Smart Optical Transmitters and Receivers for Underwater Wireless CDMA Network: Review and challenges

V.Nirmala[1]
Department of Electronics and Communication Engineering,
M. Kumarasamy College of Engineering, Karur, India

Abstract— **Underwater optical communications is a promising solution to the increasing demand for broadband links in oceans and seas. Nowadays, unmanned vehicles and devices are located in underwater communication. The increasing number of unmanned vehicles and devices, Novel Communication systems and networking protocols are required. The current underwater communication system includes of conventional end to end links and comprises strict positioning and pathway needs. In this paper, underwater wireless optical code division multiple access (UW-OCDMA) network is presented to give broadband links for viable and military applications and also review compact transmitter and receiver. In under water signature codes of mobile users are called as optical orthogonal codes (OOC).The proposed system is useful for high-speed real-time applications and this system is used as smart transceiver, communications of centralized, recentralized and relay-assisted underwater sensor networks. In particular, the transmitter sends highly directional ray to co- situated receivers, to estimate the quality of water by collecting back spread light. The transmitter has separate addressable LEDs for electronic switch beam-steering and receivers has sectioned broad array of sight and are competent to calculate the direction of coming of signals. They combined to form a challenging technology for present networking systems in the stream of unmanned devices. In conclusion, possible design challenges such as positioning and pathway, edge coverage, blockage avoidance, and raising the network capacity are described.**

Keywords— *Underwater wireless optical communications, optical CDMA networks, pointing and tracking, optical codes, Unmanned Underwater Device, Angle Diversity*

I. INTRODUCTION (*Heading 1*)

Under water communication is greatest interest in recent rising commercial and military applications. Underwater communication requires Sensors, movable devices and some observatories to interface with data rates in a small number of Mbps. It demands for a consistent, flexible and realistic multi-access network. A current study gives away that a few major solutions to this claim: acoustic and optical transmission. Recent studies have given the resolution to this required: acoustic and Wireless Communication. Due to the narrow bandwidth of acoustic method, the most attainable rates are limited to 100 kbps document and use markup styles. Besides, the low speed of waves in underwater medium, which results in a high latency in extended range communications create problems for synchronization and multiple access techniques. In association with the conventional acoustic approach, wireless optical communication has three main advantages: superior bandwidth, security and lesser time latency.

Blue green optical window is recent development in under water free space communication. It is low attenuation wavelength of electromagnetic spectrum. [1], [2], [3], [4]. Laser and LED systems are used by underwater communication for different applications. While Laser-based systems present unlimited series of communication, high data rates of information move and low latencies [5][7], LED based systems are used for low cost, power and smallness. Some inner and outer parameters of communication systems have to be considered as the environmental changes are expected during the designing of different components.[6][28]. Most of the researchers are considered as end to end links and require exact position and tracking especially on mobile devices. However, Mobile system uses collimator laser rays enough to give dedicated gimbal system. Some devices are being used for very large aperture photomultiplier tubes that increase the receiver field of view (FOV).

Large number of PMT's can be more costly and large. Hence, Compact systems are needed, which do not contain much space and energy for point and tracking. To give direction of onset information and transmit ray shape, the researchers are considered smart antenna's for RF wireless systems, which make use of capable of signal giving out. Generally optical ray propagation experience from three main things: Absorption, Scattering and Attenuation. In depth reading of beam communication in water to differentiate absorption and scattering properties of dissimilar types based on theoretical and experimental has been accomplished by Mobley in[3].Absorption and Scattering effects are modeled by using a closed form expression of double Gamma function.

