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Performance Evaluation of Unicast Reactive Ad-hoc Routing Protocols for Underwater Wireless Sensor Networks

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***Abstract*—** UWC (Under Water Communications) will enable many safety, military, Environmental and scientific applications. Instruments can be remotely controlled in ocean observatories using wireless signal transmission which is crucial and coordination of autonomous underwater vehicles and robots will be enabled, which plays the role of mobile nodes in future ocean observation networks with their re-configurability and flexibility. Underwater applications can be made viable with efficient communication protocols among underwater devices which are based on acoustic wireless technology with distance over one hundred meters will be enabled to make underwater applications viable because of its high attenuation and scattering which will affect radio and optical waves. New efficient and reliable communication protocols are required to network multiple devices which are mobile or static over the multiple hops which are required for the unique characteristics of an underwater acoustic channel, such as time varying multipath, fading, distance and limited dependent bandwidth and high propagation delays. For packet transmission, MANETs use varieties of routing protocols which are classified as pro-active, re-active and hybrid routing protocols. In this paper, two on-demand unicast reactive routing protocols are considered namely Ad-hoc On Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) in order to evaluate their performance based on Quality of Service (QoS) for UWSN. Both AODV and DSR routing protocols are implemented on the basis of on-demand gateway discovery algorithm where each node can communicate with each other through the entry and exit point of a network as and when required. Through simulation with increasing the node density using ns2 network simulator, we perceive that the performance parameters of AODV and DSR routing protocols are analysed.

***Keywords*—**Under Water Communication, Unicast, AODV, DSR, Ad-hoc

I. INTRODUCTION

Underwater Wireless communications (UWC) will enable many scientific ocean sampling, civilian, oceanographic data collection which is military applications and also includes data collection, environmental monitoring and pollution, disaster prevention, climate recording and distributed surveillance. Underwater acoustic sensor networks(UWASN's) will support some of these applications [1] which consists of devices with the capability of sensing, communication and processing which will be deployed to perform collaborative monitoring tasks which is shown in (Fig.1).Wireless signal transmission is also crucial to remotely control instruments in ocean observatories and to enable coordination of swarms of robots and (AUV)Autonomous underwater vehicles which will play the role in future ocean observation networks through mobile nodes by virtue of their re-configurability and flexibility. Underwater applications can be made viable by real time communication protocols among the underwater devices. The enabling technology such as wireless acoustic networking for underwater applications to cover distances in excess of one hundred meters, whereas shorter distances will be covered using electro-magnetic waves. Radio frequency (RF) will require high transmission power and large antennae which propagate through conductive salty water only at extra-low frequencies of (30--300Hz).Optical waves are suffer from scattering but it will not suffer from such high attenuation. Transmission of optical signals will require high precision in pointing narrow laser beams.

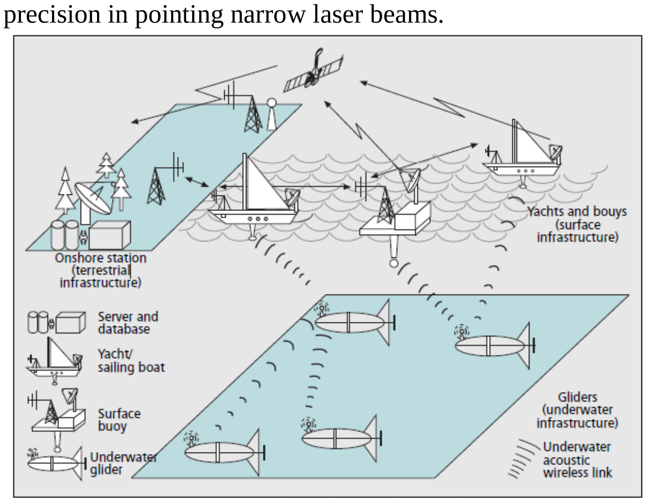

Figure 1. *Scenario of a UW-ASN composed of underwater and surface vehicles.*

Ad hoc wireless network also has a collection of dynamically and arbitrarily distributed mobile nodes and independent of fixed infrastructure. Each node in the mobile network can act both as host and a router and participates in the network in an equal way and is free to move independently in any direction [2].

