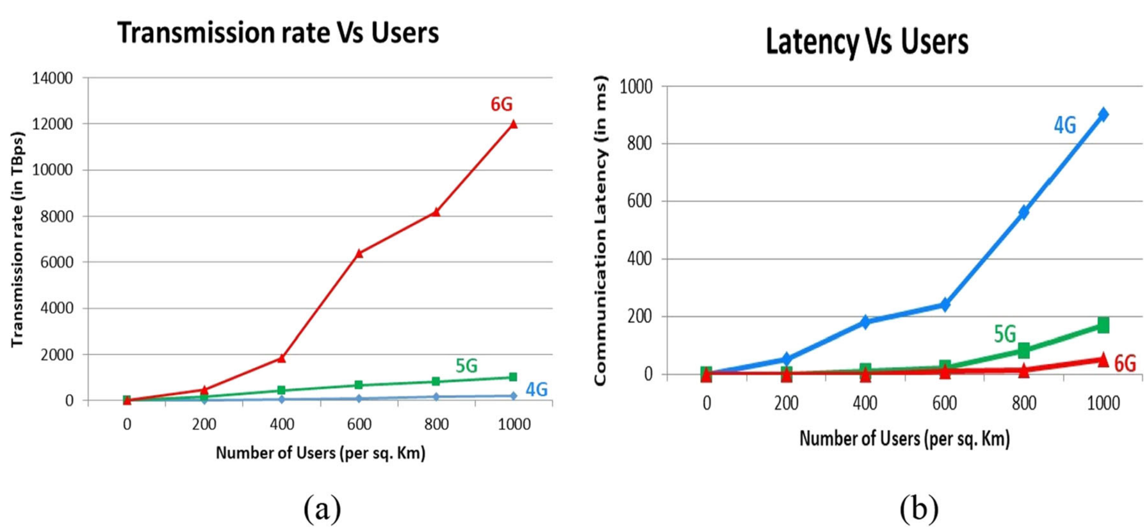

Fig. 3 Graphical Representation of number of users vs **a** Data transfer rate and **b** Communication latency

sophisticated debugging and modulation systems, and modern waveform design. The range of 5G would be at least three times that of 4G.

- Small cost: 5G networks are predicted to be 100 times faster than 4G connections. Delivering across the network 100 times more data monitoring with the same resources. Accordingly, they would need low-cost network infrastructure, reduced construction costs, and improved power savings network and consumer device features on the sides of [52].

Figure 3 gives the graphical representation of 4G, 5G and 6G transmission rate inferring that 6G data transfer rate is high with low delay compared to 4G and 5G. 5G has better transmission rate compared to 4G with less delay. The IoT networks in all three generations often contain essential functionalities. Some main IoT systems specifications are low cost of the supplies, low cost of delivery, high electricity, good protection, and privacy, and help with a broad variety of devices.

Overview of OWC

The four primary OWC techniques, notably ''Visible Light Communication'' (VLC), ''Light Fidelity'' (LiFi), ''Optical Camera Connectivity''(OCC), and''Free Space Optics'' (FSO) are considered impressive in fulfilling the requirements of 5G/6G and IoT networks with regards to their unique functions. Such systems provide divergences in terms of networks, transmitter type, receiver type, and broadcast correspondence as shown in Fig. 4.

As in transceivers and sensors, the VLC uses light-emitting diode or laser diodes (LDs) as detectors. Visible light (VL) is used as the communication medium in VLC. This provides high-speed communication protocols with illumination, using LEDs or defuse the LDs as transmitters and the receivers as PDs. VL is used for forward and infraround (IR) direction as the return path communication tool. However VL may also be used as the return direction correspondence system. The receiver devices, such as smartphones, are not fitted with high-power LEDs for most consumer equipment; thus, the VLC and LiFi uplink communication cannot be entirely achieved [53–55].

