ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 2, Issue 1, January 2013

Energy Efficient and Reliable Communication in Underwater Acoustic Sensor Networks

S.Beeno Ancy, S.Shahul Hammed

***ABSTRACT*— Normally, the communication in the earth surface is through electromagnetic or radio waves. But this is not possible in the underwater environments in an efficient way. In underwater environments radio does not work well due to its quick attenuation in water. Hence the acoustic signals are sent using the acoustic channels. If the communication is done with retransmission, it gives rise to the propagation delay and high error rate due to path loss and if the communication is done without retransmission the consumption of energy is high. In order to overcome these drawbacks Multipath Power control Transmission (MPT) is used.MPT consumes much less energy than the conventional one-path transmission scheme without retransmission. The resulting data transmission technique achieves the efficient multipath communication and provides energy efficient and end-to- end packet delivery.**

***Index Terms*: Underwater Sensor networks, Wireless networks, underwater networking, Multipath propagation, secure transmission**

I. INTRODUCTION

Location of every sensor is important and the process of estimating the location of each node in a sensor network is known as localization. While various localization algorithms have been proposed for terrestrial sensor networks, there are relatively few localization schemes for UWSNs. The characteristics of underwater sensor networks are fundamentally different from that of terrestrial networks. Underwater acoustic channels are characterized by harsh physical layer environments with stringent bandwidth limitations. The variable speed of sound and the long Propagation delays under water pose a unique set of challenges for localization in UWSN.

Manuscript received January, 2013.

S.Beeno Ancy *Department of Computer Science and Engineering, Karpagam University, Coimbatore, India*
S.Shahul Hammed*, Department of Computer Science and Engineering, Karpagam University, Coimbatore, India,*

Underwater sensor networks enable a wide range of aquatic applications, such as oceanographic data collection, pollution monitoring, offshore exploration, and tactical surveillance applications. On the other hand, the adverse underwater environments pose grand challenges for efficient communication and networking.

In underwater environments, radio does not work well due to its quick attenuation in water. Thus, acoustic channels are usually employed. The propagation speed of acoustic signals in water is about 10^3 m/s, which is five orders of magnitude lower than the radio propagation speed $(3\times 10^8$ m/s$)$. Moreover, underwater acoustic channels are affected by many factors such as path loss, noise, multipath fading, and Doppler spread. All these cause high error probability in acoustic channels. In short, underwater acoustic channels feature long propagation delay and high error probability. In such harsh network scenarios, it is very challenging to provide energy-efficient re- liable data transfer for time-critical applications (such as pollution monitoring and submarine detection)[1]. First, conventional retransmission-upon-failure approaches are hard to satisfy the delay requirements.

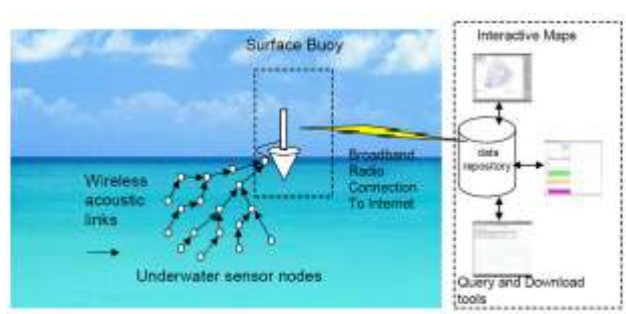


Fig 1.An example scenario for underwater sensor networks

On the other hand, with less or no retransmission, we usually need to increase the transmitting power of every node to reduce end-to-end packet error rate in order to meet

All Rights Reserved © 2013 IJARCET

certain communication reliability, as often leads to more energy consumption, thus degrading the energy efficiency of the network. Compared to its terrestrial counterpart, underwater sensor network is even more energy-constrained since underwater nodes are typically powered by batteries, for which replacement or recharging is very difficult, if not impossible, in harsh underwater environments.Therefore , minimizing the overall energy consumption becomes one of the most important design considerations for underwater networks. In summary, a new transmission scheme with short delay and high energy efficiency is desirable for time-critical applications in underwater sensor networks.

