An Analytical Incorporation of Power Priority Model with Replication and Expedition based Routing Protocol

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***Abstract*—** Delay tolerant network (DTN) is a class of wireless ad-hoc network. It works when end to end direct path does not exist between source and destination by using the Store and Forwarding routing mechanism. DTN has several features such as long delay, limited resources, high error rate, reliable transmission etc. Its application fields are in wildlife behavior monitoring, military battle field, post disaster communication, under water communication and many more. The purpose of this paper is to compare between two different strategic (Replication and Expedition based) routing protocols with the Power Priority Model, which is proposed in recently. The evaluated result of this performance analysis was obtained from Opportunistic Network Environment (ONE) simulator on various performance metrics such as, Delivery Probability, Overhead ratio, Average latency and Hop count.

Keywords- *Delay-tolerant Networking; Epedemic; Prophet; Power Priorty Model; ONE Simulator; DTN.*

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I. INTRODUCTION

Delay Tolerant Network (DTN) is the wireless network that works when the traditional TCP/IP based network failed to communicate between sender and receiver in different scenarios like as post disaster, massive fire occurrence, military battle, etc.

The concept of DTN was proposed in 2003 [1]. Later, Internet Research Task Force (IRTF) established DTN Research Group (DTNRG) and proposed the DTN network architecture [2] and Bundle Protocol [3] in 2007. It also proposed the Licklider Transmission Protocol (LTP) [4] and Saratoga [5] for improving the Bundle Protocol. DTN uses "Store and Forward" strategy for routing of messages where message is successively moved and stored in the buffer throughout the network in hops that it will finally reach its destination [6]. There are different types of routing protocols in DTN such as Epidemic [7], Spray and Wait [8], PROPHET [9], MaxProp [10] etc. every protocol has its own mechanism to send the message to the destination by following "Store and Forward" strategy.

In DTN major and foremost task is delivering the messages perfectly to the destination node. To achieve this goal many researchers proposed and established different protocols or models such as Epidemic [7], Spray and Wait [8], PROPHET [9] and MaxProp [10] etc. In this study, it showed the performance analysis of two different strategic routing protocols' DTN with the Power Priority Model [11] depending on the various performance metrics mainly the Delivery ratio, Overhead ratio, Average latency, Hop count etc. After completing the evaluation the evaluated result will help to find the find the better one between Epidemic and Prophet routing protocol

II. LITERATURE STUDY

Hoque et al. [11] presents a model named as power priority model. For DTN it will be worked with the power level of the devices. With the best effort to deliver the message to the destination by checking the devices battery power condition like as, if the next nodes' power is greater than or equal to existing node the message will be sent otherwise not, but if next node is the destination it will not check the battery power condition. For this model it followed a ranking table from lower to higher.

Alaoui et al. [12] presents Custody Transfer models and BLER for data transfer. In Custody Transfer models the bundle layer includes an option called custody transfer that provides a reliable hop-by-hop to the final destination. Depending upon the mechanism of custody transfer, the packets are transmitted in a "Store-and-forward" technique, while the responsibility of a reliable transfer is delegated to the next node in the route to the final destination. In BLER the lack of end-to-end monitoring of data transmission makes the custody transfer mechanism insufficient to guarantee the reliability of transmission and retransmission of data at certain cases, especially in shared networks. BLER is working where the custodian node is not able to forward the bundle before the expiration of the TTL due to unexpected events in shared networks.

Most of the papers which are available on DTN are focusing on the performance analysis of different routing protocols and the various models which will contribute to DTN for sustainable communication system. Finally, this paper will present an analysis of routing protocols with the help of Power Priority Model.

III. Routing Protocols of DTN

Routing Protocols of DTN are classified on two different strategies such as Replication based and Forwarding based. In replication strategy [8, 13] it creates multiple copies of a message to deliver it to the destination. Some of replication based routing protocols are epidemic, Spray and Wait, RAPID, Spray and Focus etc. In forwarding strategy [10, 14] it works with the help of previous history of distribution due to the lack of buffer spaces and resources. Some of forwarding based routing protocols are Prophet, MaxProp, FRESH etc.