In fact, if the uplink is a disseminated light and downlink monitors face major interruption, they cannot do well in transaction. The added complementary metal oxide semiconductor cameras allow photo and video recording capability [56, 57]. OCC typically uses VL or IR as effective communications. Nevertheless, as the communication medium, ultraviolet (UV) radiation may also be used. The FSO system usually uses LD and PD as both the transmitter and the receiver. However for FSO connectivity, a heterodyne optical detector receiver is also used. Nevertheless, in combination with FSO the optical monitoring system is often used as heterodyne.

Table 2 provides a comparison of OWC technologies. There are some important variations within such technologies. The VLC is distinguished by means of visible light communication. Also, the OCC program makes use of across all OWC technologies, camera or image sensor as receiver.

OWC in 5G, 6G and IoUT

The current wireless technologies lies within the range of the frequency 3 kHz–10 GHz under favorable properties of communication. The RF range of the electromagnetic

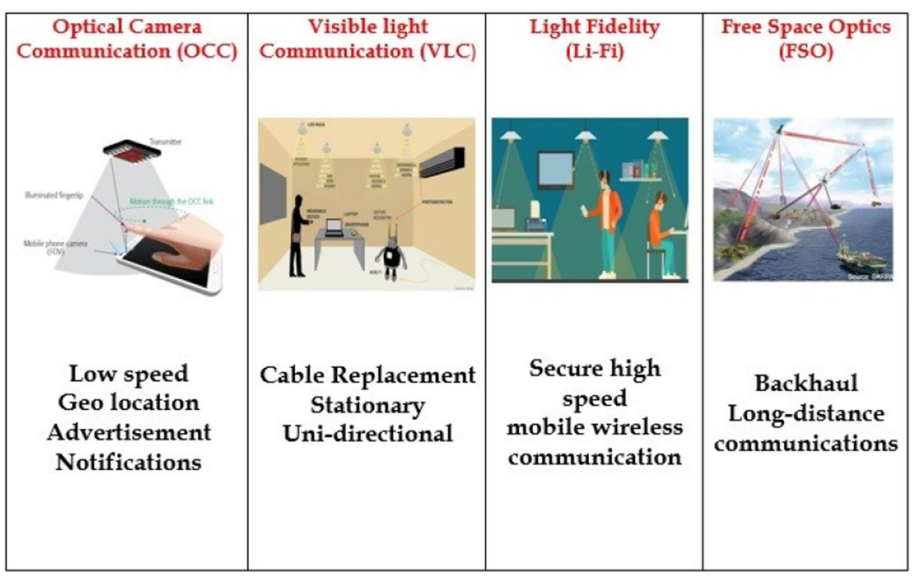

Fig. 4 OWC taxonomies for 5G, 6G and IoUT Communications

Table 2 Comparison of four different optical wireless technologies [56]

Problem	Parameter	VLC	Lifi	OCC	FSO
Topology of communication	Direction	Uni or Bi-direction	Bi-direction	Uni-direction	Uni or bidirection
Area of communication	Distance	20 m	10 m	60 m	10, 000 *km*
Deployment	Support for mobility	Not compulsory	Compulsory	Not compulsory	No
Effect on environment	Indoor/outdoor	No/Yes	No/Yes	No	Yes
Obstruction	Level of interference	Low	Lows	Zero	Low
Speed of communication	Data rate	100 Gbps using LD and 10Gbps using LED	100 Gbps using LD and 10Gbps using LED	55 Mbps	40 Gbps
Network performance	Security	High	High	High	High

spectrum ranges between 3 kHz and 300 GHz [2]. This project is virtually depleted and ineffective in supplying. The 5G/6G and IoUT networks are in strong demand. It is also regulated mainly by local and external authorities. In adhering with strict criteria, the OWC has excellent capabilities. For a wide range of applications, the OWC can be used. Machine-to-machine, chip-to-chip, vehicle-to-vehicle, vehicle-to-infrastructure, vehicle-to-vehicle networking, point-to-point and point-to-point connectivity may be done using various OWC technologies: [2, 6, 29].