In this paper, a new scheme, called multipath power-control transmission (MPT), is used for time-critical applications in underwater sensor networks. MPT is a cross-layer approach. It combines power control with multipath routing and packet combining at the destination. Distributed power-control strategies at the physical layer are used to improve the overall energy efficiency. No hop-by-hop retransmission is allowed in MPT, as that contributes to the low end-to-end delay.

II. NETWORK ENVIRONMENT

In this paper, we consider the following *multisink* underwater sensor network model: Underwater sensor nodes with acoustic modems are densely distributed in a 3-D aqueous space, and multiple gateway nodes with both acoustic and RF modems are strategically deployed at the water surface. Each underwater sensor node can monitor and detect environmental events locally. As shown in Fig. 2, when an underwater sensor node has data to report, it first transfers the data toward one or multiple surface gateway nodes (each is also referred to as a sink) through acoustic links. Then, these surface gateway nodes relay the received data to the control center through radio links. Compared to the acoustic links in water, surface radio links are much more reliable, faster, and more energy-efficient. Considering that radio signal propagation is orders of magnitude faster than acoustic signal propagation, it is safe to assume that surface gateways can send packets to the control center in negligible time and with relatively small energy consumption (acoustic communications consume much more energy than radio communications) [9].

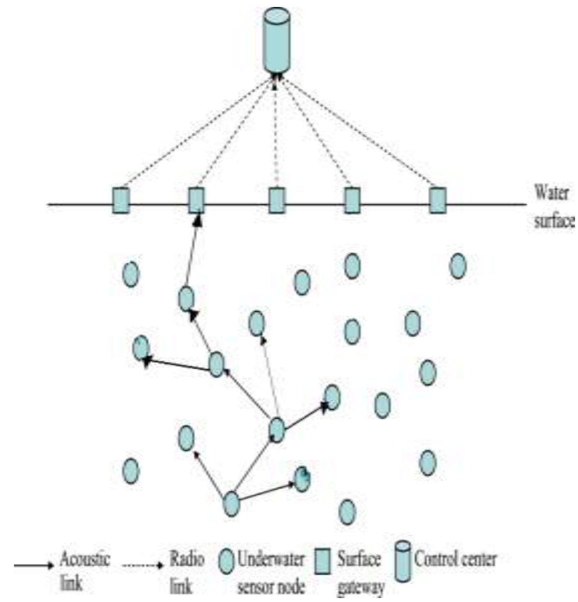


Fig 2.Network model

In addition, gateway nodes are usually more powerful and have more energy supplies). In this way, all the surface gateways (or sinks) form a *virtual sink.*

This multisink network architecture is helpful in traffic balance and multiple-path finding, as has been studied and analyzed in [8] and [5]. For our MPT scheme, this multisink architecture can effectively help to find more paths to the (virtual) sink (since any surface gateway is counted as a sink) and can greatly reduce the packet-collision probability in the MAC layer.

III. MPT DESCRIPTION

MPT can be divided into the following three parts: multipath routing, source initiated power-control transmission, and destination packet combining. The source node initiates a multipath routing process to find paths from the source to the destination. Through this route-finding process, the source will get to know some network parameters such as path length and the number of available paths.

The source node selects some paths and calculates the optimal transmitting power for each node along the selected paths across the whole network. To overcome this complex problem efficient iterative algorithm is used. If simulation result is properly used, multipath can actually

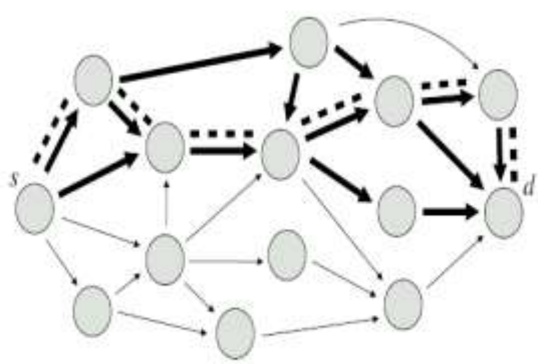
All Rights Reserved © 2013 IJARCET

reduce the total energy consumption in underwater fading environments with low end-to-end packet delays.