A. Epidemic routing protocol

Epidemic routing protocol was historically the first DTN routing protocol [7]. It is flooding based routing in nature. In Epidemic routing, every node continuously replicates messages to newly arrived nodes that do not already have the message copy. The message distribution is transitive through ad hoc networks, with messages eventually reaching their destination. Epidemic routing protocol provides guaranteed transmission of message irrespective of delivery delay [6]. The disadvantage of this routing protocol is consuming a lot of network resources. Furthermore, the message continues its propagation through the network even after being delivered [12].

B. Spray and Wait routing protocol

The routing protocol Spray and Wait limits the replication strategy of blind Epidemic routing messages by combining a number L of messages indicating the maximum allowable copies of the message [8]. In the spray phase, for each message generated at the source, L copies are distributed to L distinct relays as it shown in Figure 1, part a). If the destination is not reached during the first phase, each of the L relays spreads in turn the message to their neighbors until the attainment of the destination, which is the task of the wait phase (Fig.1, part b). The parameter L is selected depending on the density of the network and the desired average time [12].

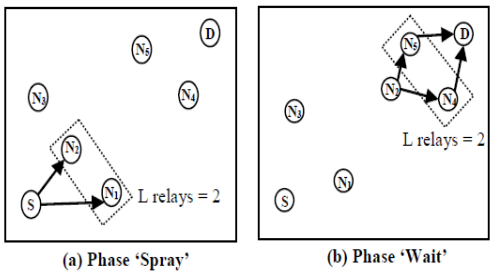

Figure 1. Spray and Wait Routing Protocol Mechanism

C. PROPHET routing protocol

To improve the delivery probability and reduce the wastage of network resources in Epidemic routing a new type of routing protocol has proposed called PROPHET [9]. In PROPHT if a node has visited a location several time then there is a possibility that this pattern will repeated in the future. In PROPHET every node uses probabilistic metric called delivery predictability to transfer messages to a reliable node. The higher delivery predictability for a node indicates that it is more reliable than other nodes to forward message to destination. PROPHET outperforms Epidemic routing. However, PROPHET has higher average delay than Epidemic routing when the buffer size of nodes are decreased. PROPHET has lower overhead than Epidemic routing [6].

D. MaxProp routing protocol

MaxProp is forwarding based routing protocol. In MaxProp routing each node initially set a probability of meeting to all the other nodes in network and also exchanges these values to its neighbor nodes [10]. The probability value is used to calculate a destination path cost. Each node forwards messages through the lowest cost path. MaxProp also uses an ordered queue which is divided into two parts according to an adaptive threshold. MaxProp assigns a higher priority to new messages and forward it first with low hop count and drops a message with the highest cost path when buffer is full. MaxProp has poor performance when nodes have small buffer sizes because of the adaptive threshold calculation. MaxProp performance is better with large buffer size [6].

IV. Power Priority Model

The purpose of this model is to try the best effort of message delivery by checking the devices battery power condition. Devices are like smart phone or PDA. If the next nodes' power is greater than or equal to the current node the message will be sent otherwise not, but if next node is the destination it won't check the battery power condition. For the battery power checking it follows the power priority table (lower to higher). The power priority model works by checking the power level of the targeted devices. It sends a message to the next node after checking the Power level of that device (e.g. smart phone, PDA etc). If receiver nodes' power is greater than or equal to sender nodes' then message will be sent; until next node is the destination node [11]. Working procedure for power priority model is given in Figure 2.

