IJCSI International Journal of Computer Science Issues, Vol. 7, Issue 5, September 2010
ISSN (Online): 1694-0814
www.IJCSI.org

The Use of Underwater Wireless Networks in Pisciculture at Amazon

Isadora Santos[1], Gleyson Souza[2] and Mauro Margalho[3]

[1,2,3] Centro de Ciências Exatas e Tecnologia, Universidade da Amazônia
Belém, Pará, Brazil

Abstract

The past decades have seen a growing interest in underwater wireless communications researches, but this faces many challenges, specially through physical processes that cause impact in this communication technique.

Despite this, underwater wireless networks seems to be a good solution for water quality monitoring in pisciculture tanks, since this service requires a lot of time and manpower. The Amazon region has many resources to increase pisciculture development so the idea of making this service automatic is very promising.

In this paper we aim to analyze the performance of this network by simulation, in order to check the viability of the underwater wireless networks in pisciculture activity at Amazon.

Keywords: *underwater wireless, Amazon, pisciculture, acoustic network, simulation.*

1. Introduction

The Amazon is known worldwide by its biodiversity and water availability. The Amazon River basin is the largest in the world, occupying an approximated area of 7.008.370 km^2, with nearly 60% located in Brazil [1]. The importance of these water resources is mainly for fishing and navigation.

It's estimated a range of three thousand species of fish in this region [2] and a high rate of deforestation due to conversion of forest to pasture lands and agriculture.

Nowadays these data are highly relevant because of the high demand for alternative livelihood activities that require little deforestation. One of these activities is the fish farming or pisciculture, as it is called the fish cultivation, mainly from fresh water, which may be ornamental or sustainable and generate jobs and finances to the population. This makes this activity a great social and economical option for this region.

However, this activity needs supporting technology, in order to have a water quality monitoring at the farms, as it has a great influence on growth and survival of fish [3] and it is too vulnerable to pollution caused by industrial and urban waste, and the use of pesticides and fertilizers.

There are many methods to monitor water quality; many of these manuals use specific equipments for each quality factor, as thermometers, Secchi disks, and conductivity measurer, among others [3, 4]. But because methods are manual they require much time and manpower. So, a promising solution to this monitoring activity and data collection would be through sensors adjoined to underwater wireless networks technology or underwater acoustic networks, as it called the underwater data communication. It has been studied for decades and is getting stronger due to tests that have been done.

The perspective of making this monitoring service automatic will open a range of improvements and growth possibilities for pisciculture activity, therefore it constitutes an important motivation factor for this research.

The purpose of this paper is to analyze by simulation the performance of underwater wireless networks at Amazonian fishing farm scenery in order to assess its implementation viability.

As underwater acoustic networks researches are not recent, many studies have expanded this knowledge, its main features, disadvantages and challenges [5, 6, 7]. Recent developments about this theme led to studies of sensor technologies [8, 9, 10] and simulations using many tools that evaluate this technology performance [11, 12]. The main difference between surveyed papers and this one is the simulation scenario and the motivation, because there has not been found studies about this subject that had been realized in Brazil with emphasis on Amazon, neither with the same purpose.

Besides this session, this paper is divided into four more sessions. The second session presents a study of the art state of underwater wireless communications referencing some related works. The third session presents the simulation details. The fourth session will discuss the case study, scenario and results analysis. And the fifth session presents the conclusion of this research.

2. Underwater Acoustic Networks

An underwater wireless communication way, called underwater acoustic network, is a research growing field in the last decades. It occurs because of the growing need of ocean security applications development, oceanographic data collect, navigation assistance and environmental monitoring [8].

Those networks are generally constituted establishing a link between instruments such as autonomous underwater vehicles or sensors that may connect to a surface station which can further be connected to radio-frequency links. This design creates an environment where scientists can extract real-time information [6].

An example of an underwater wireless network environment can be observed in Fig.1.