A) Multipath Routing

In multi path routing the source node has some packets to send, it sends a Route Request message to the destination. Any intermediate nodes receive this Route Request for the first time will forward the node. When the destination receives Route Request messages, it replies with Route Reply messages along the paths of the corresponding Route Request messages the destination node also make path selection. It can able to select node-disjoint paths and send Route Reply back to the destination. After the source node receives the Route Reply messages the routes between the source and the destination is established.

Fig 3. Multipath Routing



The traditional approach for ocean-bottom and ocean-column monitoring is to deploy underwater sensors that record data during the monitoring mission and then recover the instruments [4][5].

No real-time monitoring: The recorded data cannot be accessed until the instruments are recovered after the beginning of the monitoring mission. This is critical in environmental monitoring applications such as seismic monitoring.

No on-line system reconfiguration hence the interaction between onshore control systems and the monitoring instruments is not possible.

It is not possible to reconfigure the system after particular events occur.

No failure detection if failures or misconfigurations occur, it may not be possible to detect them before the instruments are recovered. This leads to the complete failure of a monitoring and limited storage capacity the amount of data that can be recorded during the monitoring mission by every sensor is limited by the capacity of the onboard storage devices.

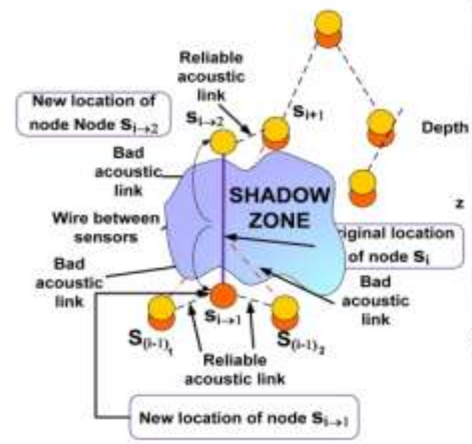


Fig 4. Nodes placed in bad acoustic links

Although recently developed network protocols for wireless sensor networks the unique characteristics of the underwater acoustic communication channel, limited bandwidth capacity and variable delays require very efficient and reliable new data communication protocols.

Different architectures are used for two-dimensional and three-dimensional underwater sensor networks and the characteristics of the underwater channel the challenges for the development of efficient networking solutions posed by the underwater environment and a cross-layer approach to the integration of all communication functionalities.

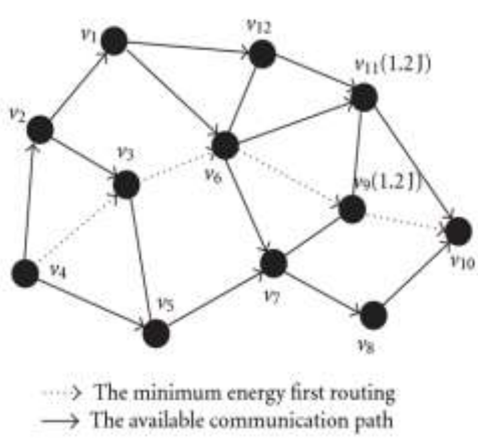
The energy efficient MAC protocol is used in dense network of sensor nodes with small node spacing short distance will extend the battery life. This reduces end-to-end delays in network by use of base station that computes route for all underwater sensor networks. Propagation delays are reduced by using MAC protocol; to integrated protocol stacks for under water communication.