A variety of routing protocols have been exploited in order to effectively communicate with other nodes. The node mobility, bandwidth, energy and physical security are all taken into considerations to find an effective routing protocol [3][4]. AODV [5] is a source-initiated on-demand routing protocol, which cuts down the number of required broadcasts by creating routes on a demand basis. When it is established, it was defined as pure on-demand route acquisition system. If nodes are not on a selected path, they all do not maintain routing information or participate in routing table exchanges [6]. DSR, which is described in [7] and [8], is a source initiated on-demand routing too. Most impairments of the underwater acoustic channel addressed at the physical layer by designing receivers that are capable of dealing with high bit error rates, fading, and the inter symbol interference (ISI) caused by multipath. Conversely, characteristics such as extremely long and variable propagation delays, limited and distance-dependent bandwidth and temporary loss of connectivity, must be addressed at higher layers.

Rest of the paper is organized as follows, Section I contains the introduction of Underwater wireless communication, Section II contain the related work of Underwater wireless communication, Section III contain the methodology, Section IV describes results and discussion, Section V contain the concludes research work with future directions.

II. RELATED WORK

In ad-hoc environments there are many routing protocols, but some of them cannot be used in underwater situations because of some limiting factors involved in it. In Proactive routing protocols, every nodes maintains one or more tables representing the entire topology of the network. These tables are updated regularly in order to maintain up-to-date routing information from each node to every other node. To maintain the up-to-date routing information, topology information needs to be exchanged between the nodes on a regular basis, leading to relatively high overhead on the network. The main drawbacks of such algorithm are respective amount of data for maintenance and slow reaction on restricting and failures. Unlike proactive protocols, reactive routing protocols do not make the nodes initiate a route discovery process until a route to a destination is required. This leads to lower overhead than with proactive protocols. In this paper we have compared two most used reactive unicast routing protocols AODV and DSR for underwater communication.

Problem Statement

It refers to the ability of the packet transmission through the network. When an Ad-hoc network contains a number of nodes, at time of communication it suffers from packet collision, overhead and bandwidth problems. While routing there may be a chance of link failure when a node is outside certain ranges. Due to these problems the ad hoc networks faces many faults like transmission errors, node failure, link failure, breakages congested nodes/links etc.

III. METHODOLOGY

Routing Protocols

In this paper, we studied the routing mechanism of existing unicast Ad-hoc routing protocols such as AODV, DSR and compare their performance in some given UWSN environments. The mechanism of proposed routing protocols is as follows:

Ad Hoc on-Demand –Distance Vector Routing (AODV)

When a source node wants to send a message to some destination nodes, it broadcasts route request message (RREQ) to its neighbours. The neighbours in turn will broadcast the message to their own neighbours. During the process of forwarding the RREQ, a node forward s a route request message to its neighbours, and it also records in its routing table the source node from which the first copy of the request came. The routing table is used to construct the reverse path for the route reply message. Once the RREQ reaches the destination node responds by unicasting a route reply message (RREP) back to the neighbours from which it first received the RREQ. When the route reply message (RREP) traverses back to the source, the nodes along the path enter the forward route tables which point to the node from which the RREP came.

Dynamic Source Routing (DSR)

Dynamic Source Routing has two major components: (i) Route Discovery and (ii) Route Maintenance. Route Discovery: When a source node wants to send a message to some destination nodes, it first locates its route cache to determine if it already has a route to the destination .If a valid roué to the destination is found , the source node will use this route to send the message. If a valid route does not exist, it will start the route discovery process by broadcasting a route request message. Route Maintenance: The node generates a route error message when it encounters a fatal transmission problem as its data link layer. If a node receives a route error message, it will remove the hop in error from its route cache .All routes that contains the hop in error will be truncated at that point too. Acknowledgement packets are always used to verify the correct operation of the rote links.

