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An Analytical Unification including the Performance Evaluation of Power Priority Model with Spray & Wait and MaxProp Routing Protocols of Delay Tolerant Network

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ABSTRACT: The Researcher's passion and engagement in the field of wireless ad-hoc networking especially in Delay-Tolerant Networking (DTN) is increasing gradually. It is a special type of wireless ad-hoc network. It's used to solve the lack of traditional network end-to-end discontinuation in the emergency scenario. It works when a traditional network fails to deliver the data from source to destination. It uses a store and forward routing method along with long delay, limited resources, reliable transmission, and tolerable error rate features. DTN classified its routing protocols based on two different strategies Replication and Forwarding. Monitoring wild-life behaviour, military areas (battlefield), post-disaster scenarios, communication fields in the underwater environment, and internet access in remote areas are the most successful application of DTN. Power Priority Model of DTN environment is one of the promising processes to deliver the data with an endurable delay ratio. The objective of this research work is to analyse and compare two routing protocols of DTN which are integrated with the power priority model. Opportunistic Network Environment (ONE) simulator will be used to evaluate this research work. ONE is a Java-based simulator. This evaluation is based on different performance parameters such as overhead ratio, delivery probability, hop count, and average latency.

KEYWORDS: Delay-tolerant Networking; DTN; Spray and Wait; MaxProp; Power Priority Model; ONE Simulator.

I. INTRODUCTION

The main principle of TCP/IP protocol is the end-to-end data transfer methodology. In case of any situation, if this traditional network fails to establish the path between source to destination, a new network concept has been introduced named as Delay Tolerant Network (DTN). Being a type of wireless network it works when the traditional TCP/IP based communication system is failed. It works in some special scenarios such as post disaster, Military battle filed, Wildlife behaviour analysis, Massive fire occurrence, etc. The Internet Research Task Force (IRTF) proposed the concept of DTN almost 17 years ago in 2003.

After 4 years in 2007 the IRTF formed a specific research team named DTN Research Group (DTNRG) to propose a dedicated Architecture of DTN network [1].

DTN uses the "Store and Forward" strategy to send messages successfully from source to destination. Based on this mechanism DTN has different types of routing protocols such as Epidemic, PROPHET, Spray & Wait and MaxProp, etc. [6]. The foremost task of DTN is delivering the messages to the destination successfully. To accomplish this perfection DTN with Power Priority Model was proposed. The power priority model with DTN was integrated for ensuring the best dedication to delivering the messages. This model has been worked by checking the targeted device's power level. Before forwarding a message between intermediate nodes it checks the power level of that device until the next device is the destination [1].

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This research study will analyse the performance between Spray & Wait and MaxProp routing protocols of DTN which is Power Priority Model integrated. The evaluation of performance will be observed on different performance parameters such as Average latency, Delivery probability, Overhead ratio and Hop count etc. As a replication based routing protocol Spray & Wait and forwarding based routing protocol MaxProp will be used in this research work. This research study will help to find a better routing protocol comparing both of them along with the Power Priority Model of DTN.

II. LITERATURE STUDY

Alaoui et al. [2] present the comparison of two categories routing protocols performance analysis based on two-pronged strategy. This research work has used Epidemic, Spray and Wait protocols for replication strategy. Prophet and MaxProp protocols were used for expedition strategy. It's contributed by combining DTNs Routing protocols and bundle layer end-to-end retransmission (BLER) for improving DTN networks. Opportunistic Network Environment (ONE) simulator has been used to perform this evaluation. The performance of DTN is observed in terms of the average latency, overhead ratios and delivery probability.

Hoque et al. [3] present the analytical comparison of Replication and Expedition based routing protocols of Power Priority Model integrated DTN. This research-based performance analysis was evaluated on Opportunistic Network Environment (ONE) simulator. ONE is a java-based simulation environment. In this performance evaluation Delivery Probability, Average latency, Hop Count and Overhead ratio were the performance metrics. The time period of this simulated evaluation was 21600 seconds, the number of nodes was 200 and transmission range was 100 meters.

On Delay Tolerant Network (DTN) most of the papers are presenting the performance analysis of DTN Routing protocols to ensure the sustainable communication System.

III. ROUTING PROTOCOLS OF DTN

Based on the Replication and Forwarding mechanism DTNs routing protocols are classified. The replication strategy works by forming multiple copies of the message. RAPID, Epidemic and Spray & Wait etc. are example of replication based routing protocols [4]. Forwarding strategy works with the help of previous distribution history of limitation in buffer spaces and resources. Prophet, MaxProp, FRESH etc. are examples of forwarding based routing protocol [5]. Figure 1 shows the routing strategies of DTN.