B) The Source Initiated Power Control Transmission

All Rights Reserved © 2013 IJARCET

The same packets sent from the source node are transmitted by the intermediate nodes along all the selected paths using the specified transmission power. Every packet should include the source identification (Source ID), the destination identification (Destination ID),

Fig 5.Data Transmission



as well as the packet sequence number in the packet header and the source node should also include power parameters in the packet header. If the header is correct, it transmits the packet to the next intermediate node without further checking and if the header is incorrect it drops the packet.

IV. EXISTING MODEL

The source node sends the packet to destination through multiple paths. But it seems to be difficult to transmit the data without packet loss and delay. It also contains the replica of the original data at the destination since it transmits the packet through multiple paths. The sensor nodes that are present in the underwater environments work with the help of the battery. Hence by sending the data from source to destination through multiple paths it reduces the battery consumption of the sensor nodes and thus reduces the life time of the nodes and it is quiet difficult to replace the nodes. In order, to overcome these issues the opportunistic data forwarding method is used.

V. OPPORTUNISTIC DATA FORWARDING

In this method, Position-based Opportunistic Routing (POR) protocol is used. Several forwarding candidates cache the packet that has been received using MAC interception. If the best forwarder does not forward the packet in certain time slots, suboptimal candidates will take turn to forward the packet according to a locally formed order. In this way, as long as one of the candidates succeeds in receiving and forwarding the packet, the data transmission will not be interrupted.

The data packets are transmitted as a way of multicast (which is actually implemented by MAC interception) with multiple forwarders. A forwarder list determined by previous hop according to local position information is inserted into the IP header and the candidates take turn to forward the packet based on a predefined orders. This redundancy and randomness make it quite efficient and robust. In addition, inherited from position based routing, POR's control overhead is almost negligible which justifies its good scalability. Both theoretical analysis and simulation results show that POR not only achieves outstanding performances in normal situations but also yields excellent resilience in hostile environments.

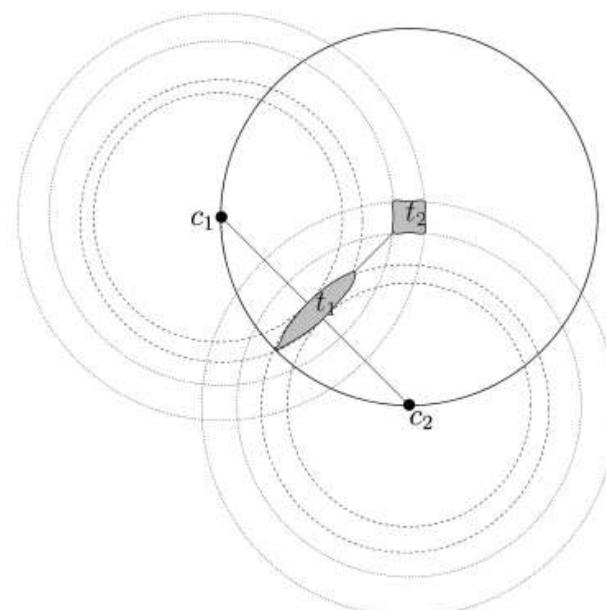


Fig 6. Nodes present in coverage region

The packet is sent from the source to all other nodes that are within the coverage region. Based on the distance between each node the packet is sent to all other nodes with certain priority. Therefore the node that has the highest priority will again sense the nodes that are present within the coverage region and then it transmits the packet. If there is

All Rights Reserved © 2013 IJARCET

any failure in the link that is transmitting the packet, the node that has the next highest priority will transmit the packet.

VI. SIMULATION

With the help of the Aqua-sim we simulate the proposed opportunistic data forwarding scheme in underwater acoustic sensor network. In our simulation, 200 mobile sensor nodes are placed within a square area of 250 m x 250 m and the mesh topology is created.