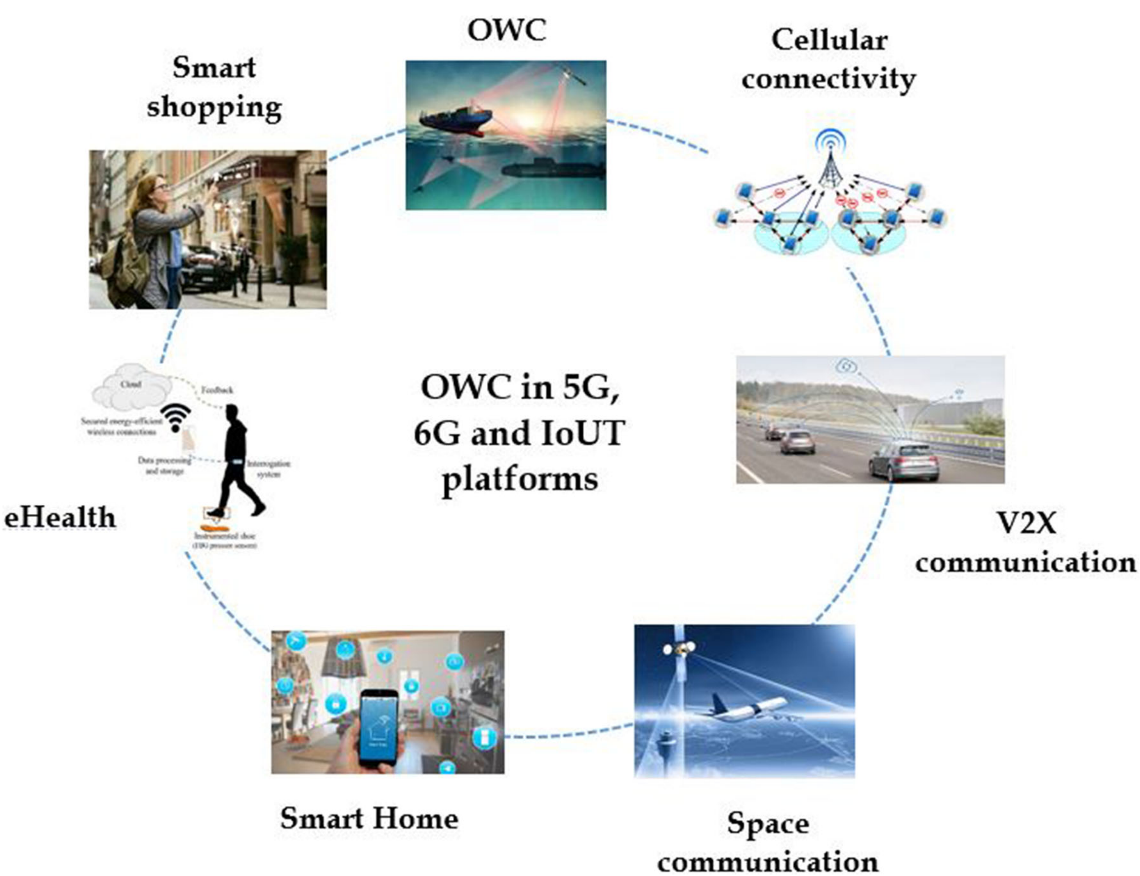

Fig. 5 OWC in 5G, 6G and IoUT platforms

Light allows communication across various ranges (over 10,000 km) of contact, such as solution for achieving extremely short-range linkages using FSO systems using "VLC", "OCC", or "LiFi" systems; short-range, easy-to-all vehicle (V2X) texting and indoor positional awareness; medium-scale cross-construction networks; long-range inter-urban downlink accessibility; and satellite-to-satellite high-range connectivity. The OWC's other main features include strong quality unregulated bandwidth, high protection, low power usage, low infrastructure and the equipment Price, no RF system and network interference, extremely feasible SNR and fast integration Lighting infrastructures already in operation. The OWC structures main disadvantage is blocking transmission via barriers.

Figure 5 indicates a 5G/6G and IoUT networks which are utilizing OWC technology. OWC networks will serve every channel in our lives, including aquatic messaging, V2X, wireless communication assistance, room touch, smart surfing, electronic health (eHealth), and home safe. The section addresses how 5G e-specific applications should be applicable to the OWC networks, 6G via IoUT implementation.

