Marine Information Technology Curriculum Report

Title: How underwater wireless communication is being used in aquaculture to generate a real-time data

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I declare that the assignment here submitted is original except for source material explicitly acknowledged, and that the same or related material has not been previously submitted for another course. I also acknowledge that I am aware of University policy and regulations on honesty in academic work, and of the disciplinary guidelines and procedures applicable to breaches of such policy and regulations.

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Date: 30/05/2020

1.0 Introduction

Wireless communication technology today has become part of our daily life; however the idea of wireless underwater communications may still seem unbelievable. However, research has been active for over a decade on designing the methods for wireless information transmission underwater. The major discoveries of the past decades, has motivated researchers to carry out better and efficient ways to enable unexplored applications and to enhance our ability to observe and predict the ocean (Essays 2018).

Each deployed and scalable sensor network in a 3-dimensional underwater space can monitor and detect environmental parameters and events locally. Hence, compared with remote sensing, Under Acoustic Sensor Networks (UWSNs) provide a better sensing and surveillance technology to acquire better data to understand the spatial and temporal complexities of underwater environments (Essays 2018).

Some of these applications can be supported by underwater acoustic sensor networks (UWASNs), which consist of devices with sensing, processing, and communication capabilities that are deployed to perform collaborative monitoring tasks. Present underwater communication systems involve the transmission of information in the form of sound, electromagnetic (EM), or optical waves. Each of these techniques has advantages and limitations (Essays 2018).

1.1 Communication method: Electromagnetic waves cannot propagate over a long distance in underwater environments. Therefore, underwater sensor networks have to rely on other physical means, such as acoustic sounds, to transmit signals. Unlike wireless links among ground-based sensors, each underwater wireless link features large latency and low-bandwidth. Because of such distinct network dynamics, communication protocols used in ground-based sensor networks may not be desirable in underwater sensor networks. In particular, low-bandwidth and large-latency usually result in long end-to-end delay, which causes big challenges in reliable data transfer and traffic congestion control. The large latency also significantly affects multiple access protocols. Traditional random access approaches in RF wireless networks might not work efficiently in underwater scenarios (Zhang *et al*., 2015).

Node Mobility; most sensor nodes in ground-based sensor networks are typically static, in contrast, the majority of underwater sensor nodes, except some fixed nodes equipped on surface-level buoys, are with low or medium mobility due to water current and other underwater activities. From empirical observations, underwater objects may move at the speed of 2-3 knots (or 3-6 kilometers per hour) in a typical underwater condition. Therefore, if a network protocol proposed for ground-based sensor networks does not consider mobility for the majority of sensor nodes, it would likely fail when directly cloned for aquatic applications (Cui *et al*., 2006).

1.2 Underwater wireless communication characteristics

Underwater wireless communication is characterized by two waves viz: acoustic waves and electromagnetic waves.These waves had been established for underwater wireless communication systems. In some cases, both of these waves are used together. These two types of waves are different in nature; electromagnetic waves are caused by interference in an electromagnetic field and acoustic waves are caused by a physical vibration of particles. Acoustic waves are naturally characterized by being able to perform well because their absorption in the underwater environment is low, but it become impractical for underwater communication when the system involved the air-water interface. On the other hand, for underwater communication using electromagnetic wave it is possible to be employed for trans-boundary air-water. High power and large antenna determine the liability of electromagnetic wave. This becomes the major challenge for it to deploy on autonomous underwater vehicles (AUV). In underwater environment the acoustic wave propagation power is smaller compared to electromagnetic wave. Therefore, the acoustic transmissions become a main consideration for underwater communication researchers (Yoong *et al*., 2009)

2.0 Why the need for underwater wireless communication in aquaculture?

The present increase in aquaculture activities made it necessary for aquaculturists to provide means through which the monitoring of various water parameters, feed utilization, fish health as well as fish waste products could be managed with less human labour input. This not only restricted to controlling or monitoring these parameters with respect to fish solely but also other aquatic organisms incorporated with the fish or naturally existing biotic and abiotic factors living in relationship with in aquaculture system. Therefore your business requires monitoring of numerous parameters of the water body to check the health of the farmed live stock. Monitoring the environment and controlling the parameters are critical – if the conditions are not correctly controlled, there can be high mortality of the stock and disastrous consequences to your operation itself.

Some key applications for underwater wireless communication in the industry are:

- ✓ Real-time data gathering and analysis from the sensors. Real-time data reticulation is important as dynamic monitoring and timely action is needed for the proper operation.
- ✓ Communications to divers employed in sub-sea farms.
- ✓ Telemetry and control systems to regulate feeding systems and other systems that need actuators.

The main objective is to improve the sustainability of aquaculture.

2.1 Real-time time parameters detection devices

Some parameters with which underwater wireless sensors are being used in aquaculture include:

Dissolved Oxygen and temperature:

Dissolved Oxygen (DO), Salinity (SAL), DO/Depth (DOD), Chlorophyll (CHLA), Turbidity, Temperature (T), BG Algae and CDOM/FDOM. Sensors are easy to install, built for the roughest of open ocean conditions and are field-ready, factory-calibrated.

aquaMeasure is a family of compact, submersible environmental sensors with underwater and in-air wireless communications. By combining underwater communications with cloud-sync technology, aquaMeasure delivers a user experience that is intuitive and unique, enabling mass amounts of data to be gathered from underwater environments and sent seamlessly to the cloud.