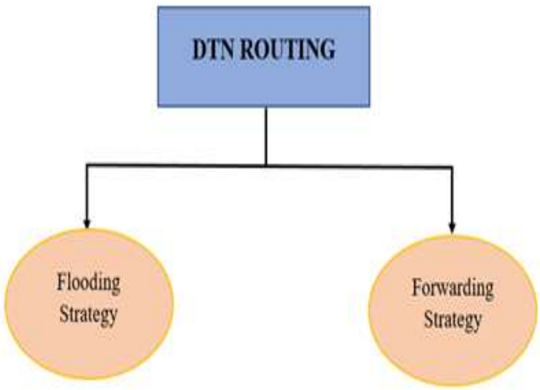

Figure1. Routing strategies of DTN

A. Epidemic Routing Protocol

The first routing protocol of DTN is the Epidemic routing protocol. In nature, it is a flooding based routing protocol. In Epidemic every node replicates messages continuously to newly arrived nodes that don't have a copy of that message. Epidemic routing protocol ensures reliable message delivery without considering the delay. So, consuming enormous network resources are the major drawback of this routing protocol. [6].

B. Spray and Wait Routing Protocol

Spray and Wait is a replication strategy based routing protocol by combining a number L of messages stipulating the maximum permitted copies of messages. In this routing protocol, the messages are generated at the source. In the Spray stage, the source node duplicates the maximum number of message copies, which is settled. It then forwards a duplicate message each time it experiences an intermediate node until only one copy of the message remains. In the event that the node carries only a copy of the message, it'll enter the holding up stage, in which the message is sent as it were when the target node is found. The main task of the wait phase is to attain the destination. Depending on the caved average time and the network density the parameter L has been selected [4]. Figure 2 represents the Spray and Wait routing mechanism.

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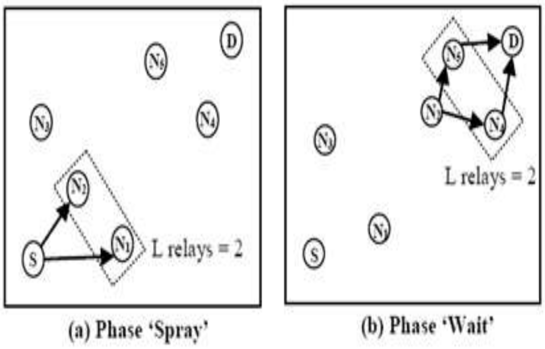

Figure2. Spray and Wait Routing Protocol Mechanism

C. PROPHET Routing Protocol

For improving the delivery probability in Epidemic routing PROPHET has been proposed as a new routing protocol of DTN. Network resources are properly managed without any wastage. A pattern has been followed to distribute the data from source to destination. Probabilistic metric called delivery predictability is used by every node for transferring messages to an authentic node. It ensures more reliability from source to destination. However, in PROPHET has a low buffer size which has an average delay rather in Epidemic. It has a lower overhead ratio then the Epidemic routing protocol [7].

D. MaxProp Routing Protocol

It is forwarding based routing protocol of DTN. In this routing protocol, initially, each node sets a probability of meeting to all the other nodes in the network and also exchanges these values with its neighbour nodes. These values are used to calculate the cost of the destination path. According to the lowest path cost, each node forward the messages. It uses an order queue. New messages are assigned in the higher priority and forward those with the minimum hop count. If buffer space becomes full then it will drop a message with the highest path cost. The performance of MaxProp routing protocol has depended on buffer sizes owing to the adaptive threshold calculation. If the buffer size is spacious its performance will be better otherwise it will be poor [8]. MaxProp routing mechanism is given in Figure 3.

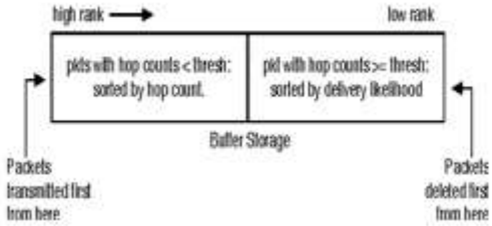

Figure 3. MaxProp Routing Protocol Mechanism

IV. POWER PRIORITY MODEL

The major role of the Power Priority Model (PPM) in DTN is making sure the message is delivered from source to destination by checking the power level of the device battery. To check the power level of every device, it follows a chart of power priority. When a device gets ready to convey a message to another device it compares the power level with itself. The message will be sent if the power level is greater than or equal, otherwise not. It will deny this order if next the node is the destination node. After checking the current device's (e.g., smart phone, PDA etc.) power level it sends a confirmation to the immediate node [9]. The mechanism of the power priority model is given in Figure 4.