IV. RESULTS AND DISCUSSION

Performance Metrics

The basic objective of our work is to evaluate and make comparison between two on-demand unicast reactive ad-hoc routing protocol based on QoS parameters mentioned below.

Routing Overhead

The routing overhead is the number of route packets which every data packets needed to allow on average. It reflects the degree of network congestion and the efficiency of node power. Routing overhead can be expressed as:

$$N_1/N_2$$

Where N1 is the no of route packets which are sent and forwarded; N2 is the number of data packet received .The routing overhead is measured in bits per second (bit/s or bps).

Average End to End Delay

The average end to end delay includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC and the propagation and transfer time. This metric is significant in understanding the delay introduced by path discovery. Average end to end delay can be expressed as:

$$\sum (T_1 - T_2)/N$$

Where *T1* is the time when the first data packet arrives to the destination, T2 is the time when the first packet is transmitted by source and *N* is the number of packet sent.

Throughput

The throughput is the percentage of the packets received by the destination among the packets sent by the source. The Throughput is given as:

$$\frac{m_1}{m_2} X\ 100\%$$

Where m1is the packets received by the destination and m2 is the packets sent by the source. The throughput is measured in bits per second (bit/s or bps).

Packet Delivery Ratio (PDR)

The ratio of the data packets delivered to the destinations to those generated by the CBR sources is known as packet delivery ratio.

PDR= Σ No of packet receive / Σ no of packet send.

Energy

The energy is nothing but the energy level in the node. If the energy level of a node becomes zero, then the node cannot receive or transmit packets anymore.

Simulation and Results

The mechanisms of the existing unicast reactive Ad-hoc routing protocols are used and their performance is simulated in typical UWSN scenarios, where the dimension of space is 1000mX1000m. In this scenario, variable number of nodes is placed and performance comparisons have been made with AODV, and DSR protocol, respectively.

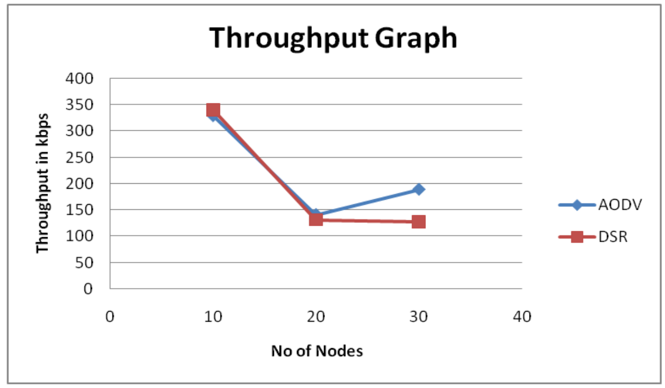

Figure 2

The average throughput which is the amount of data successfully received in a given time period that it is measured in Kilo bits per sec (Kbps). In above Fig 2 shows the throughput graph of AODV and DSR routing protocol, initially both the protocols performs same for less no of nodes, as the node numbers increases AODV achieves higher throughput than DSR.

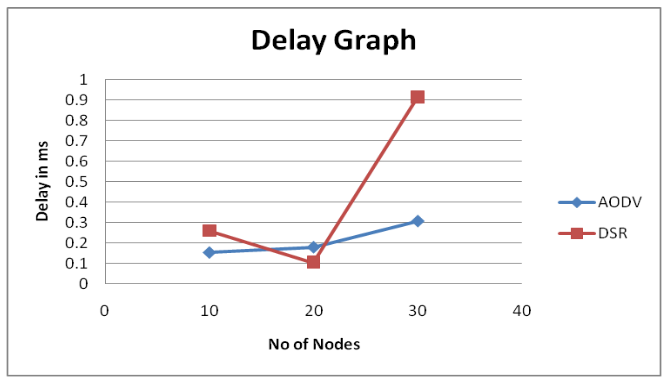

Figure 3

The average end to end delay which calculates the average time required to receive the packet. In the above Fig 3 shows the delay graph, as the node numbers varies the DSR shows the higher delay in receiving packets to destination than AODV.