This research is mainly designed for wireless optical network with multiple access competence to widen the borders and make probable communication among various set and mobile. The CDMA network can exploit a diversity of function such as imaging, real time video transmission, sensor network and also give dependable communication. In 1989 Salehi was being introduced first generation OCDMA-based systems, using optical orthogonal codes (OOC)[8], By using this scheme recent studies have been focused to free space, infrared indoors and visible light communication [9]. In addition, performance and analysis of an underwater wireless optical CDMA network is presented in [10]. In this paper, gives detailed challenges and potential applications of UW-OCDMA network mobile and fixed users exchange a words to smart transmitter and receiver. Each lively user broadcast its data using a unique OOC code. In particular, this paper illustrates the proposed UWOCDMA network structural design, Smart transmitter and receiver and discusses its potential application in local sensor networks and underwater localization. Additionally, possible challenges regarding blockage avoidance, cell edge coverage and increasing the number of active users are addressed.

II. UNDERWATER-OCDMA NETWORK ARCHITECTURE

2.1.BLOCK DIAGRAM

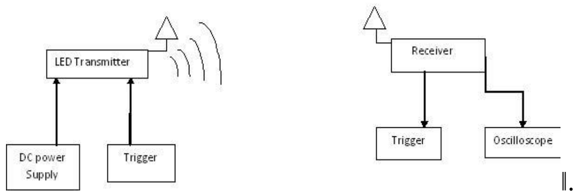

Fig. 1

The general concept of Underwater Optical communication diagram as shown in fig.1, in which a Dc supply actives the LED/Laser Source transmits the signal through antenna. In transmitter, the driver circuit and transducer are converting the Electrical signal into Light signal. In Receiver, the detector is exchanging the Light signal into electrical signal with a help of Trigger circuit. The light source propagates through underwater free space medium.

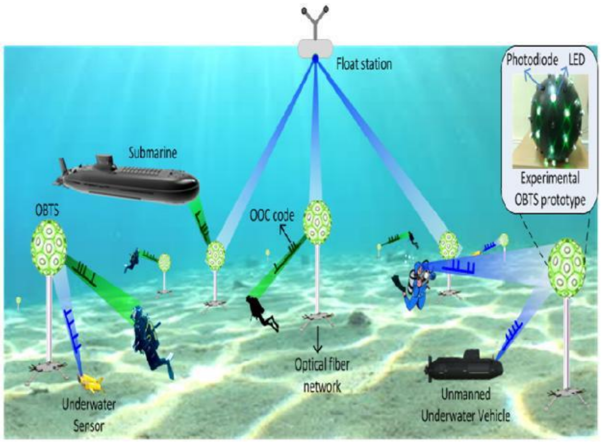

Fig.2

The Under Water OCDMA set-up is illustrated in Fig. 2, in which number OBTSs are located in the midpoint of a hexagonal cell to envelop a huge area; and there are a number of user transceivers are located. Each transceiver has a couple of optical Omni directional receiver and unidirectional transmitter. All OBTSs are interrelated with an optical network controller (ONC) via optic system which can be coupled together. [1]

2.2. STRUCTURE DESCRIPTION:

The shape of OBTS look like a ball which is made from twelve ordinary pentagonal and twenty standard hexagonal panels located in a circular geometry. This paper we considered 60 LEDs and 32 photo detectors lying on the hub of its pentagonal and hexagonal panels. Here, OBTS operates like an omni-directional transceiver. Utilizing its single signature code, each user extends its data at the transmitter. Intensity Modulation techniques exploit to modulate users data. OBTS receivers and photo detectors are activate under water communication signals. Depends on the network topology, received signal will be despread by using OOC codes or convert to an optical signal. After the conversion, the signal will transmit to the ONC through measurement and others are deliberate, using specifications fiber optic system [1]. Addition to that OBTS can act as intelligent decode and forward relay. Record of each location should design at the ONC to record the spot of mobile users (MUs) and choose to which OBTS information should forward.

