An Integration of Power Priority Model in Delay Tolerant Network Routing Protocols for Better Performance

Mohammad Ashraful Hoque* and Thouhidul Islam

Department of CSE, Southeast University, Dhaka, Bangladesh.

Abstract

Now-a-Days, researchers' engagement in the research works in the fields of networking and telecommunication sector could be seen increasing day by day. Many of them are interested in Wireless Communication Field, especially in TCP/IP (IPv4, Ipv6), MANET, VANET, OPNET etc. In recent decade Delay Tolerant Network (DTN) has become popular. In fact, as the time passes, many researchers have started working in this area. DTN is a special type of Network which evolved from the need to solve the lack of gradual end-to-end connections in some emergency scenario. DTNs Applications are including Wildlife behavior monitoring, internet access in rural areas, Military Battlefield, Post disaster communication etc. DTN environment is required where traditional networks are failed to deliver data to the destination. In this paper our objective is to design and propose a model for ensuring the best message delivery effort over DTN. Our proposed Power Priority model is developed and will be worked over the DTNs popular Spray and Wait and MaxProp Routing Protocol.

Keywords: *Delay Tolerant Network (DTN), Epidemic, Spray and Wait, PROPHET, MaxProp, ONE Simulator, Power Prioritization, Power Priority Model.*

I. Introduction

DTN (Delay Tolerant Network) works when the traditional TCP/IP based network failed to work. In different scenario such as post disaster, massive fire occurrence, military battle, wireless network range limitations etc. when traditional network is failed to communicate to send the message to the destination.

The concept of DTN was proposed in 2003 (Fall K. *et al.*, 2008). Later, Internet Research Task Force (IRTF) established DTN Research Group (DTNRG) and proposed the DTN network architecture (Cerfv. Burleighset *et al.*, 2007) and Bundle Protocol (Scott. *et al.*, 2007) in 2007. It also proposed the Licklider Transmission Protocol (LTP) (Burleigh. *et al.*, 2008) and Saratoga (Wood L. *et al.*, 2009) 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 (A. Mehto *et al.*, 2013). When source node creates a message it stores and forwards after getting next node; current node stores message until it cannot find a next node. There are different types of routing protocols in DTN such as Epidemic (A. Vahdat *et al.*, 2000), Spray and Wait (T. Spyropoulos *et al.*, 2005), PROPHET (A. Lindgren *et al.*, 2003), MaxProp (J. Burgess *et al.*, 2006) etc. every protocol has its own mechanism to send the message to the destination by following "Store and Forward" strategy. In DTN the 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 PROPHET (A. Lindgren *et al.*, 2003), MaxProp (J. Burgess *et al.*, 2006) and Message Prioritization (X. Liu *et al.*, 2014) etc.

Recently several research works has been conducted for ensuring best-effort delivery of emergency messages. We can conclude these works in two-step approach: (i) segregation of high priority messages through natural language processing based filtering and (ii) dissemination of filtered messages over DTN using a Priority-enhanced PRoPHET routing protocol which is developed by adapting the popular PRoPHET routing protocol. It successfully achieves on-the-fly message prioritization and ensures best effort delivery of such prioritized messages to their appropriate destinations (S. Bhattacharjee *et al.*, 2016). To overcome drawback of too high replication it focuses on mechanism to measure contacts between nodes to reduce replication of messages. The value of the popularity vector of

* **Corresponding Author:** Mohammad Ashraful Hoque, Lecturer, Department of Computer Science and Engineering, Southeast University, 251/A and 252 Tejgaon Industrial Area, Dhaka, Bangladesh. Email: *ashraful@seu.ac.bd*

nodes will be used for selecting most appropriate node for message forwarding. High popularity value of a given node will have more probability of successfully delivering the message. This mechanism will reduce replication of messages and hence delivery ratio will be increased and overhead ratio will also decrease significantly (S. Chahal *et al.*, 2017).

In our proposed model for the best effort of message delivery effort it checks 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 will not check the battery power condition. For the battery power checking it follows the power priority table (lower to higher).

II. Literature Study

Liu *et al.* (X. Liu *et al.*, 2014)it takes a similar approach to Epidemic Routing in that, when two nodes come into range of each other, one node can transfer a set of messages to the other via a 3-way handshake sequence. Specifically, when node A discovers node B, it sends a summary vector SVA. In the original Epidemic Routing, SVA contains the IDs of all the messages that A stores in its buffer. In their solution, it is a subset of these messages because there can be many of them after the system has been up running for some time. After receiving SVA, node B replies with SVA − MB, where MB is the set of all messages stored at node B. As such, node B essentially tells A which messages from A would potentially enrich B's collection. Next, node A retrieves messages in SVA−MB from its storage and sends them to node B in a burst to complete the handshake.