A) Impact of Node Density: Here, we gradually change the average node density of the network by changing the maximal transmitting range of every node from 450 to 750 m4. Thus, the average node density changes from 4 to 18. The average end-to-end PER is set to be 0.05.With the increase of node density, the overall energy consumption of MPT will decrease. This is because more paths to the sink node will be found with the increase of node density, which contributes to the decrease of energy consumption. However, the decrease will slow down in the high-node-density region. This is because in the high-node-density region, most usable energy-efficient paths have already been found, and continuing increase the maximal transmission range will not help much in energy consumption reduction. Besides, higher node density will introduce more collision in the net- work, which will degrade the network's energy efficiency in practice. The average node density is defined as the average number of one-hop neighbors of a node. Two nodes are neighbors if they can reach each other with their maximal transmitting power. In our simulations, the data rate does not change with the transmission range.

VII. CONCLUSION

This paper has summarized the reliable and energy efficient data transmission in underwater sensor networks, including research challenges in the direction of energy consumption. The performance of our proposed approach is analyzed with the parameters, throughput, packet delivery ratio, and packet drop and energy consumption on basis of time. This goal can be achieved if the topology and the protocol design can be able to self-adaptive when environment changes. However both topology and routing design should always take into consideration energy efficiency which is critical to an UWSN life and normal operation and used for time-critical applications.

ACKNOWLEDGMENT

Thanks to the experts who have contributed for the development of reliable and energy efficient communication in underwater acoustic sensor networks using opportunistic data forwarding and its simulated solution.

REFERENCES

[1] I. F. Akyildiz, D. Pompili, and T. Melodia, "Underwater acoustic sensor networks: Research challenges," *Ad Hoc Netw.*, vol. 3, no. 3, pp. 257–279, Mar. 2005.

[2] M. A. Bhatti, *Practical Optimization Methods With Mathematical Applications*.New York: Springer, 2000.

[3] Q. Cao, T. Abdelzaher, T. He, and J. Stankovic, "Towards optimal sleep scheduling in sensor networks for rare-event detection," in *Proc. ACM/ IEEE IPSN*, Apr. 2005, vol. 1, pp. 20–27.

[4] C. Carbonelli and U. Mitra, "Cooperative multihop communication for underwater acoustic networks," in *Proc. 1st ACMWUWNet*, Sep. 2006, vol. 1, pp. 97–100.

[5] V. Chandrasekhar,W.K. Seah, Y. S. Choo, and H. V. Ee, "Localization in underwater sensor networks—Survey and challenges," in *Proc. 1st ACM WUWNet*, Sep. 2006, pp. 33–40.

[6] W. Cheng, A. Y. Teymorian, L. Ma, X. Cheng, X. Lu, and Z. Lu, "Underwater localization in sparse 3D acoustic sensor networks," in *Proc. IEEE INFOCOM*, Apr. 2008, pp. 236–240.

[7] X. Cheng, H. Shu, Q. Liang, and D. H.-C. Du, "Silent positioning in underwater acoustic sensor networks," *IEEE Trans. Veh. Technol.*, vol. 57, no. 3, pp. 1756–1766, May 2008.

[8] M. Chitre, S. Shahabudeen, and M. Stojanovic, "Underwater acoustic communication and networks: Recent advances and future challenges," *Marine Technol. Soc. J.*, no. 1, pp. 103–116, 2008.

[9] S. Ibrahim, J.-H. Cui, and R. Ammar, "Surface-level gateway deployment for underwater sensor networks," in *Proc. IEEE Military Commun. Conf.*, Oct. 2007, pp. 1–7.

[10] V. Rodoplu and M. K. Park, "An energy-efficient MAC protocol for underwater wireless acoustic networks," in *Proc. MTS/IEEE OCEANS*,Sep. 2005, vol. 2, pp. 1198–1203.

S.Beeno Ancy received her B.E degree in Computer Science Engineering from Maharaja Institute of technology Coimbatore in 2011 and is currently doing her M.E degree in Karpagam University.

S.Shahul Hammed received his B.Tech degree in Information Technology from PSNACET in 2006 and M.E degree in Computer Science Engineering from Kumaraguru College of Technology in 2009 and currently working as Assistant Professor in Karpagam University.

All Rights Reserved © 2013 IJARCET