2.3 CHANNEL DESCRIPTION

There are 3 major factors particularly absorption and scattering have to be compelled to be thought of UW-CDMA. Absorption is a thermal process, due to photon energy defeat interface with water molecules or other particulates, where scattering is difference of photons from their unique path. defeat in energy caused by absorption and scattering are often differentiated by constant coefficient of absorption coefficient $a(\lambda)$ and scattering coefficient $b(\lambda)$, severally, with λ represent the optical wavelength [1]. The random variations in underwater medium primarily result from fluctuations in temperature and salinity and can cause weakening on the received optical signal. It has been shown in [3] that absorption and scattering contains the very low result at the wavelength gap four hundred nm $< \lambda <$ 530 nm. In this architecture, cut the back backscattered light-weight of the OBTS's optical transceivers and got selected inexperienced LEDs with middle wavelength of 532 nm for OBTS, blue LEDs with inner wavelength of 450 nm for users, and acceptable filters to pass solely the fascinating vary of wavelengths.

2.4 PROPOSED ARCHITECTURE:

In this section, the projected design for underwater network is mentioned [1].In general, 2 approaches are thought-about to interconnect OBTSs, specifically centralized and redistributed. In centralized design, all OBTSs are associated with middle ONC, which is dependable to perform information forwarding among other OBTSs. In Fig. 3(a), projected design is illustrated [1]. In ONC information, the OBTS of every alphabetic character is traced; thus ONC be integrated with

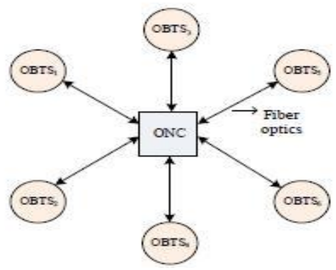

Fig .3(a)

MUs' location database

MU ID	Serving OBTS
MU_1	$OBTS_1$
MU_2	$OBTS_4$
MU_3	$OBTS_2$
⋮	⋮

Fig.3(b)

In Fig. 3(c), the design of suburbanized architecture is described. We have a tendency to note that within the suburbanized design, every OBTS has associate degree interface execution routing and traffic forwarding functionalities among OBTSs. Also, a sign protocol is employed to allocate MU-ATs over the network. Every OBTS notifies its efficient MU-AT two different OBTSs by spreading its MU-AT via a signaling packet. The headers of the sign packet include packet kind, source ID, and packet range, as delineate in Fig. 3(d). This packet is busy within the group, i.e., each node broadcasts the received packets to all its ports, thus all OBTSs get situation info of MUs.

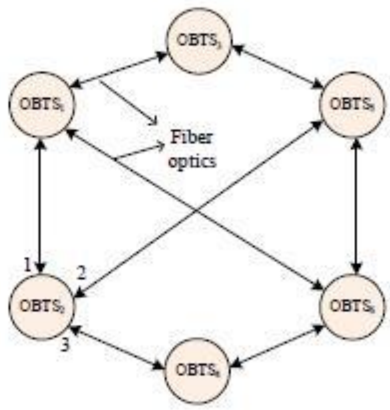

Fig.3(c)

Signalling Packet

Packet Type	Source ID	Packet Number	Payload (MU-TA or NT)

Data Packet

Packet Type	Source ID	Destination ID	Payload (Data)

Fig.3(d)

Three databases of $OBTS_2$

$OBTS_2$'s MU-TA

MU ID	OOC
MU_3	C_1
MU_5	C_2
⋮	⋮

$OBTS_2$'s NT

$OBTS_1$
$OBTS_4$
$OBTS_5$

$OBTS_2$'s RT

Destination	Output Port #
$OBTS_1$	1
$OBTS_3$	1 or 2
$OBTS_4$	3
$OBTS_5$	2
$OBTS_6$	3, 2, or 1

Fig.3(e)

In suburbanized design, additionally to info of MUs place, a routing table (RT) is critical to send transfer between OBTSs. Every node finds out its neighbors by causation Hello packets, whereby neighbors counter the Hello packets by causation their OBTS ID. So as to discover the entire configuration every node broadcasts its National Trust sporadically. By considering topology, each OBTS utilizes Dijkstra shortest path algorithmic rule in the direction of cypher its routing methods toward all different OBTSs, thereby its RT is completed by determinant the output port range for every target node. Fig.3 (e) illustrates totally dissimilar record of OBTS2 within the suburbanized design shown in Fig. 3(c).

