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Optimizing Efficient Routing in Underwater Delay Tolerant Networks

Ananya Sharma[1], Ashna Goel[2], Shubhi Mittal[3] and Preeti Nagrath[4]

[1,2,3] Student, Department of Computer Science Engineering, Bharati Vidyapeeth College of Engineering, New Delhi, India

[4]Assistant Professor, Department of Computer Science Engineering, Bharati Vidyapeeth College of Engineering, New Delhi, India

ABSTRACT

DTN is the latest growing technology breaking geographical barriers. The DTN layout & bundle protocol present a standard method for interconnecting heterogeneous challenged networks using asynchronous message switching. It furnishes a structure for dynamic routing, contact scheduling, naming, reliability and transmission status reports. Wireless Sensor Networks (WSNs) are often viewed as challenging networks because the nodes operate at low power, often with weak or intermittent radio communication. This report aims to evaluate the various routing protocols in DTN as a solution for messaging in the aquatic underwater environment through sensor networks, implementing the successful terrestrial based routing protocols, Prophet protocol and Epidemic protocol of DTN in underwater environment.

Keywords – DTN, WSN , AVS, TTL, Base Station, Routing Protocol, DTN

I. INTRODUCTION

Delay Tolerant Networks (DTN) is an opportunistic network which is infrastructure less and attempts to resolve the various issues of heterogeneous networks that are deficit in point to point and continuous connectivity. DTN is exceedingly useful in various application zones, such as: providing connectivity in remote areas where establishing a complete infrastructure is mostly not cost effective, wireless/sensor networks for wildlife tracking, military control and communication etc.

II. Literature Survey

Communication in underwater environment can also be initiated through optical network or electromagnetic waves but using acoustic waves is a more practical solution as compared to other means. As electromagnetic waves use large amount of transmission energy and optical network even though will have low power consumption but will suffer with absorption and interference and allow only shortrange communication.

Autonomous Vehicular System (AVS) have also been used in underwater scenario. AUVs constitute part of a larger group of undersea systems known as unmanned underwater vehicles, a classification that includes non-autonomous Remotely Operated Underwater Vehicles.

The existing packet delivery protocols include Epidemic protocol, which consumes network resources and is therefore not scalable. Epidemic protocol is the simplest form of routing approach where in the replicated message is forwarded to every node coming in contact. The epidemic approach has been improved by introducing controlled flooding approaches.

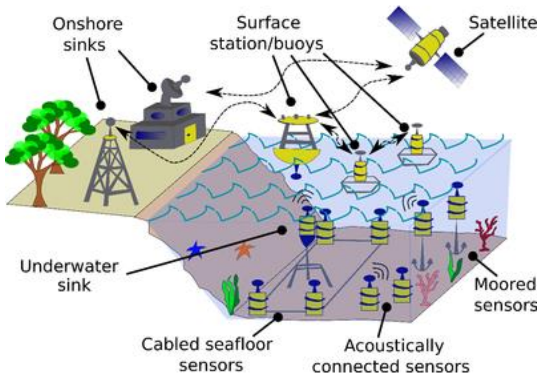

Figure 1 : Underwater Communication

III. IMPLEMENTATION

The frequency range for the underwater scenarios lies between 10 Hz to 1 MHz. We have evaluated some parameters namely, Delivery Probability, Average Latency and Overhead Ratio for different Ranges (10m and 20m) and Speed whose frequency must lie between the above mentioned range.

The evaluation of these parameters was used to find out the optimal frequency. Optimal frequency was needed to transfer the data from the Base station to the next immediate node.

Later we created one node as Base station and to transfer data from Base Station to the other node, the parameters of the nodes near the base station must match the optimal parameter and frequency. The node with the optimal parameters will get the data transferred from the Base Station.