Challenges in 5G/6G and IoUT

To implement OWC technology, a range of problems need to be tackled skillfully with 5G/6G applications, and IoUT solutions. Here are a few significant difficult topics discussed briefly [14, 58]:

- Atmospheric loss: OWC quality development is impaired by dispersion, refraction, Water accumulation, the depletion of free energy, and ambient scintillation. In the woods, rain and Dust obstruct the transmitter's optical transmission into the receiver. The standard of the contact ties in owing to poor ambient conditions the FSO is impaired. The reduction of ozone damages is challenging in terms of achieving the target of 5G networks, particularly in outdoor conditions.
- Limited OCC data rate: Some of the big disadvantages of the current OCC program is a low rate of information. Because of the cameras poor frame rate, it is difficult to have a strong data rate. In the OCC network, the current data rate reached is just 55 Mbps. This data size will have to be increased to satisfy coverage requirements in the 5G/6G and IoUT networks.
- Frequent transfer: Potential networks are made up of heterogeneous, compact dense networks which generate very frequent transfers. In optical networks, and between RF and optical networks, this will be a connection. The optic structures are quite small and can create many complications that are unnecessary. The impact of ping-pong is also a significant issue to avoid premature handing over. The characteristics of physical and data-link structures of cellular networks focused on optical and RF, This poses a big obstacle for promoting the versatility of RF/optical hybrid systems.
- Flickering rejection: Flickering is characterized as the variations that can be observed by humans in a light's brightness. This is a major concern within the OWC programs. Various modulation schemes OWC problems that can cause flickering with harmful impact on human safety. Altering LEDs may be made in a manner that prevents flickering. This is an incredibly difficult issue.
- The FSO backhaul system: 5G/6G backhaul services must accommodate a large amount of data rate to support user-level high-scale services; otherwise, there will be a bottleneck issue. Therefore, consideration of rising the FSO backhaul capability growing the amount of traffic is a daunting activity.
- Restricted uplink connectivity utilizing OWC technologies: Most consumer devices are equipped with low density LEDs to increase the control leakage. The low-power LEDs, VLC, and LiFi are unable to do uplink well in range. Most Consumer equipment LEDs use low-power lights that are conveniently linked to high-power downlink lights and, thus, restrict connectivity to the uplink. Additionally, the receiver has a slight deflection or movement user equipment can disrupt communication links with uplinks easily. This is also a significant question for To help uplink connectivity with VLC and LiFi systems in the future, be solved.
- Inter-cell intrusion: Handling electrical inter-cell conflict is a significant concern in implementation for the optical networks VLC and LiFi. The concentrated use of LEDs for the Optical wireless communication systems can build heavy congestion in 5G/6G and IoUT networks. Therefore, the optical disturbance between cells is a complex problem.
- OWC Machine Learning: Learning-based networking would be the main necessity in initial contact networks of 6G. The ever-growing hierarchical nature of the network and its specifications request automated power and decision-making in stressful settings. Supervised learning will be included in the class for other OWC-focused applications including patient monitoring, home automation security, and OWC data mining. OWC data interpretation, such as similarity, classification, spatial and temporal interpretation, and flow analysis may be more effectively conducted through unsupervised learning. Integrating machine learning into 6G OWC networks allows for smart network allocation, correction of auto mistakes, decision-making, and the reassignment of networks, among others. The machine learning method is a key need in large

OWC limited indoor mobile robot networks to execute functions effectively and reliably.

