IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 3, Issue 3, June-July, 2015
ISSN: 2320 – 8791 (Impact Factor: 2.317)
www.ijreat.org

Grid Quorum Based Energy-Efficient Delay-Aware Routing Protocol For UWSN

Mrs.S.Jaipriya[1], A.Manigopal[2], Ms.S.Tamilarasi[3], Mrs.N.Padmapriya[4]

[1]M.E-Applied Electronics, [2,3]Assistant Professor, [4]HOD/Assistant Professor, Department of ECE,
Selvam College of Technology, Namakkal, India.

Abstract

Underwater Sensor Networks are typically distributed in nature and the nodes communicate using acoustic waves over a wireless medium. Such networks are characterized by long and variable propagation delays, intermittent connectivity, limited Bandwidth and low bit rates. Due to the wireless mode of communication between the sensor nodes, a Medium Access Control (MAC) protocol is required to coordinate access to the shared channel and enable efficient data communication. As more research is being done on underwater systems, data collection and environment monitoring become major components. These raise the need for an effective way to collect data and monitor the environment. Most of the existing UWSN medium access control (MAC) protocols handle the collision problem in a single-hop or light-loaded environment. They fail to function effectively in a multi hop network consisting of more sensor nodes with heavier traffic loads. Using the concept of GRID quorum systems is propose in a distributed multiple-rendezvous multichannel MAC protocol, MM-MAC, to reduce collision probability and improve the traffic efficiency.

Keywords-Underwater sensor networks; MAC protocol; Cyclic Quorum; Grid Quorum Algorithm

I. INTRODUCTION

Ocean bottom sensor nodes are deemed to enable applications for oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, assisted navigation and tactical surveillance applications. Multiple Unmanned or Autonomous Underwater Vehicles (UUVs, AUVs), equipped with underwater sensors, will also find application in exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions. To make these applications viable, there is a need to enable underwater communications among underwater devices. Underwater sensor nodes and vehicles must possess self-configuration capabilities, i.e., they must be able to coordinate their operation by exchanging configuration, location and movement information, and to relay monitored datato an onshore station.Wireless underwater acoustic networking is the enabling technology for these applications. Underwater Acoustic Sensor Networks (UW-ASN) consist of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring tasks over a given area. To achieve this objective, sensors and vehicles self-organize in an autonomous network which can adapt to the characteristics of the ocean environment.

Underwater networking is a rather unexplored area althoughunderwater communications have been experimented since World War II, when, in 1945, an underwater telephone was developed in the United States to communicate with submarines.

Acoustic communications are the typical physical layer technology in underwater networks. In fact, radio waves propagate at longdistances through conductive sea water only at extra low frequencies (30-300 Hz), which require large antennae and high transmission power. Optical wave do not suffer from such high attenuation but are affected by scattering. Moreover, transmission of optical signals requires high precision in pointing the narrow laser beams. Thus, links in underwater networks are based on acousticwireless communications.

This can be obtained by connecting underwater instruments by means of wireless links basedon acoustic communication.Many researchers are currently engaged in developing networking solutions for terrestrial wireless ad hoc and sensor networks. Although there exist many recently developed network protocols for wireless sensor networks, the unique characteristics of the underwater acoustic communication channel, such as limited bandwidth capacity and variable delays, require for very efficient and reliable new data communication protocols.

A. Major challenges in the design of underwater acoustic networks are:

- Battery power is limited and usually batteries cannot be recharged because solarenergy cannot be exploited.
- The available bandwidth is severely limited.
- The channel suffers from long and variable propagation delays, multi-path andfading problems.
- Bit error rates are typically very high.
- Underwater sensors are prone to frequent failures because of fouling, corrosion

B. The depth of water is a serious factor impacting UWSN

The factor that influent the underwater communication as follows:

- **Transmission loss:** Attenuation and geometric spreading are the main concern of the transmission loss. The attenuation mainly refers to the energy absorption or conversion into heat. Attenuation of radio waves in water increases both with increase in conductivity and increase in frequency. The geometric spreading can also spread the energy of signal because of the expansion of wave fronts.
- **Multipath:** The propagation in multipath can severely degrade the signal. The link configuration such as horizontal channels characterization determines the geometry of multipath.
- **Noise:** Environment noises include man-made noise and ambient noise. Man-made noise mainly refers to machinery noise like pumps while natural noise refers to seismic and biological phenomena can cause ambient noise.
- **Propagation delay and delay variance:** Large propagation delay and high delay variance can be reduced the throughput of the system.