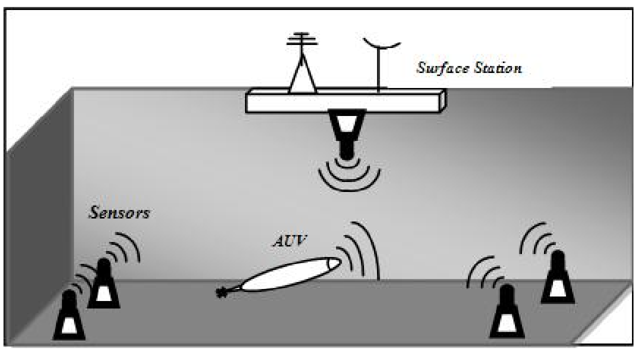

Figure 1. Example of an Underwater Acoustic Network environment.

One of the first uses of this technique occurred during the II World War, in 1945, when the United States developed a telephone which communicated with submarines [8, 13].

The underwater wireless communication is provided through acoustic waves, but this is not the only way of transmitting underwater signal. The electromagnetic waves suffer from high absorption in water and propagate only at extremely low frequencies and elevated transmission power [14]. The optical waves, instead, suffer with high scattering. That fact makes the acoustic transmission the best solution.

Despite this, the development of systems based on wireless communication underwater faces significant challenges due to the fact that the propagation characteristics in the underwater environment are too variable [7], in other words, different environments suffer different physical processes, so, an application that works effectively at an ambient may fail completely in other.

Other challenges faced by this network are the limited bandwidth, delay propagation, high bit error rates and connectivity loss in some areas [5, 6, 8].

But it is expected for those networks that it can provide the control data exchange, video, images and voice. In order to reach this aim a lot of researches are being developed currently focused on efficient communication algorithms, modulation schemes, appropriated protocols for its characteristics and mobile underwater communication techniques [13].

3. Performance Analysis by Simulation

Due to the cost, lack of equipments and difficulties to perform tests at the ocean, simulations using suitable softwares have been the most used option on researches about underwater wireless networks.

The simulations allow a faster performance evaluation, for various protocols, and get really close of real results, besides that there are a lot of tools for this purpose.

The simulation tool used on this research was Network Simulator (NS-2) also used at [12]. NS-2 has a great acceptation level by international scientific community, it is developed in C++ and TCL languages and it has an open source, hence it is in constant development process for seeking improvements. More information about this tool can be found at [15].

Associated to NS-2 a patch for dynamic libraries use has been installed. Among other features, it allows the use of different modules in simulation without recompile NS [16]. Also, it was installed NS-MIRACLE (Multi-InteRfAce Cross-Layer Extension library for the Network Simulator) which is a library package that increases the functionalities of NS-2 and makes easier the simulations of moderns communication systems because it permits the coexistence of various modules at the same protocols stack. The download can be done at the page [17]. The dei80211mr library [18] which has also been installed provides an 802.11 implementation for NS-2 and aggregates too many features.

Those cited changes were necessary to enable the underwatermiracle module installation, essential for this paper. This ns-miracle module allows a detailed simulation from underwater channel, with the implementation of different MAC protocols and two PHY layer models. The documentation and download about this module are at [19].

All those tools were developed by SIGNET Lab of Padovia University at Italy [20].

4. Case Study

4.1 Scenario Description

The used scenario in this simulation is based in a pisciculture tank with 4.500m^2 and 1,5m depth, since such tanks can vary from a few square meters until many hectares, and can be rectangular or square [21]. Normally the small tanks (between 100m^2 and 500m^2) are used for subsistence fishing farm, or domestic, the tanks with hectares size are most difficult to manage, so they are rarely used. And for commercial use, for big companies, the tanks normally measure between 1.000m^2 and 5.000m^2. The depth varies between 0.5m and 2.0m.

The water quality monitoring is provided by three fixed sensors located at the coordinates: node 1 (X=5m; Y=5m), node 2 (X=5m; Y=35m) and node 3 (X=105m; Y=5m), as shows Fig. 2. Those distances were configured so that makes perceptible the performance difference according to distance variation.

