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Network Lifetime Improvement of Underwater Sensor Networks

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Abstract — **Underwater sensor network is capable to perform operations in broad range of applications that application perform different in USN some applications likes distributed tactical surveillance, mine reconnaissance, ocean sampling networks , seismic monitoring, environmental monitoring, equipment monitoring, Disaster prevention, assisted Navigation and undersea explorations these all are the benefits of the underwater sensor networks. An efficient technique of communication has been adopted in the block zone by using the combination of adaptive duty cycle and Network coding approach. Energy efficiency of the bottleneck zone will get increased due to more volume of the data that would be transmitted to the sink with the same number of transmissions. Hence the lifetime of the underwater sensor network is increased. This work archive to the enhancement of the underwater network lifetime by considering a network coded adaptive duty cycle WSN. By applying the above techniques we finally achieve the improve throughput of nodes. This proposed system investigates life time improvement approx 8% - 14%, and minimizing energy consumption. This paper is also referring to as useful for providing brief overview about each and every protocol and responsible for whole underwater wireless sensor network.**

Keyword: adaptive duty cycle, network coding underwater sensor network

I. INTRODUCTION

In our earth 25% covered by human being and rest space is covered by water that could be oceans and river also. In underwater wireless sensor network much small water living thing like crocodile, fish and some more. Consider a scientist work on a particular thing so some specific devices should be in underwater wireless sensor network that can work in underwater wireless sensor network system which should be capable to communicate within underwater. Today increasing the need some particular routing protocol which can work into underwater wireless sensor network. For the latest point of research scenario USN with several different routing protocol present that play some particular role in the underwater wireless sensor network that why some scientists are working for developing algorithm. Underwater routing sensor network not only useful for providing high reliability which should be capable to control high flexibility of information forwarded to the SINK node but also its delay comparatively low. Underwater sensor network is capable to perform operation into long terms non time severe aquatic monitoring applications where GPS support is not needed. The routing protocols architecture easily adapt to changing configuration. Decrease energy consumption and the network nodes network conflicts as much as possible. Some important challenges are also involving for routing protocol underwater sensor network that challenges are node mobility, High propagation delays, Error prone acoustic underwater channels. According to this paper it's not only helpful for providing information about routing protocol for USNs but also useful for working scientist and those people who are including in research activities and is also useful for providing correct way which one is correct routing protocol USN and which one is perfect for project that can be easily determine by this paper. [1]

II DESIGN COMPONENT FOR UNDERWATER SENSOR NETWORK

Various factors i.e. multipath, transmission loss, propagation loss and noise these are four major issues which comes in underwater sensor network.[13]

A. Transmission loss [13]: Transmission loss is integration of geometric spreading and attenuation. It is not dependent on frequency. Geometric spreading is expansion of wave fronts that increase the distance of propagation. Generally attenuation provoked by increasing frequency and distance, absorption because of conversion of acoustic energy into heat.

B. Noise [13]: It is classified into two ways as manmade noise and ambient noise. This mainly concentrates on the machinery noise and shipping activity.

C. High delay [13]: The propagation speed in the underwater sensor magnitude is less in comparison of radio channel.

D. Multipath[13]: generally this term is refer to as more than one way for reduction of the acoustic communication signal that creates that is refer to as Inter Symbol Interference. The more than one geometry depend on the connection configuration. There are two channels like horizontal channel and vertical. Horizontal channels may have long more than one way spreads while Vertical channels may have little time dispersion.

III ROLE OF UNDERWATER SENSOR NETWORK

Underwater sensor network is capable to perform operations in broad range of applications that application perform different in USN some applications likes distributed tactical surveillance, mine reconnaissance, ocean sampling networks , seismic monitoring, environmental monitoring, equipment monitoring, Disaster prevention, assisted Navigation and undersea explorations these all are the benefits of the underwater sensor networks. however, no system is perfect, thus, even with all the above specified benefits of the system, a few drawbacks still available i.e. more power need, costly device, spatial correlation and Intermitted memory.