DO measurements are crucially important in optimizing feeding and maintaining healthy fish. Ongoing low dissolved oxygen levels on a farm can significantly affect fish behavior and lead to mortality. Conversely, supersaturated water can be highly dangerous for fish, leading to similar behaviors. Not every farm is the same. DO levels can be affected by numerous variables; size of fish, net fouling, water temperature, salinity and atmospheric pressure. Levels continuously vary throughout a day, so it is crucial that aquaculture farmers measure DO in real-time.

Fig. 1: Dissolved Oxygen and Temperature (DOT) Wireless Sensor/Data Logger (www.innovasea.com)

Salinity:

Salinity is an important measure of water quality as many species of fish survive in different ranges of salinity. In aquaculture, abrupt changes in salinity can cause high levels of stress and can even lead to mortality. Although changes in salinity are uncommon, greater fluctuations are found in areas affected by tidal forces or near a freshwater source. It is recommended that salinity is measured in realtime to capture changeover events and to utilize preventative measures. Salinity can also be used to convert DO saturation measurements into mg/L.

Fug. 2: SAL Wireless Sensor/Data Logger (www.innovasea.com)

Blue green algae:

Blue green algae (BG Algae) are a bacterium that grows in both fresh and marine water ecosystems. In aquaculture environments, signs of BG Algae are not always visible and blooms can have an almost instantaneously disastrous effect on farm biomass. Negative effects can include low dissolved oxygen and the production of toxins, which can lead to extremely high levels of mortality. In areas known for potential algae blooms, or high levels of BG Algae, realtime monitoring is extremely important.

Fig. 3: BGA (Marine) Wireless Sensor/Data Logger (www.innovasea.com)

Turbidity:

Turbidity is most often a result of suspended particles of solid matter in marine environments; if water is turbid it appears ‘cloudy’. Turbidity is an important measure of water quality because increased levels of turbidity raise water temperatures, which can be harmful to biomass and affect fish feeding behavior and welfare. Sudden changes in turbidity can also be an indication that a new pollutant source is under development, or entered the water. Real-time monitoring of turbidity helps ensure that nothing goes unnoticed and can provide greater insights for other parameters.

Fig. 4: TURB Wireless Sensor/Data Logger (www.innovasea.com)

Chlorophyll:

Measuring chlorophyll in water is important in order to estimate levels of phytoplankton; if a high level of chlorophyll is detected, it is an indication that a high level of phytoplankton is present in the water. In aquaculture, the size of the biomass and possible pollutants entering the water can have a major impact on macronutrients and phytoplankton biomass. In order to gain a clear vision for sustainable use of aquaculture and marine habitats, assessment of water quality depending on phytoplankton is important.

Fig. 5: CHLA Wireless Sensor/Data Logger (www.innovasea.com)

Coloured or chromophoric dissolved organic matter:

Coloured or chromophoric dissolved organic matter (CDOM) is a naturally occurring matter that consumes UV light in water. CDOM in part will fluoresce when it absorbs light of a certain spectrum; this called fluorescent dissolved organic matter or FDOM. CDOM/FDOM sensors are used to measure dissolved organic material (DOM) in fresh and marine water ecosystems. Aquaculture sites close to human influences such as logging, agriculture, effluent discharge and wetland drainage can be subject to varying levels of CDOM/FDOM, making it crucial to measure both parameters continuously and in real-time.

Fig. 6: CDOM/FDOM Wireless Sensor/Data Logger (www.innovasea.com)

Feed utilization:

aquaHub is the core of the system deployed in the field and can be easily mounted to existing aquaculture infrastructure or feed barges. Utilizing a digital receiver, communications modem and state of the art electronics, the aquaHub can support up to 100 aquaMeasure sensors within a 500m radius. The aquaHub was made with the understanding of the remoteness of aquaculture environments, so it supports many telemetry protocols for cloud communications including Cellular, Wi-Fi and Iridium. It is designed in a rugged, waterproof housing, that stands up to the rough, open water conditions of remote locations. The hub also supports third-party sensors like weather stations, via its auxiliary sensor port and features internal memory for backup purposes.

Fig. 7: HUB Wireless Sensor/Data Logger (www.innovasea.com)

Current:

aquaCurrent is a cloud-based platform that allows you to view and analyze data from all of your aquaculture sites in real-time, no matter where you are. The software provides a set of continuously evolving analytics tools that give you the ability to easily view data how you want, in the format you decide. In addition to viewing and analyzing your data from an intuitive and easy to understand web portal, aquaCurrent can let you know if something is wrong at any time. Notifications and alerts allow you to receive crucial updates in real-time, allowing for a quick passage back to aquaCurrent to view the whole picture. aquaCurrent works to keep your data secure, safe and available to you, whenever you need it. By utilizing advanced cloud architecture, aquaCurrent delivers on its promise to be the future of realtime environmental monitoring software.

Fig. 8: CURRENT Wireless Sensor/Data Logger (www.innovasea.com)

2.2 Advantages

- Makes ponds/net management easier hence reduce expenses
- Helps in being proactive against possible risks of health abnormalities
- It also reduces the harvesting time as arising problems are easily detected
- Feed wastage is minimized

2.3 Disadvantages (Subha et al., 2007).

- Battery power is limited and usually batteries cannot be recharged also because solar energy cannot be exploited.
- The available bandwidth is severely limited.
- Channel characteristics including long and variable propagation delays Multi-path and fading problems.
- High bit error rate.

4.0 Conclusion

Underwater wireless communication technology enables a platform to build up a network connection between underwater devices with offshore based station. Hence the use of these devices makes it easier for aquaculturists to properly manage their farms, hence determining the sustainability aquaculture.

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