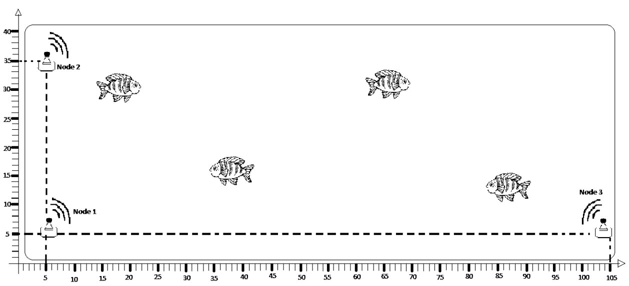

Figure 2. Example of the simulated scenario.

The sensors capture data relative to factors such as pH, temperature, dissolved oxygen, electric conductivity and transparency and send them in broadcast, using Constant Bit Rate (CBR) traffic. At this simulated scenario the traffic begins at node 1, configured as the only transmission node, and it is received by nodes 2 and 3. After the informations are received, actions would be taken to normalize the water quality, e.g. devices can be activated to discharge chemical products in the water, or alarms can sound.

Considering that those data require low bandwidth to be sent, the power transmission was set at the band of 1.0x10^{10} and the packet send rate as 3.000 bytes, because it was considered enough to send those data. The frequency was set at the range of 8 KHz that is characteristic of underwater wireless networks.

Those used values in simulation were configured to this scenario believing that if good results are obtained, certainly good results will be obtained for smallest scenarios.

Title: The title should be centered across the top of the first page and should have a distinctive font of 18 points Century. It should be in a bold font and in lower case with initial capitals.

4.2 Results

From the obtained simulation results, graphics were generated to prove the model characteristics and analyze the viability of underwater acoustic communications for pisciculture water monitoring.

The evaluated performance factors were: blocking probability (Graphic 1), receiving power by distance (Graphic 2), Signal-Noise ratio by distance (Graphic 3) and throughput (Graphic 4).

From the graphic 1 in Fig. 3, blocking probability can be calculated. This factor is obtained with the division reason of the dropped packets number by the received packet number. The worst efficiency was in node 3 with approximated value of 5% of blocking probability, this is considered so low that does not compromise the data transmission required at the scenario.

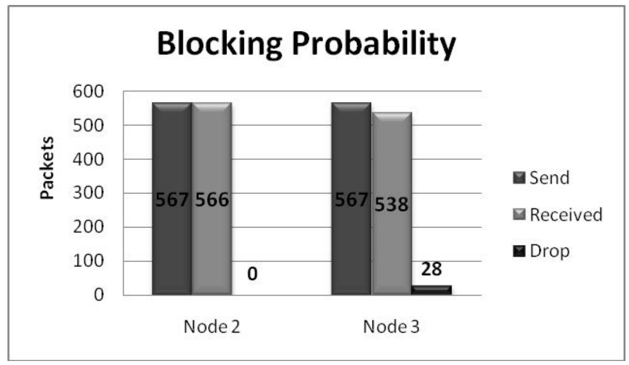

Figure 3. Graphic 1 – Blocking Probability

Another evaluated factor was the reception power rate related with the node distance, which can be observed at the second graphic in Fig. 4. It was observed that increasing the distance between the nodes decreases the reception power rate. However, as this scenario size is considered big in comparison with a normal pisciculture environment, such as the distance between nodes, this reduction of reception power rate is not enough to affect negatively the data transmission quality.

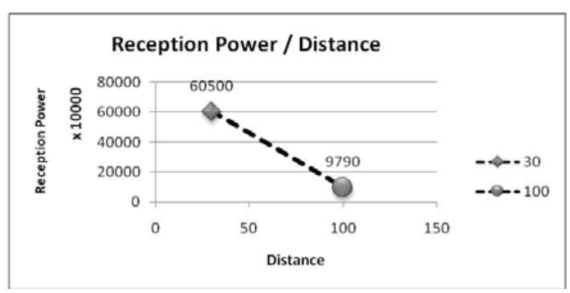

Figure 4. Graphic 2 – Reception Power by distance

The Signal-Noise ratio (SNR) in reason of distance, presented in graphic 3 at Fig. 5, shows that the greater the distance between nodes, the smaller the signal-noise ratio.