III. DESCRIPTION OF SMART OPTICAL SYSTEMS

3.1 Existing Methods:

1. In underwater optical communication: Photomultipliers tubes (PMTs) are considered to accomplish extensive FOV since they need terribly massive space.PMTs even encompass a large size of aperture starting from ten millimeter to five hundred millimeter (20 inches) in length [2].

2. retro-reflector: A retroreflector can be used to address power, range, and positioning necessities at the receiver [11]. It strikes out the requirement for a transmitted optical beam on a stage holding knowledge and decreases the information by retro-reflecting.

3. Indoor optical wireless: There are some explorations within the field of interior optical wireless in the work of circular photodiode groups for widening FOV [12]. Initial models are built and depressed attenuation channels such as the indoor optical wireless channel [13][14].

4. In RF communication: global RF communications have gained from recent growth in abstraction diversity and good antennas. Conversely, in optical systems, we have a tendency to not have the RF communication and ability to use coherent beam-forming or phased arrays [2].

3.2 Smart Optical Transmitter:

The transmitter has the following uniqueness [2]:

- Electronic switched beam-steering.
- Improved radial asymmetry.

Light Emitting Diode may be semiconductor devices that create a comparatively slim band lightweight. The light-emitting diode speed will be modulated is typically restricted by the amount of brightness. This means a tradeoff among power and speed, while larger LED size gives higher brightness [15], [16]. The transmitter consists of a small hexagonal pyramid with an outsized range of LEDs. The transmitter is including its individual lens that converge the in depth FOV of the light-emitting diode to a restricted beam during a explicit direction. Every light-emitting diode is unambiguously addressed and determined, that permits the modulator to select AN output direction.

3.3 Smart Optical Receiver:

The development of good receiver is provided omni directional system to reduce information and following needs. Probably scale back informs and following requirements, this style additionally probably permits one to calculate and measure viewpoint. This may be used in combination with a CDMA system. This will increase applications such as localization, navigation help, and mesh networking. Using MIMO techniques, this optical approach presumably additionally communicates point of view for enhancing the illustration of end -to-end links [2].

The high-quality receiver has the following uniqueness:

- Improved field of view
- Direction of arrival evaluation

A smart optical transmitter will do analysis of the quality of water by using its backscattered signal and a co-position receiver with a help of attenuation coefficient of the channel [2]. This data permits the transmitter to; do modification in transmitting power, data rate, code rate, or other parameters. Electronic equipment can be used and are power-assisted by the actual reality that the transmitter and the backscatter-receiver are co-located [2], [17]. Each OBTS associated with number of transmitters and receivers called as Smart Optical Transceivers.

IV. PROBABLE APPLICATIONS

Besides the purpose of the UW-OCDMA system, that provides a reliable and versatile communication link for underwater mobile users in a very comparatively massive space, there square measure nonetheless several different probable application which make use of this infrastructure by accumulating minor quality to the system [1].

4.1 Underwater Sensor Network:

Underwater detector networks can realize important roles in work climate modification, disaster in observance biological, biogeochemical, organic process and environmental change within the ocean, ocean and lake environments, in pollution observance, and in serving to regulate and preserve oil production facilities. Sensors accumulate on the sea floor or UUVs set with sensors as shown in Fig.4

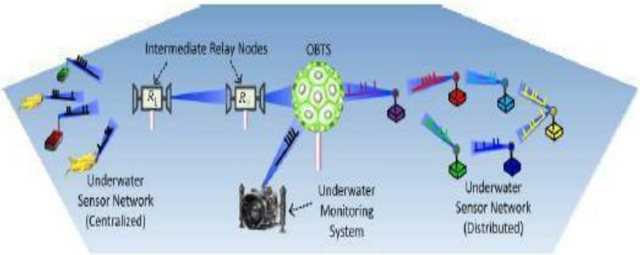

Fig.4

4.1.1 Centralized underwater networks:

In the centralized device system supported with UW-OCDMA, every device employs its appointed OOC code to transmit information to the close OBTS which can be settled comparatively distant from them. Human action straight with the OBTS is not possible because it is very low battery high-powered sensors. To solve this problem, we are able to include one or additional relays during a serial design to gather sensors' information from a shorter distance.