A. Fastest way for finding underwater information *[1]:* Underwater sensor is the fastest and latest manner of determining information which is existed in underwater sensor network. This information is not only useful for human being but also useful for researchers.

B. Monitor the environment & climate [13]: Most of researchers wish to know about what is taking place inside the water. It depends on the situation consider if water is less so monitoring is required. But if water is more like a ocean so monitoring is necessary because without monitoring we can never ever examine the problems. Underwater sensor network system is capable to solve the issues those issues are climate part. USN play major part in detection of climate change, enhance weather forecast. Generally underwater sensor network not only scan the climate but also useful in chemical, nuclear and biological activates.

C. Underwater device monitor system [13]: For monitoring the USN where as costly devices are there all these devices are more expensive that is play safety role in USN.

D. Undersea Explorations [13]: Underwater sensor network perform operation for finding the paths for laying undersea cables, eliminate underwater reservoirs.

E. Ocean Sampling Networks [13]: Autonomous underwater vehicles are capable for cooperative adaptive sampling of the 3D coastal ocean atmosphere.

F. Disaster Prevention [13]: Underwater sensor network system is capable to perform seismic activity that begins from remote locations which offer tsunami warnings to coastal regions.

G.* Assisted Navigation *[13]: Underwater sensors are capable to perform bathymetry profiling, also able to find location of dangerous rock, submerged wrecks.

IV PROBLEM IN UNDERWATER SENSOR NETWORK

A. **More expensive Devices [13]:** Underwater sensor devices are more expensive. And no more supplier's offers these such type of devices because these are devices are part of research oriented activity. Underwater sensor devices are not easily present in the market.

***B.* High power require for communication *[13]:* In** underwater communication, more power is require because for interchanging data inside in water require more electricity.

C. Hardware Protection requirement [13]: Inside the water lot of underwater devices are existed not only for scanning but also scientific work also there that is why more security is needed inside the water for safety of the underwater components.

D. Intermitted data transfer [13]: Compare to terrestrial sensor network system where very small memory is available But in underwater sensor network data transferring could generate big disrupt at the time.

E. Reading problem in space sensors [13]: Basically terrestrial sensors are concerned to each other. But In underwater sensor network it may not be possible in higher distance sensors but unlikely it could be co-related in higher distance among sensors.

F. More sparse deployment [13]: In USN the deployment is usually sparser but in comparison of terrestrial sensor networks are densely deployed.

G. Propagation delay [13]: This is also a major issue which comes underwater sensor networks time. Propagation delay is orders of magnitude higher than in terrestrial channels and Radio Frequency variable.

H. Impaired channel [13]*:* The underwater channel is impaired due to fading and multipath.

J. Fouling and corrosion [13]: Underwater sensors are vulnerable to failures due to corrosion and fouling.

K. Localization [11]: Localization is the challenging component that is needed for data labeling while some time serious applications need data without time delay.

L. High Maintenance [11]*:* Underwater sensors needs are increasing because for underwater sensors are very expensive which are not easily existed in the market and underwater sensor provider and consultants are not present everywhere that is why cost is increasing. Underwater sensors are too expensive because for USNs high maintenance is needed.

F. Temporary losses [13]*:* For the connectivity time packet forwarding time it could be loss between the data transmission.

V DESIGN ISSUE FOR ROUTING PROROCOL UNDERWATER SENSOR NETWORK

The main problems for routing protocols development for USN *[1] are:*

A. Harsh deployment atmosphere is the major challenging factor which comes under routing protocol for USN.

B. Bandwidth capacity is low because routing protocol for USN comes from high bit error rates.

C. Another problem associated to low energy issue. For every battery energy is needed.

D. Node mobility is also another issue which comes under routing protocol for USN because if they are not anchored at the sea bottom. This situation conclusion in a dynamic configuration

E. Radio single are not effective in comparison of routing protocol for USN. Because it offers high propagation delays.

F. High propagation delays are the major factor of routing protocol for USN.

VI. DIFFERENT ROUTING PROTOCOL IN UNDERWATER SENSOR NETWORK

There are ten different routing protocols existed for USN.(a) Vector-Based Forwarding Protocol or location-based routing protocol, (b) Robustness Improved Location protocol,(c) Depth-Based Routing protocol, (d) Hop-by-Hop Dynamic Addressing Based protocol,(e) Focused Beam Routing Protocol,(f) Path Unaware Layered Routing Protocol,(g)Adaptive Routing protocol,(h)GPS-free Routing Protocol, (i) A Low Propagation Delay Multi-Path Routing Protocol,(j) Pressure Routing Protocol. There is brief overview about general routing protocol USN.