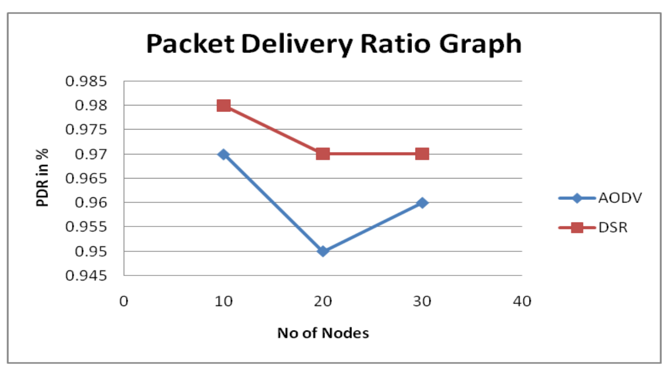

Figure4

The Packet Delivery Ratio (PDR) which represents the ratio between the number of packets originated by the application layer source and the packets received by the final destination. In the above Fig 4 shows the packet delivery graph, DSR achieves more in delivering packets to destination, as it finds the dynamic routes to destination, where as AODV gives routes on demand, thus reducing the delivery ratio.

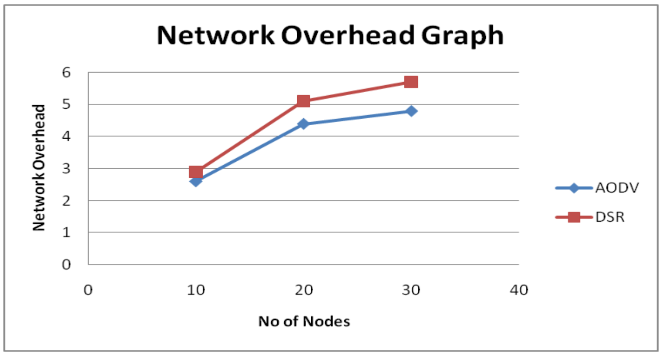

Figure5

The routing overhead is the number of route packets which every data packets needed to allow on average. In Fig 5 the route computation overhead for DSR is higher, as it computes routes dynamically without being demanded. Hence the communication overhead is more while routing computation than AODV.

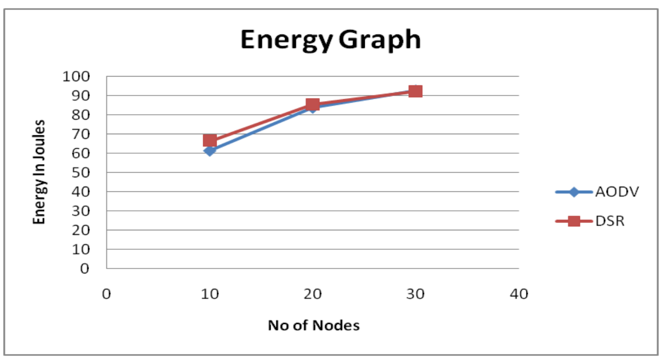

Figure 6

Above Fig 6 shows the average energy consumption of the nodes in transmitting and receiving packets. The consumption of energy for both AODV and DSR is almost same but a slight difference in values, where AODV consumes less energy and increases network lifetime.

V. CONCLUSION AND FUTURE SCOPE

This paper was conducted to study the mechanism of two on-demand unicast reactive Ad-hoc routing protocols AODV and DSR in order to exploit an appropriate protocol scheme for UWSN. These routing protocols were compared with respect to routing overhead, average end to end delay, energy consumption, packet delivery ratio and throughput when subjected to change in overall number of nodes and the percentage of nodes. Hence according to simulation result we conclude that the overall performance of AODV is much better than DSR.

Future work will be focus on evaluating the impact of variable speed and location information of the nodes on the routing protocol performance and cryptographic security for secure routing of data packets.

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Authors Profile

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