Future technologies in OWC

1. Energy storage system for WSN: Energy harvesting (EH) or energy storage is the capture method and converting wasting resources into available electricity power where the heat requirement is of water, signals of RF acceleration. EH permits operation of equipment removing where there is no traditional power source. Because of less opportunity to alter batteries and powered sensor node condenser in the underwater climate, communication connection like EH to boost network effectiveness is needed. Wireless power transmission (WPT) is one of the EH approaches by which the nodes themselves charge batteries produced by the area of the electrical radiation network. WPT uses it mainly for fast Distances (near field) and not distances (far-field). This depends on the specifications of the program. Reliable to pass energy concurrently with the knowledge due to the discontinuity and in feasibility of channels over long distances. To satisfy this necessity, instead, the definition of wireless information and power transmission at the same time (SWIPT) investigated in [19]. The writers addressed in [59] discussed and agreed on different resources restrictions SWIPT as integral spectral enhancement technique performance, energy use and power transmission Wait for them to be transmitted concurrently Power and details. High demand Radio growth is considered as the energy storage frequency system (RE-EH) for mega capacitor charging batteries or the energy contained in Wireless Sensor (WSN) networks. The RF environment's power supply retains RFEH from countless electricity-generating gadgets worldwide. So wireless apps may now use power multiplier to collect energy from RF signals over time.

- Near-field: Near-field is the distant region from which the antenna transmits the standard transmitting spectrum. WPT technique depends on length. Since a larger gap from antenna receiver decreased the power transmission phenomena in linear terminology. This could result in less power being transmitted. The high energy resistance can be transferred inductively, capacitive and with resonance couplings are inductive.
- Far-Field: The distant field where the gap in the transmission antenna can be more regulated larger than the diameter including WPT far-off area. In the remote example, the power may be transmitted over long distances without having Space for electrical wire and is officially known as transfer of electromagnetic radiation waves as a medium by microwave and laser technologies.
- SWIPT is an important technique of recent growth Instead of WPT which helps to have the facility Power and knowledge, via wireless networking. The process of electricity and knowledge transmission In SWIPT the evaluation element is relevant device energy [19].
- UWSNs-EH plays a key role in exposure to data in the marine areas. Because of the diversity of applications, UWSNs are important. UWSN's systemic problems in achieving a reliable and efficient power supply to achieve the eco-energy conditions for high productivity [60]. Multi-source energy harvester network then on "Microbial Fuel Cell" (MFC) and Piezoelectric acoustic carbon storage systems with acoustic assisting network trigger is proposed.

  The establishment of UWSNs, however, has several problems since the signal distribution like energy limits, complex conditions, topological variation, and high probability of error signal forwarding. Batteries don't hold long-term strength supply power of sensor nodes in an underwater scenario. Energy storage is therefore a viable option for the enduring delivering resources to sensor nodes [61]. Energy usage is another issue for UWSN. Refilling and restoring batteries are also more challenging in aquatic environments [62]. Potential acoustic-optical undersea approach and integrated wireless sensor networks (AO-UWSN) energy harvesting technique proposed to support the acoustics and optics communications [62, 63]. An unconventional electricity scheme UWSN mining dependent on galvanic resources are researched [19, 64, 65].

2. Massive MIMO: Massive Multi-output Multi-output Data (MIMO) in underwater connectivity allows real-time activities, good quality

transfer of data between floats Buoy, and a broad hydrophone collection. Gigantic MIMO is also classified as MIMO, a very large multiuser (MU-MIMO), Hyper-MIMO, or MIMO systems of full dimensions [66]. Multimedia monitoring technology underwater needs strong data-traffic demands. The Introduction of Underwater MIMO channels support the various types of multimedia visualization of the corresponding objects, Audio, and meeting video [63]. So the probability to get a high bandwidth standard. In this process, there are multiple antennas at the base stations to transmit signals from the big hydrophone variety community [66].The Downside in a large MIMO network link is a point to point and the signals fading as obtained by a sufficient number of hydrophones. A point-to-point substitute MIMO (MU-MIMO) network power optimization strategy suggested under [66]. The hydrophone collection will operate in cubic, triangular, or circle. The critical distance there will be more than half of the antenna components in between of those wavelengths. Each hydrophone should specify that a position to achieve directivity in transmission. UWSNs are comprised of human computers and network nodes Such as the ROV and AUV compatible tools. The Boat climate has special function restrictions for large latency cases, low bandwidth, disappearing issues, and power usage is strong. MIMO device offers a successful approach to improve energy performance, capability, and power production. The bulk of current sensor networks having floating buoy and base station (BS) are built with a single buoy acoustic transducer with the code Single-Input–Single-Output Communication Performance (SISO). So MIMO is used to boost data at UWAC with carrier aggregation rate to allow underwater transmission in real-time, of high quality from AUVs to water boots with a broad variety of hydrophones. This is the potential dimension and explored extensively in [66].