II. NETWORK MODEL IN UWSN

A network model between two nodes in UWSN environment is shown in Figure 1. The network is composed of underwater sensor nodes, underwater sink node andSurface sink node. The underwater sensor nodes are deployed to the bottom of the monitored environment such as ocean and river. While underwater sink nodes take charge of collecting data of underwater sensor deployed on the ocean bottom and then send to the surface sink node.

Lastly, surface sink node is attached on a floating buoy with satellite, radio frequency (RF) orCell phone technology to transmit data to shore in real time.

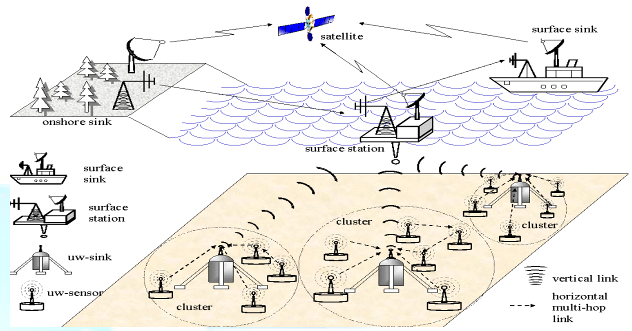

Figure 2.1: Underwater sensor networks

The depth of the fresh water for this research is lower than 100 m while the range between two nodes is about 6m until 20m for short range communication. The MAC protocol is very important in ensuring data reliability to the underwater sensor network. Differentapplications required different requirements on MAC protocol. In this project, the aim is to design a MAC protocol for long term applications such as water qualitymonitoring for agriculture purposes. This application is not sensitive to end-to-end delay because the communication link of UWSN is using RF electromagnetic waves that have high propagation speed which is 3×10^8 m/s. Hence, the propagation delay is very low and can be ignored. The most important goal of MAC protocol for such underwater sensor network is to solve the data packet collision efficiently in terms of energy consumption. Another goals of the designing MAC protocol in this project are to achieve guarantee high network throughput, low energy consumption and low channel access delay.

A reason why current terrestrial Radio Frequency (RF) based MAC protocol cannot be used directly in UWSN because of the harsh physical characteristics of underwaterChannel. Currently, the existing MAC protocol for UWSN is using acoustic as a link for communications. There has no existing MAC protocol that can be adapted in UWSN using RF electromagnetic link. This project will be developed a MAC protocol that can be adapt in UWSN for shallow water environment using RF electromagnetic link. A major difference between RF and acoustic propagation is the velocity of propagation. Radio waves travel at the speed of light as mentioned above. The speed of sound in water is around 1500 m/s, and it varies significantly with temperature, density and salinity, causing acoustic waves to travel on curved paths.

III. NETWORKING CHALLENGES FOR UNDERWATER SENSOR NETWORKS

In this section, we focus on the networking challenges for underwater sensor networks. Due to the unique characteristics of underwater acoustic channels (long latency and low bandwidth) and the harsh underwater environments (resulting in high channel dynamics), technology used in terrestrial radio networks could not be applied to underwater acoustic networks.

A. Physical Layer

Outside water, the electromagnetic spectrum dominates communication, since radio or optical methods provide long-distance communication (meters to hundreds of kilometers) with high bandwidths (kHz to tens of MHz), even at low power. In contrast, water absorbs and disperses almost all electro-magnetic frequencies, making acoustic waves a preferred choice for underwater communication beyond tens of meters. Propagation of acoustic waves in the frequency range of interest for communication can be described in several stages. Fundamental attenuation describes the power loss that a tone at frequency f experiences as it travels from one location to another. The first, basic stage, takes into account this fundamental loss that occurs over a transmission distance d.

The second stage takes into account the site specific loss due to surface-bottom reflections and refraction that occurs as sound speed changes with depth, and provides a more detailed prediction of the acoustic field around a given transmitter. The third stage addresses the apparently random changes in the large-scale received power which are caused by slow variations in the propagation medium.