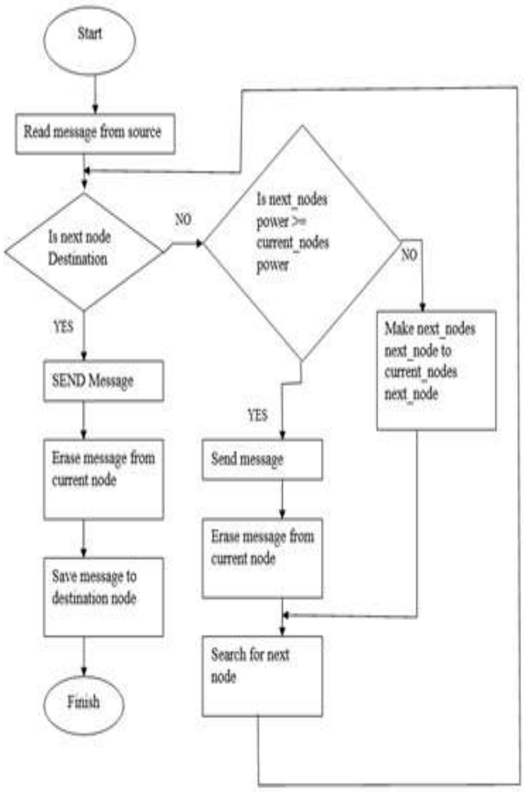

Figure 4. Procedure of Power Priority Model

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V. RESEARCH SIMULATION

A. Simulation Environment Setup

In this research work, Opportunistic Network Environment (ONE) is used for the simulation process.It is a Java-based simulation environment and combines the visualization, movement modeling and routing simulation of Delay Tolerant Network (DTN) [10]. Map-based movement model of Helsinki City Scenario (HCS) is used for simulation purposes. The HCS movement is shown in Figure 5.

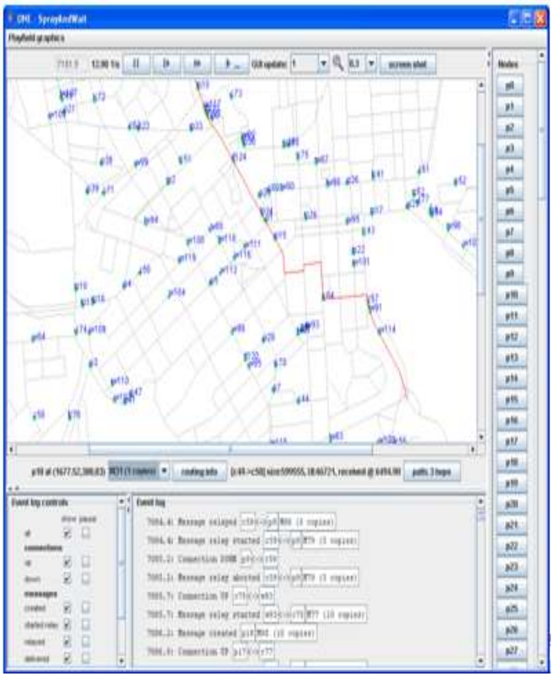

Figure 5. Screenshot of Simulation

i. Delivery Probability: It is the ratio result of generated messages from source to destination which are delivered perfectly within a timing frame.

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

Here,
D; mentioned the number ofdelivered messages to the destination.
C; mentioned the number of generated messages from the source.

For the n time, the average delivery probabilities from a node to another node may be calculated using the following formula-

$P_{avg\,(n)(a,b)} = P_{avg\,(n-1)(a,b)} * \sum_{1}^{n-1} \left(t + P_{(a,b)n} * t_n\right) /$ 1ntn (2)

ii. Overhead Ratio:
Overhead Ratio is the ratio result of transmitted messages over the number of delivered messages.

Overhead Ratio= (3) $\frac{(R-D)}{D}$

Here,
D; mentioned the delivered messages to the destination.
R; mentioned thenumber of successful transmissions between different nodes.

iii. Average Latency:
Average latency is the calculation of the required time between the message creation and its delivery to the destination.

iv. Hop Count:
Hop count refers to the number of passing nodes from source to destination during the message traverse duration.Hop count also helps to determine the approximate distance of path for a message from source to destination.

B. Simulation Parameters

To evaluate this performance analysis of two different DTN routing protocols following parameters has been followed. Table 1 represents the specified values of different parameters.

Table I. Simulation Parameters Table

Parameters	Values
Simulation Duration	43200 sec
No. of Nodes	230
Routing Protocols	Spray and Wait, MaxProp
Interface	Bluetooth
Buffer size	12 Mb
Message Size	50 Kb to 1 Mb
Transmit Range	98 meters
Message TTL	300 min
Character Size	32 KB
Transmit Speed	2 Mbps

VI. RESULT ANALYSIS

In this section the simulated results of two different routing protocols are illustrated.We have concentrated on comparing the performance with respect to four metrics:average delay average, average delivery rates, overhead ratio and hop count. The results shown here is the duration of 432000 sec or 5 simulation runs.

A. Delivery Probability

Figure 6. Comparison of Delivery Probability.