4.1.2 Distributed underwater networks:

Distributed sensing element system could be assortment of mobile and sensors every of that has sensing, receiving, transmission and computing capabilities. Such networks square determines of self-deployment; i.e., ranging from some compact initial configuration, the nodes within the system will unfolded specified the world coated by the system is maximized. During this, the OOC-encoded knowledge made by a supply sensing element is conveyed with middle sensors till it reaches the OBTS [1]. Preparation of those sensors in our UW-OCDMA system removes the requirement for intermediary relay nodes, however will increase the quality of the sensors' structure.

.

4.2 Underwater Positioning:

Global positioning system receivers are wide employed in terrestrial space to work out the placement of a mobile user. However, this can be impossible in underwater because GPS signals don't broadcast through water. The structure of the planned UW-OCDMA system are often used as a capable to different GPS; since the OBTSs are located at permanent locations, they will function as a reference nodes [18].

V. POSSIBLE DESIGN CHALLENGES

5.1 Blockage prevention:

In bound underwater areas, we tend to might have period communication, whereas there's not any line of sight (LOS) link to any of OBTSs. In such cases, relay nodes may be utilized with relatively easy infrastructure to produce a reliable communication link between MUs and therefore the near OBTS, as shown in Fig. 6(a).[1]. Throughout transmission, the communication of the MU transmits its signal to relay R1 that is found in LOS with each OBTS and MU. To realize higher performance, additional relay nodes (Fig. 6(c)) may be utilized to create a parallel relaying configuration. During this theme, all relays will receive a similar signal from OBTS and transmit them to the MU; or once channel state in formations (CSI) are on the market at the OBTS, the relay with the foremost reliable channel may be chosen.

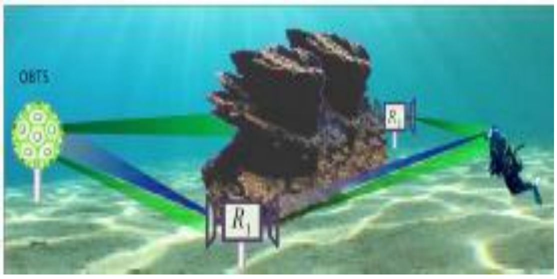

Fig.6(a)

Fig.6(b)

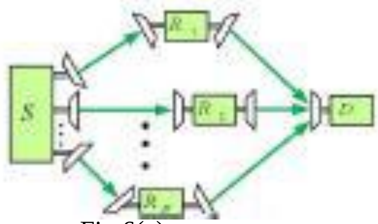

Fig.6(c)

5.2 Cell-Edge Coverage:

One of the foremost necessary problems in planning a cellular network is however the network will envelop cell-edge users suffering from small received signal to noise ratios (SNRs). A potential approach is that each one the neighboring OBTSs, that have comparatively the same distance to the cell-edge, at the same time transmit optical signal to the letter of the alphabet so as to make a multiple input single-output (MISO) configuration as shown in Fig.6(a). Different links will be thought-about as temporary parallel channels, readying of multiple transmitters as shown in Fig. 6(b) will improve the system performance, particularly for extremely turbulent channels. However, it requires perfect synchronization approach along with OBTSs to transmit data with appropriate time delays.