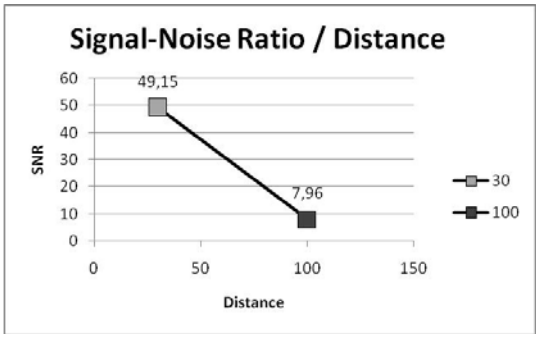

Figure 5. Graphic 3 – Signal-Noise Ratio by distance

Finally, graphic 4 at Fig. 6 shows the throughput at the two receptors nodes in the simulation instants. It could be verified that on both nodes the throughput oscillated between 3.000bps and 3.500bps, which is really close to the 3.000 bytes rate established. At the second node, which has the smallest distance, the throughput was constant in almost all instants, what differs to the third node, most distant, that obtained a biggest variation on throughput. Even so, this rate is considered viable to this application.

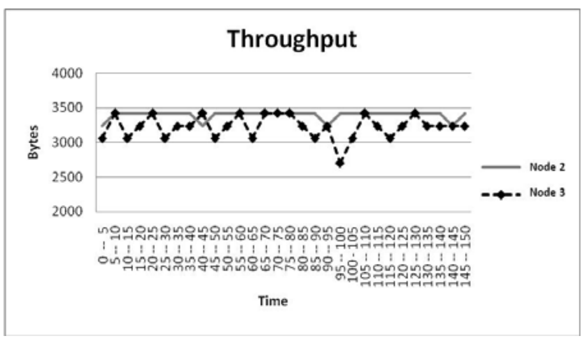

Figure 6. Graphic 4 – Throughput

5. Conclusions

This paper presented a performance analysis for the proposed use of underwater wireless networks at pisciculture tanks for water quality monitoring.

The obtained results by simulation demonstrates the viability of the proposal, since the used scenario has dimensions considered large for this type of activity, therefore in smallest scenarios, the results tend to be better.

Because the data to be collected do not require high transmission power and neither high bandwidth, the proposal appears to be suitable for automation of water monitoring in pisciculture activity, as it needs a lot of time and manpower because the measurements are performed more than once a day.

In a region like Amazon that has resources to greatly increase the pisciculture development, the proposal to automate this service is very promising, as it would enhance fish production and would improve not only the region's economy but also the population livelihood that depends of the activity.

With the growing interest in underwater wireless networks by researchers, many improvements are still expected for this technology, which will encourage, in the future, applications even better, such as marine species recognition, transmission by submarine pictures or video, which would contribute not only to the pisciculture activity but with other underwater applications.

References

[1] Ministério do Meio Ambiente, "Plano Nacional de Recursos Hídricos." [Online]. Available: http://pnrh.cnrh-srh.gov.br/. [Accessed: Apr. 11, 2010]

[2] Ministério do Meio Ambiente, "Agência Nacional de Águas." [Online].Available:http://www2.ana.gov.br/Paginas/portais/bacias/amazonica.aspx. [Accessed: May 11, 2010]

[3] V.K. Silva, M.W. Ferreira, and P.V. Logato, "Qualidade da água na Piscicultura.", unpliblished.

[4] J.S. Vieira, J. Sampaio, G. Gomiero, P. Vieira, and R. Logato, "Aspectos gerais da piscicultura," 1991.

[5] M. Stojanovic, "Underwater wireless communications: current achievements and research challenges," *IEEE Oceanic Engineering Society*, 2006, pp. 2-7.

[6] E. Sozer, M. Stojanovic, and J. Proakis, "Underwater acoustic networks," *IEEE Journal of oceanic engineering*, vol. 25, 2000, pp. 72-83.