Figure 6 illustrates the average massage delivery probability of Spray & Wait and MaxProp routing protocols with and without the Power Priority Model. According to the result, the delivery probability ratio in integrated MaxProp is superior to others which are more than 90%. Because a node does not forward a message to another node as soon as it finds the receiving node but also checks the power level. Here, the history of node encounters has not been used for forwarding decisions.

B. Overhead Ratio

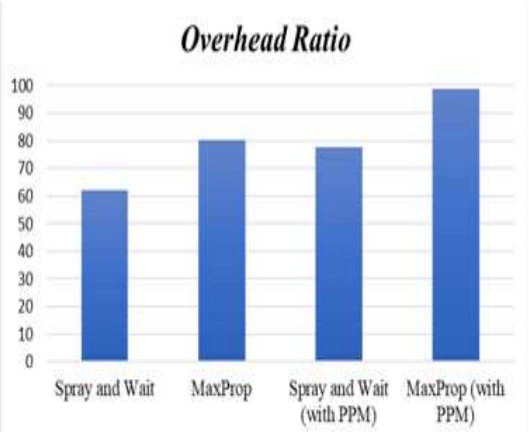

Figure7. Comparison of Overhead Ratio.

Figure 7 illustrates the Overhead ratio of Spray &Wait and MaxProp integrated with Power Priority Model. Here it is observed that the overhead ratio is notably increased compared to conventional MaxProp and Spray and Wait protocol. For Spray and Wait overhead ratio is remarkable while Maxprop protocol provided the best outcome (almost 98%) as a result of its resource consuming message forwarding mechanism. To find the result, cost calculation of destination path and device power level inspection was considered simultaneously.

C. Average Latency

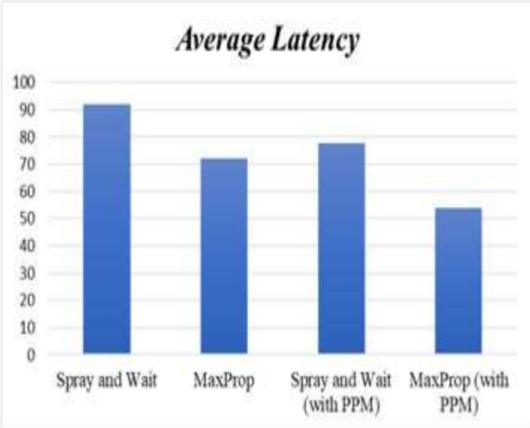

Figure 8. Comparison of Average Latency.

Figure 8 represents the Average Latency (Long average latency means that the message must occupy valuable buffer space for a longer time) Spray & Wait and MaxProp routing protocols including and excluding the Power Priority Model. The bar chart shows the average latency of integrated MaxProp and Spray and Wait decreases against the message generation rates. The result shows that Integrated Maxprop does provide a low latency value compared to the other three as it uses a pre-calculated destination path resulting in required less time to get the best result than any other routing protocol.

D. Hop Count

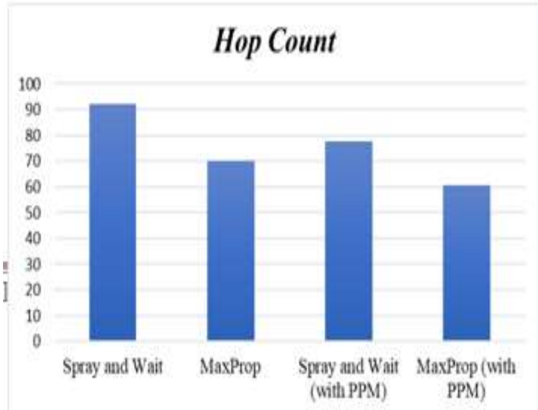

Figure 9. Comparison of Hop Count

Figure 9 illustrates the Spray & Wait and MaxProp routing protocols including and excluding the Power Priority Model. Following chart shows the Hop Count of integrated MaxProp is significantly outperformed regular Spray and Wait and MaxProp. Integrated Spray and Wait is also uses less hop count to deliver a message than traditional Spray and Wait. This result is predictable due to the acknowledgment of active node is used in Power Priority Model between source and destination which causes less node traversal.

VII. LIMITATIONS AND CONCLUSION

In spite of advanced features of DTN, it has few drawbacks such as availability of rapid end to end path, buffer size limitations for intermediate nodes.

This research work followed the Power Priority Model integrated routing protocols of DTN. Java-based simulator 'ONE simulator' was used to simulate this comprehensive research work, in term of some parameters such as delivery ratio, hop count, overhead ratio and latency. By analyzing this simulated result on several parameters, forwarding based MaxProp routing protocol with Power Priority Model performed very well. Following this work, Power Priority Model will be integrated with remaining routing protocols of DTN to optimize according to the DTN performance parameters.

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