VII. Routing Protocols for underwater sensor network

A. Vector Based forwarding protocol: [2]:

VBRP protocol is called location based routing protocol. This is planned for underwater sensor network. Generally it refer to as the issue which is useful to enhance the lower delay and successful rate. Its architecture is based on underwater sensor network and it is just a location based protocol which play important role in the USN. VBF is known as vector based routing forwarding protocol. Sometimes VBF also refer to as routing pipe which performs a particular task for making connection between source, destination and packet delivery. The data packet is collection of the objective, sender location, sender and range field. Energy efficiency, Robustness, High success of data delivery and energy effective these four feature comes under location based protocol which are not existed in USN that is why a new routing protocol called VBF is introduced. This protocol is useful for packet carry routing related information and no state information is needed at nodes as well as scalable with respect to size of network. In VBF only those nodes near to the routing vector are included in data sending. Thus it is effective. Furthermore, our self adaption algorithm permits a node to evaluate its significance in its neighborhood and hence adjust its forwarding scheme to save more energy.VBF utilities path redundancy (managed by the routing pipe radius) to offer robustness agent node failure and packet loss. The simulation results have established the VBF proving performance.

B. Robustness Improved Location protocol [3]:

RILP protocol is also similar to location based routing protocol and also planned for underwater sensor network as well as it behaves like VBF. This is also known as hop to hop vectoring based sending protocol but this protocol is much better as compared to location based routing protocol. One major issue which comes in location based routing protocol that is (i) too sensitive to routing pipe radius (ii) low data delivery in sparse network. Above these two problems are eliminated in robustness enhanced location protocol that's why some researcher mostly dictate this protocol. Another important comparison between both of vector based forwarding protocol and location based routing protocol is that hop to hop vector based forwarding protocol enhances the data delivery ratio in sparse networks in comparison of VBF that conduct simulations to measure Hop to Hop Vector Based Forwarding protocol and the results indicate that Hop to Hop Vector Based Forwarding protocols leads much better performance in comparison of VBF in sparse networks. Additionally, HH-VBF is less sensible to the routing pipe radius threshold. HH-VBF, an improved version of the VBF routing protocol for USNs. The new proposal proposes a hop-by-hop technique, which is simple while new and it can importantly enhance the robustness of packet delivery in sparse networks: improving the data delivery ratio whereas taxing less energy.

C. Depth-Based Routing protocol [8]:
DBRP is depth based routing protocol. It is acting like greedy algorithm in which every sensor is separated. Every sensor depends on its depth and the depth of the prior sender is capable to build the overall result on whether to send a packet. For instance consider a node data forwarded its broadcasts. So here are several neighboring nodes compute their depths and useful to build a depth difference with the forwarding node upon reception of the data packets. Nodes which have lesser depths in comparison of the sender accept these data packets, while other nodes simply drop them. Aqua-Sims describe terms for simulations, writers utilize NS2 to involve underwater sensor network simulation packages extension. It is helpful for performance of the average end to end delay, packet delivery ratio and total energy consumption. Some difference comes here depth based routing protocol where every node should have fitted with a depth sensor, which can increase the cost on one side while on the other side, can increase energy consumption. Another limitation refers to as broadcasting which is useful to establish the complexity of the routing because of making more nodes candidate for sending the data packets. Third limitation is the dramatic change of performance as node density changes. This protocol is integration of forwarded packet and the route discovery. After all nodes deployed in the water, they will initiate to determine their underwater depth; and begin the route discovery procedure to select their next hop nodes. Overall Conclusion is packet from the source node through the multi hop forwards to sink node.