The same network protocol may perform differently under a different frequency allocation moving to a higher frequency region will cause more attenuation to the desired signal, but the interference will attenuate more as well, possibly boosting the overall performance. Also, propagation delay and the packet duration matter, since a channel that is sensed to be free may nonetheless contain interfering packets; their length will affect the probability of collisions and the efficiency of re-transmission. Finally, power control, coupled with intelligent routing, can greatly help to limit interference.

B. Medium Access Control and Resource Sharing

Multi-user systems need an effective means to share the communications resources among the participating nodes. In wireless networks, the frequency spectrum is inherently shared and interference needs to be properly managed. Several techniques have been developed to provide rules to allow different stations to effectively share the resource and separate the signals that coexist in a common medium. In designing resource sharing schemes for underwater networks, one needs to keep in mind the peculiar characteristics of the acoustic channel. Most relevant in this context are long delays, frequency-dependent attenuation, and the relatively long reach of acoustic signals. In addition, the bandwidth constraints of acoustic hardware must also be considered. Signals can be deterministically separated in time (Time Division Multiple Access, TDMA) or frequency (FDMA). In the first case, users take turns accessing the medium, so that signals do no overlap in time and therefore interference is avoided. TDMA can be more flexible, but requires synchronization among all users to make sure they access disjoint time slots. Many schemes and protocols are based on such an un delaying time-division structure, which however needs some coordination and some guard times to compensate for inconsistencies in dealing with propagation delays.

CDMA-based medium access protocols with power control have been proposed for underwater networks, and have the advantages of not requiring slot synchronization and being robust to multipath fading. While these deterministic techniques can be used directly in multi-user systems, data communication nodes typically use contention-based protocols that prescribe the rules by which nodes decide when to transmit on a shared channel. In the simplest protocol, ALOHA, nodes just transmit whenever they need to (random access), and end-terminals recover from errors due to overlapping signals (called collisions) with retransmission.

More advanced schemes implement carrier-sense multiple access (CSMA), a listen-before-transmit approach, with or without collision avoidance (CA) mechanisms, with the goal of avoiding transmission on an already occupied channel. While CSMA/CA has been very successful in radio networks, the latencies encountered underwater (up to several seconds) make it very inefficient underwater. In fact, while ALOHA is rarely considered in radio systems due to its poor throughput. T-Lohi exploits collision avoidance tones, whereby nodes that want to transmit signal their intention by sending narrowband signals, and proceed with data transmission if they do not hear tones sent by other nodes, providing lightweight signaling at the cost of greater sensitivity to the hidden-terminal problem. CSMA-based protocol that uses synchronization is to reduce the probability of collision, but is also subject to longer delays due to guard times.

C. Reliable Data Transfer

Reliable data transfer is important in UWSNs, especially for those aquatic exploration applications requiring reliable information. There are typically two approaches to reliable data transfer: end-to-end and hop-by-hop. The most common end-to-end solution TCP (Transmission Control Protocol). In UWSNs, due to the high and dynamic channel error rates and the long propagation delay, TCP's performance will be problematic. There are a number of techniques that can be used to render TCP's performance more efficient. However, the performance of these TCP variants in UWSNs is yet to be investigated. Another type of approach for reliable data transfer is hop-by-hop. The hop-to-hop approach is favored in wireless and error-prone networks, and is believed to be more suitable for sensor networks. One possible direction to solve the reliable data transfer problem in UWSNs is to investigate coding schemes, including erasure coding and network coding, which, though introducing additional computational and packet overhead, can avoid retransmission delay and significantly enhance the network robustness. In a network coding scheme is proposed for underwater sensor networks. This scheme carefully couples network coding and multi-path routing for efficient error recovery.