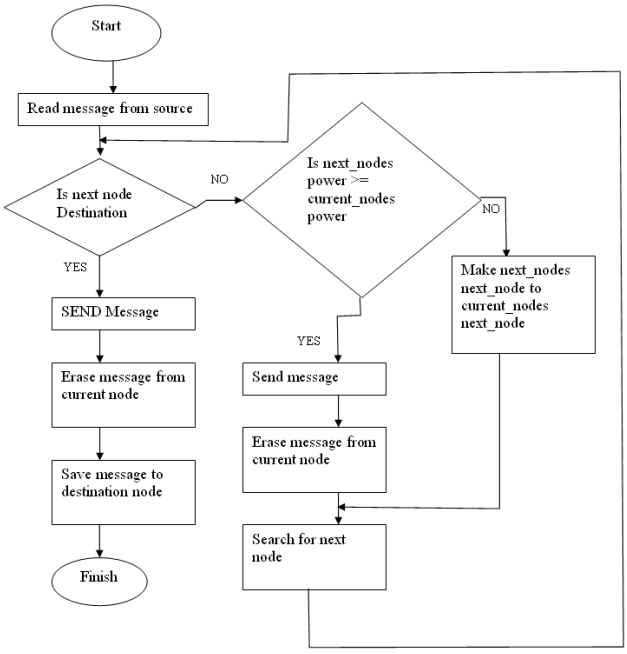

Figure 2. Procedure of Power Priority Model

V. SIMULATION

A. Simulation Enviornent Setup

The For the simulation process Opportunistic Network Environment (ONE) is used. ONE is a Java-based simulation environment that combines movement modeling, routing simulation, visualization and reporting in one program [15]. For simulation purposes the map-based movement model of Helsinki City Scenario (HCS) is selected. The simulation setup information is given in details in Table 1.

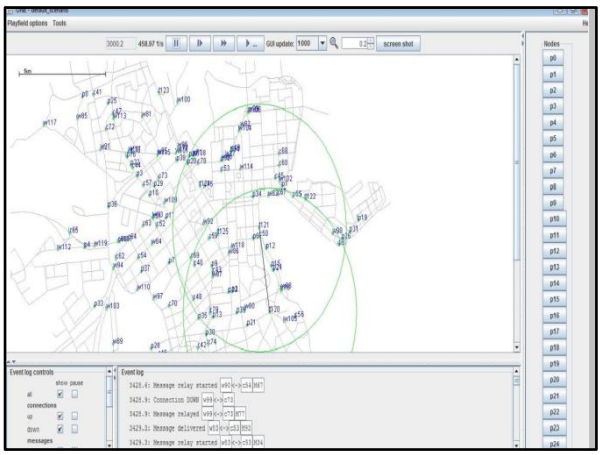

Figure 3. Screenshot of Simulation.

B. Performance Metrics

For comparing the performances of DTNs routing protocols which integrated with power priority need several parameters to test. The parameters which are used in the result analysis session are described in this session.

i. Delivery Probability:

Delivery Probability is the ratio result of the generated messages which are delivered to the final destination perfectly within the given time.

$$\text{Delivery Ratio} = \frac{D}{C} \quad (1)$$

Here,
D: Number of messages delivered to the destination.
C: Number of messages created at the source.

ii. Overhead Ratio:

Overhead Ratio is the ratio result of message transmissions over the number of messages which are delivered.

$$\text{Overhead Ratio} = \frac{(R-D)}{D} \quad (2)$$

Here,
D: Number of messages delivered to the destination.
R: Number of successful transmission between nodes.

iii. Average Latency:

The average latency is the calculated time which is required between the creation of a message and its delivery to the destination.

iv. Hop Count:

In DTN, hop count refers the number of nodes which the message traverses between the source and destination. It also helps to determine the approximate path distance from the source to the destination for a message.

C. Simulatoin Parameters

For the simulation of this performance analysis between two routing protocols the assigned values of different parameters as given in Table 1.

TABLE I. SIMULATION PARAMETERS TABLE

Parameters	Value setting
Simulation Time	21600 sec
No. of Nodes	200
Routing Protocols	Epidemic, Prophet and Power Priority.
Interface Type	Bluetooth
Buffer size	10 Mb
Character Size	32 KB
Transmit Range	100 meters
Transmit Speed	2 Mbps
Message Size	50 Kb to 1 Mb
Message TTL	300 min

VI. RESULT ANALYSIS

After completing the simulation for different routing protocols with Power Priority Model the simulated results are described in the following paragraphs.

A. Delivery Probability

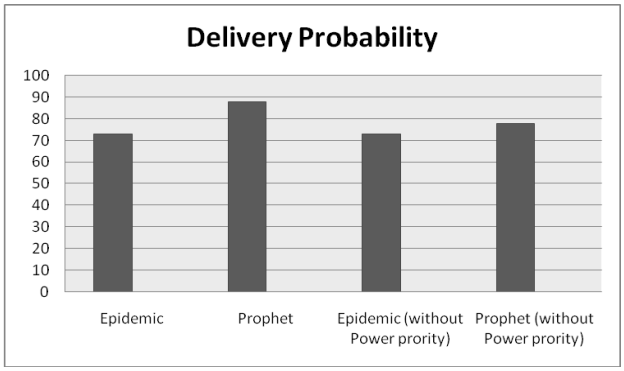

Figure 4. Comparison of Delivery Probability.