D. Hop to Hop Dynamic Addressing based Routing protocol [6]:
Effective communication is the major issue in USN. Radio signal cannot spread well in deep water, and substitute radio signal with the acoustic channel. This substitution solution in several effects i.e. low bandwidths, high error possibility and high latency because of less propagation speeds. A new routing protocol known as Hop by hop dynamic addressing based for severe underwater monitoring missions. This protocol uses on multi sink architecture and also scalable, energy effective and robust. This protocol also useful for design monitoring underwater missions. The objective of hop by hop dynamic addressing based routing protocol is to increase the delivery ratio, optimize energy consumption and decrease the message latency.

E. Focused Beam Routing Protocol for Underwater Acoustic Networks [16]:
For the recent point of research scenario USN with Focused Beam routing protocol. The focused beam routing protocol operates on Sparse network. With respect to this routing protocol there are one mobility fixed nodes. There are location information need own location and sink location. Generally Focused Beam routing protocol operates on geographic routing. This is called scalable routing mechanism that is based on the location information. Focused Beam routing protocol where fixed and mobile underwater acoustic networks can operate without any clock synchronization. According to performance if we are assuming various network loads and node densities so a discrete event underwater acoustic network modeler should be utilized. First of all we will realize the effect of node density on the results and performance and we can compare with Dijkastra's shortest path algorithm. The mechanism should be capable to dynamically find minimum energy routes with the least network knowledge. Routing protocol is useful to verifying no. of nodes randomly positional within 200 km2 grid region, 4 sinks positioned at comers.

F. Path Unaware Layered Routing Protocol [5]:
This routing protocol just integration of two phases one is known as layering phase and second is known as communication phase. Communication phase is useful to describe on fly that come from source node to sink node across the concentric layers. Another layering phase is useful to concentrate on layers of spheres is built around the sink node with every node relating to only one of the spherical layers. There are selected sphere radiuses because it is based on packet delivery latency and possibility of successful packet sending that's why this is called layering phase.

G. Adaptive Routing protocol [9]:
The objective of Adaptive Routing protocol is to provide support to fulfill different application need and also useful to achieve a medium end-to-end delay, good trade-off among delivery ratio and energy consumption for all packets. There is a main idea resource reallocation and exploit message redundancy means several copy of same message. The outcomes of Adaptive routing protocol obtain a medium end to end delay, good performance trade-off among delivery ratio and energy consumption and different packet delivery according to application needs.

H. GPS-free Routing Protocol [7]: This GPS-free Routing Protocol is generated for USNs. This is called Distributed Underwater Clustering Scheme. It is also useful to compensate the high propagation delays of the underwater medium and decreases the proactive routing exchange. According to performance evaluated, this protocol obtains good PDR for dense network. This protocol is scalable and useful for good performance. This protocol supports to obtain a very high PDR when it is assumable to decrease the network overhead and also increase the throughput. The GPS-free Routing Protocol uniformly disseminated n nodes like N=100 volumes is 75X75X20000 cubic meter. The mobility pattern randomly walks speed 0 to 5 m/s. The rate of this protocol is 6.6 Kbit/s.

I. A Low Propagation Delay Multi-Path Routing Protocol [15]: This protocol is called multi path touting protocol. A Low Propagation Delay Multi-Path Routing Protocol builds a route from source node to the destination node which contains n no. of multi-sub paths during the routing path structure. Multi sub paths are useful for sub paths form forwarder to its two-hop neighbors through a relay node in the neighborhood of both receiver and sender nodes. Generally this technique is helpful to keep data collision at recipients however they achieve packets from different relay nodes.

J. Pressure Routing Protocol [14]:

This protocol operates in underwater sensor network. Pressure Routing Protocol is hydraulic pressure depend on whatever cast routing protocol that uses the pressure levels in other way we can say that the depth information to find paths for sending packets from source node to the surface buoys. The Pressure Routing Protocol introduced a new opportunistic routing mechanism that has an effective underwater dead end recovery technique along with the nodes clustering and co-channel interferences.