D. Multi-hop Routing

Forwarding data from source nodes to command/control stations efficiently is very challenging in UWSNs, especially in mobile UWSNs for long-term applications. In such networks, saving energy is a major concern. At the same time, routing should be able to handle node mobility. This requirement makes most existing energy efficient routing protocols unsuitable for UWSNs. Various routing protocols are,

- Vector based forwarding (VBF)
- Focused beam routing (FBR)
- Reliable and Energy Balanced Routing Algorithm (REBAR)
- Information-Carrying Routing Protocol (ICRP)
- Directional Flooding-Based Routing (DFR)
- Distributed Underwater Clustering Scheme (DUCS)
- Depth Based Routing (DBR)
- Hop-by-Hop Dynamic Addressing Based Routing (H2-DAB)

E. Localization

Localization of mobile sensor nodes is indispensable for UWSNs. Some applications such as aquatic monitoring demands high-precision localization, while other applications such as surveillance network requires a localization solution that can scale to a large number of nodes. However, underwater acoustic propagation characteristics and sensor mobility pose great challenges on high-precision and scalable localization solutions in that:

- Underwater acoustic channels are highly dispersive, and time delay of arrival (TDOA) estimation is hampered by dense multipath.
- Acoustic signal does not travel on a straight path due to the stratification effect;
- Underwater acoustic channels have extremely low bandwidth that renders any approach based on frequent message exchange not appealing;
- Large scale sensor deployment prevents centralized solutions; and
- Sensor mobility entails dynamic network topology change.

IV. QUORUM SYSTEM

Wireless sensor networks (WSNs) have recently received increased attention for a broad array of applications such as surveillance, environment monitoring, medical diagnostics, and industrial control. As wireless sensor nodes usually rely on portable power sources such as batteries to provide the necessary power, their power management has become a crucial issue. It has been observed that idle energy plays an important role for saving energy in wireless sensor networks. Most existing radios (i.e., CC2420) used in wireless sensor networks support different modes, like transmit/receive mode, idle mode, and sleep mode.

In idle mode, the radio is not communicating but the radio circuitry is still turned on, resulting in energy consumption which is only slightly less than that in the transmitting or receiving states. Thus, a better way is to shut down the radio as much as possible in idle mode. In order to save more idle energy, it is necessary to introduce a wakeup mechanism for sensor nodes in the presence of pending transmissions. The major objective of a wakeup mechanism is to maintain network connectivity while reducing the idle state energy consumption. Existing wakeup mechanisms fall into three categories are,

1. On-demand wakeup scheduled rendezvous
2. Asynchronous Wakeup
3. Quorum-Based Wakeup Scheduling Paradigm

A. On-demand wakeup scheduled rendezvous:

As pointed out by the previous work. In on-demand wakeup mechanisms, out-of-band signaling is used to wake up sleeping nodes in an on-demand manner. For example, with the help of a paging signal, a node listening on a page channel can be woken up. As page radios can operate at lower power consumption, this strategy is very energy efficient. However, it suffers from increased implementation complexity.

In scheduled rendezvous wakeup mechanisms, low-power sleeping nodes wake up at the same time periodically to communicate with one another. Examples include the S-MAC protocol and the multi-parent schemes protocol.

B. Asynchronous Wakeup:

Compared to the scheduled rendezvous wakeup mechanism, asynchronous wakeup does not require clock synchronization. In this approach, each node follows its own wakeup schedule in idle state, as long as the wakeup meet this requirement, nodes usually have to wake up more frequently than in the scheduled rendezvous mechanism. However, there are many advantages of asynchronous wakeup, such as easiness in implementation and low message overhead for communication. Furthermore, it can ensure network connectivity even in highly dynamic networks.

C. Quorum-Based Wakeup Scheduling Paradigm

Quorum-Based Wakeup Scheduling Paradigm also called quorum-based power saving (QPS) protocol has recently been proposed as a solution for asynchronous wakeup scheduling. In a QPS protocol, the time axis on each node is evenly divided into beacon intervals. Given an integer n, a quorum system defines a cycle pattern, which specifies the awake/sleep scheduling pattern during n continuous beacon intervals for each node. We call nthe cycle length, since the pattern repeats every n beacon intervals. A node may stay awake or sleep during each beacon interval. QPS protocols can guarantee that at least one awake interval overlaps between two adjacent nodes, with each node being awake for only O(pn) beacon intervals. Most previous works only consider homogenous quorum systems for asynchronous wakeup scheduling, which means that quorum systems for all nodes have the same cycle length and same pattern. However, many WSNs are increasingly heterogenous in nature that is the network nodes are grouped into clusters, with each cluster having a high-power cluster head node and low-power cluster member nodes. Thus, it is desirable that heterogenous sensor nodes (cluster heads and cluster members) have heterogenousquorum-based wakeup schedules (or different cycle lengthes). We denote two quorums from different quorum systems as heterogenous quorums in this paper. If two adjacent nodes adopt heterogenous quorums as their wakeup schedules, they have different cycle lengthes and different wakeup patterns. The heterogeneous quorum-based power saving problem is therefore how to guarantee that two nodes with heterogenous quorums as their wakeup schedules can discover each other within bounded delay in the presence of clock drift.