3. Non-orthogonal multiple accessed enabled underwater communication: A challenging Non-orthogonal Multiple Access (NOMA) has Different networking methods for new century network connectivity [67]. In the Underwater world, ROVs and AUVs are moving around the sensor nodes for collecting oceanographic knowledge from the network. This concern needs all uplinks, and then downlinks. NOMA can be added and mixed rapidly with massive MIMO and millimeter waves to further assist and improved machine performance underwater reported in [68]. Implementing the UWOC, NOMA reduces bandwidth distribution issues, and increase the encoding performance of the transmitted data addressed at [67]. NOMA is an important technology that enables achievement Strong demands on bandwidth and efficiency like high system output, low latency, and solid connectivity. NOMA should support various mass communication. At the same time, users minimize delays. The prediction of the future. NOMA suggested a plan for the division in UWASN and power distribution system equivalent transfer times (ETT) which can prevent wasteful underwater resource generation connection for the potential, as proposed [68].
4. mm-waves in underwater communication: An alternative technique that supports at UWAC is the millimeter wave's frequency band. The distribution of duration and wavelength of the mm-waves measures from 1–10 mm and 150–1500 kHz which causes effective communications performance. A Submarine [69] communications through millimeter waves see better similarities to wireless optical contact because of high-frequency carriers experience a significant loss of propagation and far better-blocking sensitivity than RF-system. Therefore mm-waves are considering to deliver broad bandwidth transfer and efficiently boost coordination efficiency for the future growth [70] cellular connectivity. For more opportunities, broad selection of mm-wave frequency bands in acoustic contact underwater helps improve efficiency in transmitting knowledge. Wireless 5G supports high terrestrial data transfer to underwater use vibrations in millimeters. Accordingly, the millimeter waves are a potential substitute for conventional wave's fiber optic cable for smartphone link. This has a maximum connection rate of 10 GBps which allows data transmission problems to be solved Based on surface and underwater communication [70].
5. Internet of Underwater Things (IoUT): "Internet of Things" (IoT) relates to wired computers that are capable of Work and quick

access through wireless insightful way plus wired access over the Internet. IoUT makes compatibility Data between physical objects, like computers, home Appliances, pre-transport mode every unique Computer systems, cameras, actuators. The necessity of IoUTs to track, sea life study, defense Exchange of information, the study of natural hazards, prevention and discovery of large amounts of seas, and Understanding underwater habitats [36]. The relevant marine instruments and marine cameras are the essential IoT components known as IoUTs used to enhance QoS Of the [36] Method. Consequently, the direct transmission of sensing knowledge from artifacts underwater is difficult. As per underwater communication sensor nodes set and tied, turn sensed data acoustically into a ROV or UUV sink or buoy attached directly to onshore base station buoys via RF link. Much of the job Multistage AUVs regional positioning system researched by UWSNs [71]. The related detection work ocean emissions by adhoc cellular decentralization network of sensors suggested at [72]. The water bodies are less well-defined historically than they are now, studied and known less than the Moon or even mars. The electrical conductivity data like the dissolved oxygen, and in the aquatic setting temperature by portable remotely operated vehicles and underwater sensor networks. The IoUTs help us work in Large structures or "Rock scrapers" with the tunnel has 25 underwater legends, and it supports communicate quickly with a base station. The Forecast IoUTs control underwater houses besides "Medipods" treat illness and provide medication Where necessary, or remote surgeon [73]. The prospect of Man is dependent on close management and reliable tracking Use of marine environments.