VIII. ENERGY CONSUMPTION MODEL

A sensor node takes energy at several states, i.e., like sensing and producing data, transferring, obtaining and sleeping state. In this work, the radio model [22] has been changed for a duty cycle based WSN. Energy savings has been performed at the node level by moving between the active and the sleep states.

Energy consumption by the source node per sec across a distance d which has path loss exponent n is,

$$E_{tx} = R_d(\alpha_{11} + \alpha_2 d^n)$$

Where R_d shows the data rate of transceiver relay, α_2 is the per bit energy consumption and α_{11} is the per bit energy consumption by the transmitter in the transmit op-amp [22]. Overall energy consumption in time t by the source node (leaf node) without behaving as a relay (intermediary node) is,

$$E_s = t[p(r_s e_s + E_{tx}) + (1-p)E_{sleep}]$$

where E_{sleep} shows the idle mode energy consumption of the sensor node per sec, r_s is the sensor's average sensing rate and is also equal for all the nodes, e_s is the energy consumption by a node to sense a bit, the possibility p is the average proportion of time t that the sensor node utilize in active mode. Hence, p is the duty-cycle. A sensor node lies in the idle state till time t with possibility (1-p). The per sec energy consumption by an intermediary node that behave as a relay mote is provided by

$$E_{txr} = R_d(\alpha_{11} + \alpha_2 d^n + \alpha_{12})$$

Where α_{12} is that energy which is consumption by the sensor node for receiving a bit. Overall energy which is consumed till time t by an intermediary (relay) node is

$$E_r = t[p(r_s e_s + E_{txr}) + (1-p)E_{sleep}]$$

IX. ADAPTIVE DUTY CYCLE

A system N sensor nodes distributed uniformly in the region A is assumed. All N sensor nodes are Adaptive Duty Cycle Enabled (moving between active and dormant state depending on their Queue value) in the zone B, the nodes are classifying into two groups i.e. relay sensor and Linear Network Coder Sensor nodes. The data has been transferred by the active relay sensor nodes(R) which produces inside as well as outside in the bottleneck zone. The relay nodes can interact to the sink utilizing a single hop communication, the relay node interact to the another Liner network coder node and relay node utilizing a multi hop communication in the congested area . The active Linear Network Coder sensor nodes encode the relay node data before transferring it to the sink node. It utilizes the single hop for interaction with the sink node. The leaf sensor nodes will sense the data periodically and transfer all of them to the neighboring nodes towards the sink node. The intermediary sensor nodes senses the data periodically and further it will relay the sensed data and obtained data towards sink node S. Every sensor node that has got a no. of Received queue and sensed Queue which are associated to it, one or more to other nodes, more to the sink node. Except Sink node and the Leaf (or) Terminal node, the packets are reached and depart on every sensor node. The introduced technique is to dedicate the buffer at every node to a single FIFO queue. The switch starts to the sensor node as an active state as the buffer occupancy increases a threshold until buffer occupancy decreases below the threshold level again. The sensor node would go to the sleep state if the size of buffer below the threshold.