5.3 Increasing Number of Supported Users

In this Paper UW-OCDMA network, the ability of every sensible transmitter and Receiver, in terms of the amount of layered MUs, depends on the amount of OOC codes (Nc) in OCDMA system [19]. Within the first approach, there's not any interference between neighboring OBTSs, whereas within the second, neighboring OBTSs would possibly interfere along, if they use identical code set. Though within the 1st approach OBTSs do not interfere along, the capability of the network is restricted to NC. Thus, reusing OOCs is a sexy resolution to extend the capability of underwater cellular network, only if we have a tendency to resolve its interference issue. WDM/OCDMA-based system provides higher capability; it wants a lot of sophisticated hardware in each OBTS and MU. Rather than single band transceivers utilized within the OCDMA theme, in WDM/OCDMA counterpart, multi wavelength transceivers square measure needed.

VI. Conclusion

The simplicity and importance of implementing the use of a smart optical transmitters and receivers for underwater wireless optical communication systems are presented. Increased Field of view and to evaluate the point of view by the smart optical receiver along with the evaluation of quality of water by calculating the optical backscatter from transmitter is represented. Also overview of, challenges and potentials of the underwater wireless optical code division multiple-access network based on optical orthogonal codes (OOC) are explained. This network stratifies the primary aim of the military and viable demands of the underwater communication. In UW-OCDMA design a set of optical base transceiver stations (OBTSs) are located at the center of hexagonal cells to cover a large underwater area. All OBTSs have number of smart transmitter and receiver can be connected with fiber optic hub called optical network controller (ONC). Additionally, applications of the proposed network in communicate support with underwater local sensor networks and localization and location are offered. Finally, probable design challenges concerning blockage prevention, cell-edge coverage and limitation in network capacity and overcome these issues are addressed.

REFERENCES:

[1] Farhad Akhoundi , Mohammad Vahid Jamali , Navid Bani Hassan , Hamzeh Beyranvand , Amir Minoofar and Jawad A. Salehi , *Fellow*, *IEEE* ”Cellular Underwater Wireless Optical CDMA Network: Potentials and Challenges‖IEEE Journal on 25feb 2016

[2] Simpson, Jim. A; Hughes,Brian L; Muth,John F ―Smart transmitters and receivers for underwater free-space optical communication,‖IEEE Journal on selected areas in communications, VOL. 30, NO. 5, JUNE 2012

[3] C. D. Mobley, Light and water: Radiative transfer in natural waters.

[3] [2] [2] C. Pontbriand, N. Farr, J. Ware, J. Presig and H. Popenoe, ―Diffuse high-bandwidth optical communications,‖ in Proc. OCEANS Conf, 2008, Quebec, Canada, Sept. 15-18 2008.

[3] B. Cochenour, L. Mullen, and A. Laux, ―Phase Coherent Digital Communications for Wireless Optical Links in Turbid Underwater Environments,‖ in Proc. OCEANS Conf. 2007, Vancouver, BC, Canada, 2007.

[4] M. Doniec, I. Vasilescu, M. Chitre, C. Detweiler, M. Hoffmann- Kuhnt, and D. Rus, ―AquaOptical: A lightweight device for high-rate longrange underwater point-to-point communication,‖ in Proc. OCEANS Conf. 2009, Biloxi, MS, Oct 26-29 2009.

[5] F. Hanson and S. Radic, ―High bandwidth underwater optical communication,‖ Applied Optics, vol. 47, no. 2, p. 277, Jan. 2008.

[6] W.C. Cox, ―A 1 Mbps Underwater Communication System Using a 405 nm Laser Diode and Photomultiplier Tube,‖ M.S. thesis, North Carolina State University, Raleigh, 2007.

[7] J.A. Simpson, ―A 1 Mbps Underwater Communications System using LEDs and Photodiodes with Signal Processing Capability,‖ M.S. thesis, North Carolina State University, Raleigh, 2007.

[8] J. A. Salehi, ―Code division multiple-access techniques in optical fiber networks. Part I. fundamental principles,‖ *IEEE Trans. on Commun.*, vol. 37, no. 8, pp. 824–833, 1989.

[9] J. A. Salehi, ―Emerging OCDMA communication systems and data networks [invited],‖ *Journal of optical networking*, vol. 6, no. 9, pp. 1138–1178, 2007.