Figure 4 shows that the massage delivery probability [6] of Prophet with power priority model is higher than the Epidemic routing protocol; because delivery probability depends on the message generation and the delivery of that message properly. Furthermore, Prophet with power priority is higher than Epidemic for permissible copies of messages as

Prophet routing protocol delivers the message to the destination by checking the power level.

B. Overhead Ratio

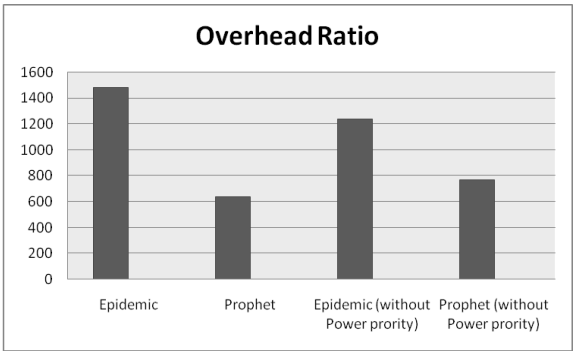

Figure 5. Comparison of Overhead Ratio.

Figure 5 shows that the Overhead ratio [6] of Epidemic with power priority is notably better than the Prophet routing protocol; because overhead ratio depends on the number of the message transmission for each messages. Since before sending the messages Epidemic checks the device power level in each time with its mechanism, it transmissions cost is lower.

C. Average Latency

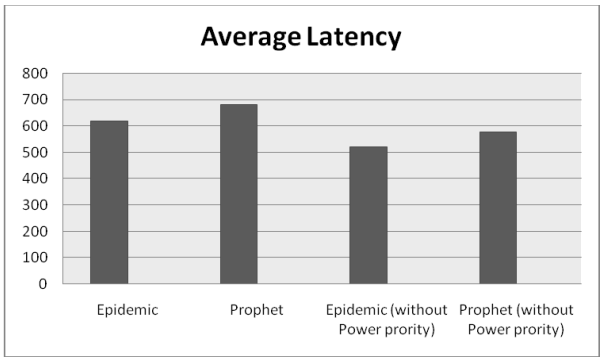

Figure 6. Comparison of Average Latency.

Figure 6 shows that the Average Latency [12] of Epidemic is moderate than the Prophet routing protocol; for the reason that average latency depends on the average time between the messages generated and accepted by the destination node.

D. Hop Count

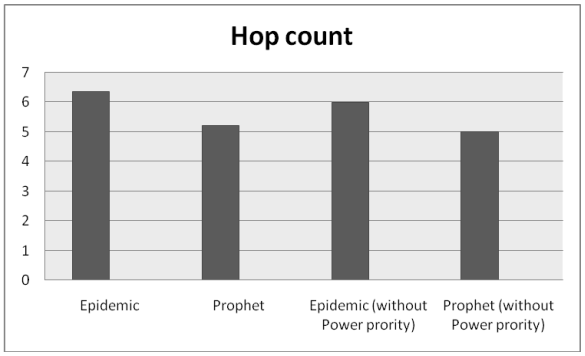

Figure 7. Comparison of Hop Count.

Figure 7 shows that the Hop count [12] of Epidemic with power priority; which is superior to the Prophet routing protocol as the hop count depends on the total number of nodes that message traverse. In Epidemic the number of nodes that messages traversed is a bit lesser since before sending the messages it checks the power level with the next node except destination node. It doesn't send the messages randomly to other nodes.

VII. Limitations and Conclusion

In Power Priority Model message will be sent as described when receiver nodes' power is greater than or equal to sender nodes' until next node is the destination node. DTN also faces some routing challenges such as instantaneous end to end path may not be exist always, extra delay for the large queuing system, buffer limitations at intermediate nodes [11].

In this paper, well known routing protocols of DTN are simulated under four different scenarios with the help of java-based simulation environment ONE simulator. After analyzing the simulation result between two different strategic routing Protocols on several parameters, Replication based routing protocol - Epidemic's performance was excellent with Power Priority model for Overhead ratio and Hop count. On the other hand, Expedition based routing protocol - Prophet's performance was excellent with Power Priority model for Delivery probability and Average latency. In future, this work will be extended for another two different routing protocols of Replication and Expedition based routing protocol.

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