We consider 15 nodes in the simulation scenario, out of which 1 node is acting as the base station for all other nodes i .e the sensor node. The 14 nodes have sensors attached to them, which are used by the base station to sense that the node is in the vicinity. Whenever the Base Station node has to send a message, it first senses the nodes near to it using the acoustic sensors, and then the sensor node whose parameter values are equivalent to the optimal parameter values will be used to transfer the message from the Base Station. For routing the messages to further nodes, we keep in mind that the frequency range for the acoustic signal is between 10 Hz and 1 MHz, so the frequency of the node to which the message has to be transferred should fall between the above mentioned range. Otherwise it may lead to loss of the messages, i.e. message may get dropped. Other parameters, i.e. Delivery Probability and Average Latency are considered, following the path which takes least time to deliver the message(s) to the sensors nodes from the base station so that they are delivered before their TTL becomes 0.
Frequency is evaluated based on transmission range and wavelength by the following formula.

Frequency = Transmission Speed/Wavelength

IV. SIMULATION SETUP

The epidemic and our proposed routing protocols were analyzed on Opportunistic Network Environment(ONE) simulator. This simulator is designed for evaluating the performance of DTN routing protocol. ONE simulator uses Java programming language. The main functions of ONE are modeling the node movement, inter node contacts. The interface in network is sensor nodes with the transmit range of 10 meters and 20 metres ,and multiple transmission speeds. Actually there are two wireless technologies available for ad-hoc connectivity and the other option is Bluetooth. But bluetooth is not a practical option for underwater environment due to constantly changing topology and multiple interferences. The time simulation is 6440 sec. The simulation configuration consists of varying speed, range, buffer size, message size and time to live (TTL).

A. Simulation Parameters

Table 1 represents the simulation parameters used for the analysis of the protocol.

Table 1

Parameters	Values
Total Simulation Time (sec)	6440
Routing Protocol	Prophet, Epidemic (Modified)
Node Buffer Size	1M, 50M, 100M
Number of Nodes	14
Number of Base Stations	1
Message TTL	300 minutes
Message Size	250kB - 500kB
Message Creation Rate	One message per 25-35 sec
Interface Transmit Speed	250K, 500K, 750K, 1000K
Interface Transmit Range	10 m, 20m
Node Movement Spread	Min=0.5 m/s Max=1.5 m/s
Movement Model	ShortestPathMapBasedMovement

B. Performance Metrics

The following performance metrics are used for the analysis:

a) Overhead Ratio: This metric is used to estimate the extra number of packets needed by the routing protocol for actual delivery of the data packets. It is defined as follows -

(Number of Relayed Packets - Number of Delivered Packets) /(Number of Delivered Packets)

b) Delivery Probability: It is the fraction of generated messages that are correctly delivered to the final destination within a given time period. It is defined as follows-

Number of packets delivered /Number of packets created

c) Average Latency: It is the measure of average time between when the message is generated and when it is received by the destination.

V. RESULTS AND ANALYSIS

In the simulated environment, we have modified and observed the performance of both the protocols, prophet and epidemic with regard to the metrics defined above. The results presented here are obtained by running the simulations as per the parameters defined in Table 3.1.

A. Delivery Probability

From Fig 3.1, The delivery probability of Epidemic routing protocol in the considered scenario (Transmission Range - 20m) is almost constant as the transmission speed increases from 250K to 750K, in contrast to this, the delivery probability of Prophet routing protocol increases significantly as the transmission speed increases.

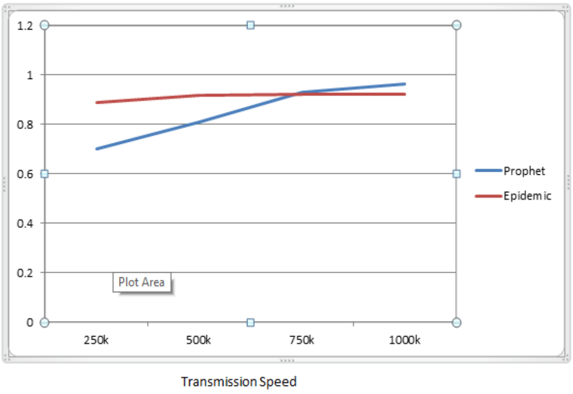

Fig 2

B. Average Latency

From the Fig 3.2, it is evident that the average latency experienced by the packets in Epidemic routing protocol is less than that of Prophet with the increase in the Transmission Speed. But in Prophet as the Transmission Speed increases the Average Latency tends to decrease. This is because as the speed of the transmission increases the packet will be either delivered to the destination node quickly or it is being discarded due to lifetime expiry. So, the overall latency of Prophet decreases with the increase in the Transmission speed.