a) Cyclic quorum system pair (cqs-pair)

For cqs-pair, a fast constructing scheme is proposed via the multiplier theorem and (N, k, M, l)- difference pair defined by us. The cqs-pair is an optimal design in terms of energy saving ratios given a pair of cycle lengths (n and m, n<=m). The fast constructing scheme can greatly improve the speed of finding an optimal quorum comparing with previous exhaustive methods. We also analyze the performance of cqs-pair in aspects of expected delay (n-1)/2<E(delay) < (m-1)/2, quorum ratio, energy saving ratio, and practical issues on how to support multicast/broadcast

Figure 3.1:cyclic quorum system pair

For example, in a tiered topology, the cluster-heads or gateway nodes can select a quorum from the system with smaller cycle length as their wake up schedules, to obtain smaller discovery delay. In addition, all members in a cluster can choose a quorum from the system with longer cycle length as their wakeup schedules, in order to save more idle energy.

b) Grid quorum system

In a grid quorum system, shown in Figure 4.2, elements are arranged as a √n x√n array (square). A quorum can be any set containing a column and a row of elements in the array. The quorum size in a square grid quorum system is 2√n-1. An alternative is a "triangle" grid-based quorum in which all elements are organized in a triangle fashion. The quorum size in "triangle" quorum system is approximately √2√n.

. Regarding gqs-pair, the prove that any two grid quorum systems can form a gqs-pair. Our contributions are in three aspects:

(1) We explicitly propose a formal algorithm based on Multiplier Theorem for quick quorum scheduling assembling (i.e. O (n2)), especially for the case of n = q2 + q + 1. This is the first formal algorithm for cyclic quorum construction.

(2) We propose a solution to the heterogeneous cyclic quorum design which is referred as asymmetric design and is claimed to be NP-complete. Although our work cannot address the general case of asymmetric design, it provides a solution to a simple and practical scenario: there are only two different schedules for the entire network.

(3) We explicitly analyze the performance of cqs-pair and gqs-pair and highlight the tradeoff between average neighbor discovery and energy consumption ratio, which was not done in previous work. Comparing with our preliminary results in, we propose an additional heterogenous quorum

system pair, qps-pair and analyze its performance in terms of average discovery delay and energy saving ratio.

We also present more implementation details over a wireless sensor network platform of Telosb motes, and present extensive experimental evaluations to validate the analytically-established performance trade-off of our designs. With the help of the heterogenous quorum system pair, sensor nodes can achieve better trade-off between energy consumption and average discovery delay.