[7] J. Preisig, "Acoustic Propagation Considerations for Underwater Acoustic Communications Network Development," *Society*, 2006, pp. 1-5.

[8] I. Akyildiz, D. Pompili, and T. Melodia, "Underwater acoustic sensor networks: research challenges," *Elsevier's Ad Hoc Networks*, vol. 3, 2005.

[9] I.F. Akyildiz, D. Pompili, and T. Melodia, "Challenges for Efficient Communication in Underwater Acoustic Sensor Networks.pdf," *SIGBED Review*.

[10] J. Heidemann, W. Ye, J. Wills, A. Syed, and Y. Li, "Research Challenges and Applications for Underwater Sensor Networking," *Information Sciences*.

[11] J. Han, J. Huang, and M. Ran, "Design and simulation of an underwater acoustic network," *Wireless, Mobile and Sensor*

[12] A.F. III and M. Zorzi, "Modeling the Underwater Acoustic Channel in ns2," *Work*.

[13] M. Stojanovic, "Underwater acoustic communications," *ELECTRO-IEEE CONFERENCE-*, 1995.

[14] A.P. Miguens, "Noções sobre geração, transmissão, propagação e recepção das ondas eletromagnéticas e acústicas," *Navegação: A Ciencia e a Arte*, vol. III, 2000, pp. 1221-1264.

[15] NS2, "User Information." [Online]. Available: http://nsnam.isi.edu/nsnam/index.php/User_Information. [Accessed: May 12, 2010]

[16] Università degli Studi di Padova, "A patch for effectively using Dynamic Libraries in NS-2." [Online]. Available: http://www.dei.unipd.it/wdyn/?IDsezione=3970. [Accessed: May 12, 2010]

[17] Università degli Studi di Padova, "NS-MIRACLE: Multi-InteRfAce Cross-Layer Extension library for the Network

Simulator." [Online]. Available: http://www.dei.unipd.it/wdyn/?IDsezione=3966. [Accessed: Apr. 14, 2010]

[18] Università degli Studi di Padova, "dei80211mr: a new 802.11 implementation for NS-2." [Online]. Available: http://www.dei.unipd.it/wdyn/?IDsezione=5090. [Accessed: Apr. 14, 2010]

[19] Università degli Studi di Padova, "Underwater Communications." [Online]. Available: http://www.dei.unipd.it/wdyn/?IDsezione=5216. [Accessed: May 12, 2010]

[20] Università degli Studi di Padova. Department of Information Engeneering, "SIGNET." [Online] Available: http://telecom.dei.unipd.it/labs/read/3/. [Accessed: May 12, 2010]

[21] E. Carballo, A.V. Eer, T.V. Schie, and A. Hilbrands, *Piscicultura de água doce em pequena escala*, Agromisa Foundation, 2008.

Isadora Mendes dos Santos is a student of Computer Science Bachelor's degree at the University of Amazônia, Brazil. She participated in some research projects including the CODPON networks (Continous Displacement Plan Oriented Network). Her research interests include computer networks, underwater acoustic networks, network performance evaluation.

Gleyson Correa de Souza is a student of Computer Science Bachelor's degree at University of Amazônia, Brazil. Research interest: computer networks.

Mauro Margalho Coutinho is a lecturer and researcher in the Center of Science and Technology, at University of Amazônia, Brazil. Mauro Margalho is Msc in Computer Science (emphasis in Network Computer) by Federal University of Pernambuco and PhD in Electrical Engeneering (emphasis in Telecommunication Systems) by Federal University of Pará. Currently holds the position of coordinator of Computer Science Bachelor's degree Course at the University of Amazon and member of the editorial board of the TRAÇOS journal as well as the head of computer network department from Assembléia Legislativa do Pará (Legislative Power from Pará). Professor Mauro Margalho participated in several research projects, highlighting the creation of the CODPON networks (Continous Displacement Plan Oriented Network) project. Areas of interest include digital TV, mobile computing, computer networks and accessibility.