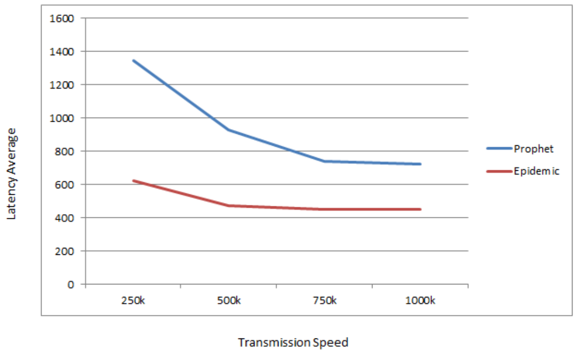

Fig 3

C. Overhead Ratio

Overhead ratio of Prophet routing protocol increases marginally from 146 packets to approximately 201 packets (Fig 3.3.), whereas the overhead ratio of Epidemic routing protocol increases from 140 to 200. As the transmission speed increases the overhead ratio of Prophet routing protocol increases. In complete scenario the overhead ratio of Epidemic routing protocol is approximately 2% less than the Prophet routing protocols.

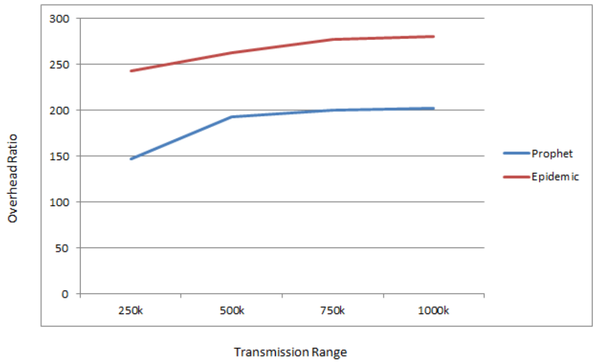

Fig 4

VI. CONCLUSION

Most of the routing protocols in DTN operate with the assumption of infinite buffer and bandwidth. However, these resources are limited in situations of calamities or situation wherein achieving environment stability is difficult. The work considers the DTN environment which is highly mobile and opportunistic in nature and which limits the duration of contact.

We already know from earlier research works that Prophet is a better routing protocol than Epidemic with respect to factors like latency, delivery probability, overhead ratio in the terrestrial scenario. Even though average latency of epidemic protocol is better than that in prophet algorithm, the overall performance of the prophet algorithm is better epidemic protocol.

Both algorithms can prove to be beneficial with choice depends on the parameters on case to case basis. Although, according to the statistics when the functionalities of both the algorithms are combined they can provide even better results.

VII. FUTURE SCOPE

Modification of DTN routing protocols is done for Prophet and Epidemic protocols individually for their implementation in underwater scenario. Evaluation can be done by combining both the algorithms i.e taking combining the advantages of both the protocols while they eliminate the disadvantages of each other. It can also be extended by performing the evaluation using real-world mobility traces or real-time networks with physical nodes which will lead to accurate results. Security is also an important consideration since most of the applications aim at it; the transmitted message should reach the base station without any intervention. Implementing some cryptographic techniques in the project may enhance the security of system. Further testing should be done to observe the DTN protocol working in mission like scenarios at higher data rates. Analysis should be done to determine challenges and benefits associated with DTN protocols at higher data rates. The performance of DTN-like networks in underwater scenario in terms of throughput and information delivery rate and latency could be enhanced by eliminating the magnitude of interferences encountered during data forwarding with the aim of improved reliability, security, performance and delivery guarantee is a remarkable research area and could be quite well-suited especially for mission-critical DTNs applications, as water poses challenges as a medium for communication.

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