Underwater Optical Wireless Sensor Network Using Visible-Light Communications

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A wireless sensor network (WSN) consists of multiple spatially distributed wireless terminals. Each wireless terminal is an autonomous sensor node. And each sensor node equipped with a wireless transceiver, a microprocessor, and a battery or energy harvesting device. The sensor nodes of a WSN are scattered in a specific physical space to collect information from these wireless sensors. Because the WSN is a multipoint simultaneous measurement system, hence it is effective for grasping distribution changes of environmental situations and physical phenomena. And it is also one of core technologies used in current IoT (Internet of Things).

On the other hand, the expansion of human activities in marine environments such as the monitoring and exploration of the ocean, offshore oil field exploration and so on make the needs for underwater WSN (UWSN) is increasing. Like this that the developments of marine environment and resources have many tasks for the observations and analysis of many phenomena including marine physics, marine chemistry, marine biology, and so on. And data among these different fields are related to each other. Therefore, how to construct a smart UWSN is also interesting and important in the aquatic world with multi-data, so, data between different instruments can mutually use and reference.

However, the techniques of conventional terrestrial WSN to the marine environments have intrinsic difficulties. In fact, the major obstacle in using radio for underwater communication is the severe attenuation due to the conducting nature of seawater. In particular, the attenuation is very high for high-frequency radio waves and, since the current terrestrial technology for wireless communication is often based on high frequency in the order of Gbps, so it is practically impossible to use terrestrial techniques in underwater application.

An alternative to radio wave communication is using visible light wave. Seawater exhibits a window of reduced absorption in the visible spectrum, as shown in Fig. 1. [1] Particularly between 400-650nm, where water is relatively transparent to light and absorption takes its minimum value. Also, because the inherent high bandwidths and space divisionality of the light waves, make the techniques of underwater optical wireless communication (UOWC) a most important approach to construct the UWSN. [2]

An UOWC-based UWSN with mesh topology is proposed as shown in Fig. 2. [3] It consists of a gateway sensor node, i.e. main node and multiple sensor nodes, i.e. subnodes. One node corresponds to one observation instrument. Each node is connected to other nodes and contructing a mesh, such, multiple communication paths can be generated. The links between each subnode are optical wireless channels. The space division and visibility of visible light can ensure each sub node is independent and identifiable both the space and the time. These sub-node data are long-distance transmitted to a land station by using optical fiber via a main node. First, an LED (Light Emitting Diode)-based UOWC transceiver with wavelength-adaptation function has been developed. The LEDs are incoherent source, it neither like as a coherent laser to damage the marine creatures, yet does not lose the inherent high speed of light, and can as a lighting equipment for underwater lighting. Adaptive-control technique is used for seawater turbidity of the spatio-temporal change. Further studies and developments include that to analyze underwater optical channel and optimal network topology.

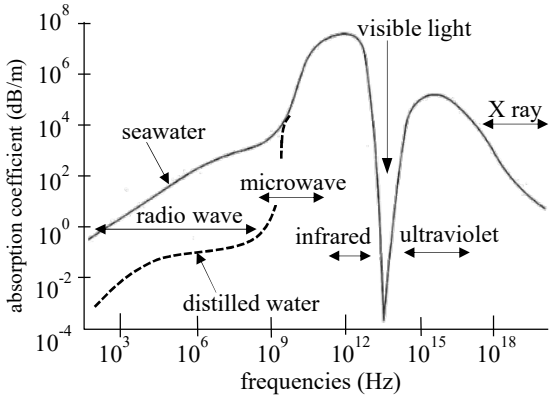

Fig1. Absorption coefficients of electromagnetic wave in the water.

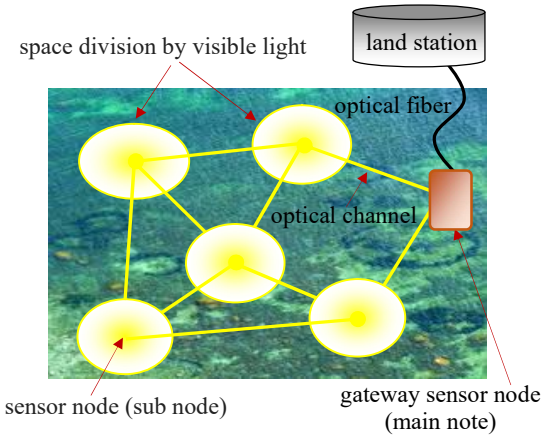

Fig2. The underwater optical wireless sensor network.

1. S. Nakao, *Defense Technology*, *Attenuation of electromagnetic waves in seawater*, 22-30 (1987).
2. L. Ghelardoni, A. Ghio, and D. Anguita, *IEEE 27th Convention of Electrical and Electronics Engineers in Israel*, *Smart underwater wireless sensor networks*, pp.1-5 (2012).
3. X. Lin, *IEICE Trans. Fundamentals*, *Underwater wireless communication system of adaptation wavelength using visible light*, **E100-A (1)**, 185-193 (2017).

Presentation Method (Keynote / Invited / Regular Oral / Poster): Invited