Future 5G and 6G aspects

Several issues have to be considered for future communication in 5G and 6G. Few are listed below [74]:

- Heterogeneous barriers to hardware: 6G will involve a very huge proportion of heterogeneous kinds of communication systems, such as frequency range, communication protocols, service delivery etc. In fact, the connection points and computer phones in the device environments would be substantially different. The huge MIMO technology would be more improved from 5G to 6G, so a more complicated design may be expected. Machine learning and AI should be part of connectivity, though. Often, the architecture of the equipment is specific for various contact systems. Unsupervised and enhanced instruction may also generate difficulties in integrating equipment. Consequently, combining all the contact structures onto a common network would be difficult.
- Autonomous wireless networks: The 6G framework would have complete support for AI-based control technologies including autonomous vehicles, UAVs and Industry 4.0. They need many heterogeneous subnetworks to be interconnected, such as automated computation, inter—operable approaches, sensors mounted, artificial intelligence, automated network, device computers, and heterogeneous wireless systems, to allow autonomous wireless systems [56]. Therefore, the ultimate production of the device is dynamic and difficult. For example, it would be far more difficult to build a completely autonomous driver less vehicle network as 6G professionals are required to build completely automated self-driving vehicles that work better than human-controlled automobiles.
- System capability: A range of different devices would arrive with the 6G program. Devices, like smartphones, should be capable of coping with the new features. In particular, achieving 1 Tbps performance, AI, XR, and advanced sensing utilizing individual devices is difficult, despite connectivity apps. The 5G devices may not accept some of the 6G functionality, and enhancement of capabilities in 6G devices that also increase the cost. Billions more smartphones would be linked to the 5G network, and we need to be sure all certain systems are compliant with the 6G system too.
- High-capacity backhaul connectivity: The 6G link networks should be quite heavily developed. Such communication networks are often of a varied type and are common across a regional area. 6G backhaul networks must handle the immense volume of data required to connect in between transit networks and the network layer in order to allow high-speed connectivity at the consumer level; else a shortage will be generated. The fiber optics and FSO networks are potential substitutes to backhaul high-speed connectivity; thus, any expansion of these networks' ability is difficult for 6G's increasingly rising data demand.
- Spectrum protection and interference: Efficient usage of 6G spectrum including spectrum exchange methods and sophisticated spectrum management strategies is very important owing to a shortage of spectrum resources and intervention issues. For optimizing

resource utilization with [74, 43] QoS optimization, efficient spectrum management is essential. In 6G, researchers need to answer issues such as how to transmit the spectrum and how to monitor the process of the spectrum in the sensor network that coordinates the distribution of the same frequency. Scientists will [75]intend to explore whether the interruption may be canceled using traditional forms of canceling interruption, such as canceling simultaneous interference and canceling consecutive interference.

Conclusion

Underwater connectivity is a medium for creating a network link between floating objects, with challenging features and critical obstacles for the communication channel and the climate. The technologies discussed give the implementation framework potential approach and good explanation. 5G wireless network, connectivity technique proposed to support RF, acoustics and optical signal transmission to enhance connection issues. 5G networking is planned to be introduced to the industry by 2021. 6G interactions are expected to begin in 2027 and 2030. To reach the goals of 5G/6G and IoUT, based on the physical internet challenge. High size, high bandwidth, low latency, high protection, low fuel usage, high QoE, and highly efficient bandwidth for 5G wireless communication are the most critical and difficult issues. Even RF-based systems for future 5G/6G and IoUT networks cannot meet those requirements. One alternate approach for RF networking is the OWC technologies. Certain network targets can be accomplished by the cooperation of RF and optical wireless networks. This report provided a comprehensive look into how OWC technology such as VLC, LiFi, OCC, and FSO can offer a viable option for IoUT's potential 5G/6G rollout and networks. To do otherwise, we briefly explained the qualities of 5G, 6G, and IoUT systems here. Each specification of 5G, 6G, and IoUT is explained individually with the recent studies relating to OWC. This paper also discusses 5G, 6G in optical wireless technologies, the Internet of Underwater Things with future directions in underwater, the research aspects that are to be considered in 5G/6G.

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