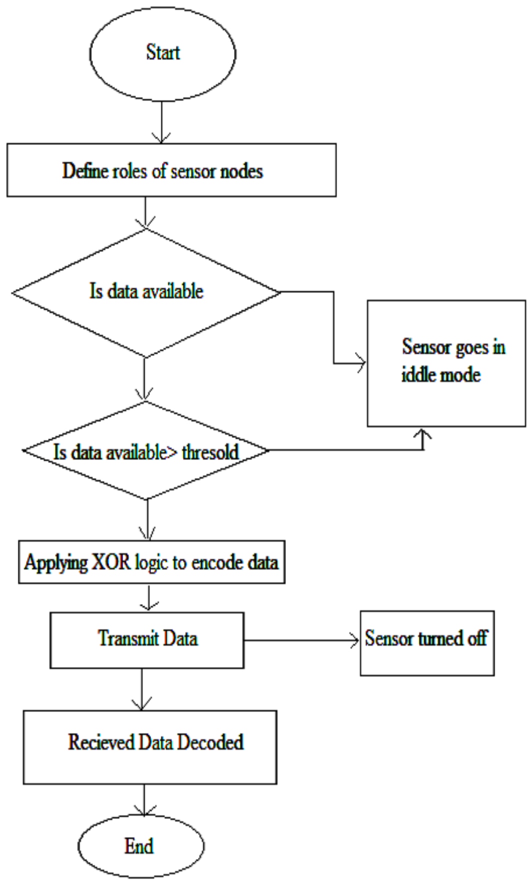

Figure 1: Proposed Algorithm

X. RESULTS AND ANALYSIS

We shall measure the performance with respect to throughput. Unless otherwise mentioned in some performance comparisons, data arrival rate of a stream is 1 packet/sec and packet loss rate is 0.2. The packet size is 128 bytes. For a default connection data rate of 9600bps, this is same as 9.38 packets/s. The packet arrival rates in all performance diagrams are packet arrival rates at the source node but not essentially at a queuing node (such as sink or relay) whose performance evaluation is under investigation.

Throughput: Fig 7a is the throughput viewed at a sink node (both *T1* and *T2* are symmetrical in performance) as a function of the packet arrival rate at the source node when packet size is set to 128 byte, 196 byte and 256 byte, respectively. For a network without Network coding and utilizing a packet size of 128 byte, the throughput is increasing less or more linearly in terms of the increasing packet arrival rate before leveling off at 4.8 packets/sec beyond a packet arrival rate of 8 packets/s. By utilizing NC, one can view the throughput can level off at a higher level of 6.2 packets/sec and beyond a higher packet arrival rate of 9 packets/sec.

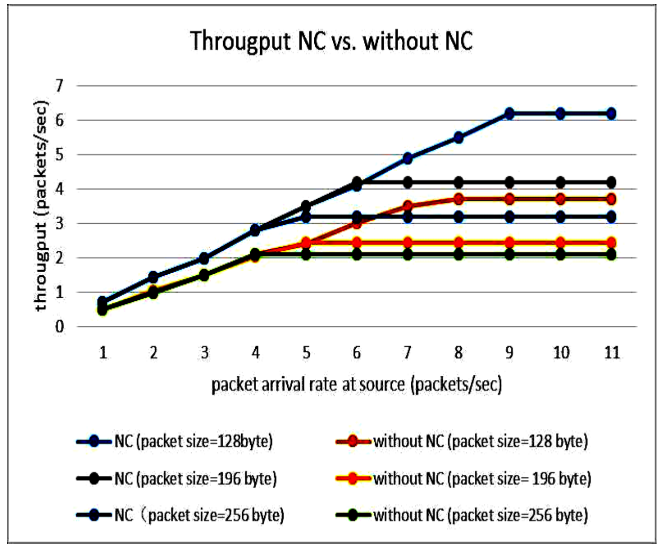

Figure 7 a: Throughput with Different Packet Size, Big Network

CONCLUSION

Underwater sensor network is capable to perform operation into long terms non time severe aquatic monitoring applications where GPS support is not needed. The routing protocols architecture easily adapt to changing configuration. Decrease energy consumption and the network nodes network conflicts as much as possible. Some important challenges are also involving for routing protocol underwater sensor network that challenges are node mobility, High propagation delays, and Error prone acoustic underwater channels. Our results have ensured that network coding has the power of enhancing the performances of network throughput and reliability. Meanwhile, we have also examined the drawn and tradeoffs a conclusion that network coding is not always beneficial. It may not be efficient or the performance may become worse under some situations. The results show that network coding would increase the throughput and reduce the end to end delay of USN. Since, the PDR does not seem to be good. Much time was consumed in setting up the network model and the underwater channel mode, in the incorporation of channel coding operation in terms of the topologies, as well as in the debugging to assure the correct operation of our simulations. Then some simulations assure, adopted by the analysis of the network nature. We have finally learned some debugging mechanisms such as trace instructions from OPNET. Not only we can utilize it to adopt the packet path, but also study the detail operation of a procedure. It is simpler to determine the location and cause of the problems. Some of these can be briefly explained in the lessons we have learned from our OPNET experience. First, one should be careful about the Transit conditions.

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