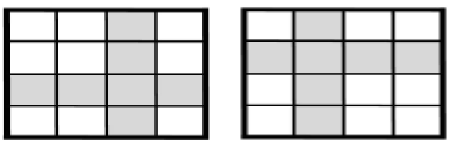

Figure 3.2:Grid quorum systems

1. Architecture of Proposed Grid Quorum System

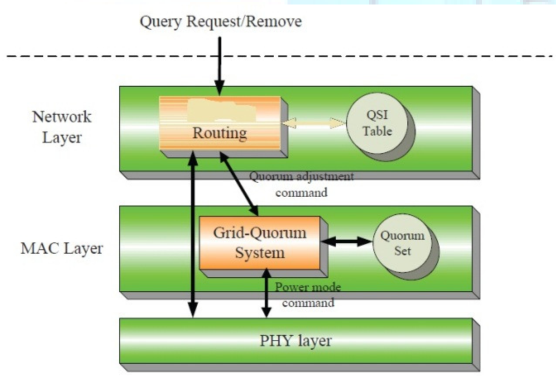

Figure: 3.3The Proposed Layer Architecture Of Grid Quorum System

2. Grid Quorum System Set Combination

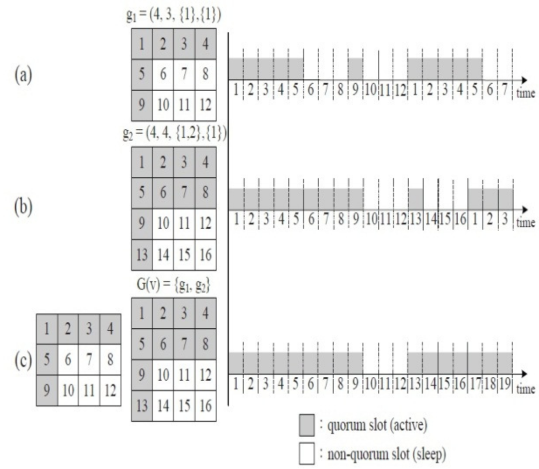

Figure 3.4: Grid Quorum System Set Combination

V. SIMULATION AND RESULTS

To assess the performance of MM-MAC, A simulation analysis of networks under heavy traffic load has been carried out, compared with previously proposed MAC protocols with cyclic quorum algorithm for UWSN networks. Using network simulator with graphic user interface environment as Fig.4.1. The simulated environment is a 6km x 6km square. Each node was distributed randomly over the simulated environment. To examine the efficiency of the protocol under a heavy traffic load, there was always a packet in the buffer ready to be sent in each node. Transmission range of each node was 10 km. In other words, each node was able to listen to all signals from other nodes in the network. Routing algorithms was unnecessary in this network because this was a single-hop network, so that, we would evaluate the performances of different MAC protocols in a simple way. To assess as fairly as possible, we minimized the difference among the protocols.

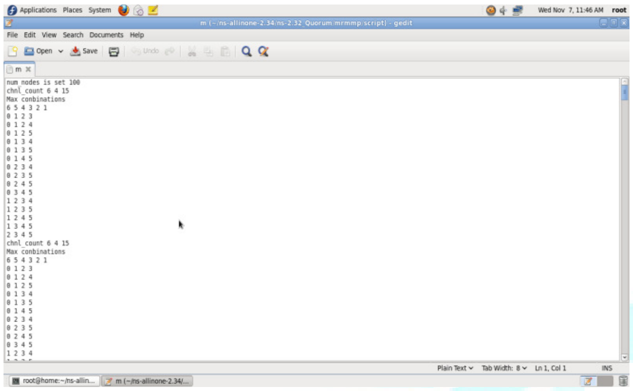

Figure 4.1: Routing of deployment nodes

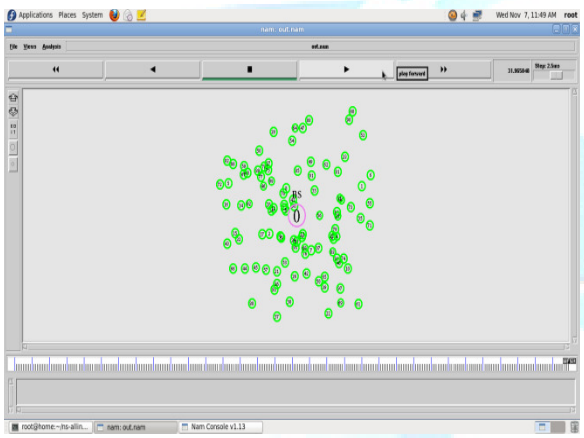

Figure 4.2: Node deployment

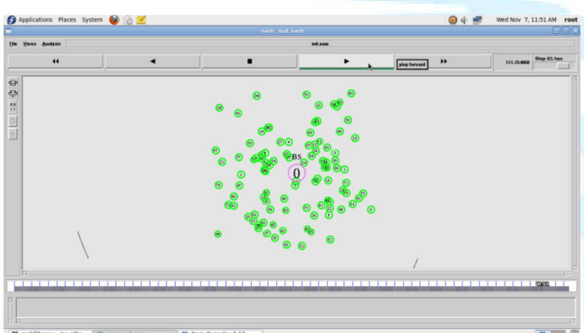

Figure 4.3:Node Rearrangement

V. APPLICATION SCENARIOS

The above described features enable a broad range of applications for underwater acoustic sensor networks:

- **Ocean Sampling Networks:** Networks of sensors and AUVs, such as the Odyssey-class AUVs, can perform synoptic, cooperative adaptive sampling of the 3D coastal ocean environment Experiments such as the Monterey Bay field experiment in August 2003 demonstrated the advantages of bringing together sophisticated new robotic vehicles with advanced ocean models to improve our ability to observe and predict the characteristics of the oceanic environment.
- **Environmental Monitoring:** such as pollution monitoring (chemical, biological, etc.), monitoring of ocean currents and winds, improved weather forecast, detecting climate change, understanding and predicting the effect of human activities on marine ecosystems, etc.
- **Assisted Navigation:** Sensors can be used to locate dangerous rocks or shoals in shallow waters, mooring positions, submerged wrecks, etc.
- **Distributed Tactical Surveillance:** AUVs and fixed underwater sensors can collaboratively monitor areas for surveillance, reconnaissance, targeting and intrusion detection systems.
- **Mine Reconnaissance:** The simultaneous operation of multiple AUVs with acoustic and optical sensors can be used to perform rapid environmental assessment and detect mine like objects.

VI. CONCLUSION

We proposed an efficient MM- MAC protocol for UWSNs in this paper. The proposed MM-MAC protocol with grid quorum algorithm should provide collision avoidance, traffic control and controlling communication channels which are shared by many nodes to avoid collisions and maintain reliable transmission conditions. The separation of control and data transmissions also helps reduce the collision probability of data packets. Simulation results verified that MM-MAC has better performance in that it achieves higher throughput, reduce the traffic rate and keeps the retransmission overhead low. We believe that the proposed scheme is a promising multichannel MAC protocol with grid quorum algorithm for UWSNs since it achieves a great improvement over existing MM-MAC protocol with cyclic quorum algorithm.

REFERENCES

1. MelikeErol-Kantarci, Hussein T. Mouftah, and SemaOktug, “A Survey of Architectures and Localization Techniques for Underwater Acoustic Sensor Networks” IEEE Communications Surveys & Tutorials, Vol. 13, No. 3, Third Quarter 2011.
2. Chih-Cheng Hsu, Ming-ShingKuo, Cheng-Fu Chou, and Kate Ching-Ju Lin, “The Elimination of Spatial-Temporal

Uncertainty in Underwater Sensor Networks" IEEE/ACM Transactions on Networking.

3. Chih-Min Chao, Jang-Ping Sheu, "An Adaptive Quorum-Based Energy Conserving Protocol For IEEE 802.11 Ad Hoc Networks" IEEE Transactions On Mobile Computing, Vol. 5, No. 5, May 2006
4. Hwee-Xian Tan, Winston K. G. Seah , "Distributed CDMA-Based Mac Protocol For Underwater Sensor Networks" 32nd IEEE Conference On Local Computer Networks.
5. Shouwen Lai, BinoyRavindran, Hyeonjoong Cho, "Heterogeneous Quorum-Based Wake-Up Scheduling in Wireless Sensor Networks" IEEE Transactions On Computers, Vol. 59, No. 11, November ``2010.
6. Affan A. Syed, Wei Ye, John Heidemann, "T-Lohi: A new class of MAC protocols for underwater acoustic sensor networks," in Proc. IEEE INFOCOM, 2008, pp. 231–235.
7. Tiansi Hu, YunsiFei, "Qelar: A Machine-Learning-Based Adaptive Routing Protocol For Energy-Efficient And Lifetime-Extended Underwater Sensor Networks" IEEE Transactions On Mobile Computing, Vol. 9, No. 6, June 2010.
8. Uros M. Pesovic, Joze J. Mohorko, Karl Benkic, ZarkoF.Cucej ,"Single-Hop Vs. Multi-Hop – Energy Efficiency Analysis In Wireless Sensor Networks" Telekomunikacioni Forum Telfor 2010.
9. C.-M. Chao and Y.-W.Lee, "A quorum-based energy saving MAC protocol design for wireless sensor networks," IEEE Trans. Veh. Technol., vol. 59, no. 2, pp. 813–822, Feb. 2010.