Alaoui *et al.* (E. A. A. Alaoui *et al.*, 2015) it presents two models for the data transfer: Custody Transfer models and BLER. 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 focusing on DTN are mainly highlighting the performance analysis of different routing protocols. Finally in this paper we present a model which will help a message to deliver to the destination with the best effort.

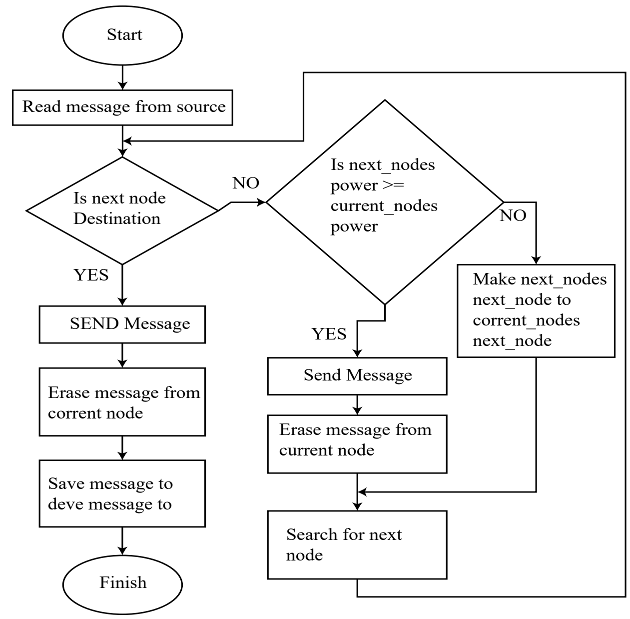

Figure 1:Flowchart of Proposed Model

III. Proposed Model

In any situation all devices asset is its' power. Any devices are basically in 3 stages, e.g. Active, Sleep and Shut down. Active stands for device is in working mode, Sleep stands for device is On but doesn't engaged in any task, and Shut Down stands for device is switched Off. The main goal of this model is to send 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. Flow chart of this proposed model is given in Figure 1.

III.A Power Prioritization Table

For calculating power level it follows a power prioritizing table. The base of this table is how much battery power is consumed for typing and sending each Character of a message.

Table 1: Power Priority Table

Power Priority Rank	Battery Power Level
5	80-99 %
4	58-79 %
3	36-57 %
2	14-35 %
1	4-13 %

Battery Power Priority Rank of the Devices is leveled as 1, 2, 3, 4 and 5 (Lower to Higher) by the remaining battery percentages. Its' initial range from 4% charge because for each Character of a message we assumed 8 KB (required storage); for each Character (8KB) we assumed 0.01% battery power. As our highest value of message is 1MB

So,

1MB = 1024 KB

(1024*0.01)/8 %

= 1.28 %

Firstly, a device receives and then sends,

= 2 * 1.28 %

= 2.56 %

≈ 3 %

For the highest size of message we need at least ≈ 3% battery power, so battery power level starts from 4%.

III.B Proposed Algorithm

Algorithm: Power Priority
Input: Power (pow)
Output: Message + Power (pow)

```
do
pow(node)// pow: Power of Battery
if(Battery Percentage >= 4 &&Battery Percentage <= 13)
        Power Priority Rank = 1
else if(Battery Percentage >= 14 && Battery Percentage<= 35)
Power Priority Rank = 2
else if(Battery Percentage >= 36 && Battery Percentage <= 57)
Power Priority Rank = 3
else if(Battery Percentage >= 58 && Battery Percentage <= 79)
Power Priority Rank = 4
else
        Power Priority Rank = 5
returnPower Priority Rank
while(next_node != destination)
if(pow(next_node) >= pow(current_node))
                send message
                erase from buffer
                current node = next node
else
        next_node(current node)=next_node(next_node)
send message
erase from buffer
save message
```

III.C Sample Messages and Example

In a Post Disaster scenario victim's messages pattern and its required battery power will be as following,

Table 2: Power Priority Table

Sl. No.	Message Type	No. of Character	KB	Battery Power (%)
1	Help	4	32	0.64
2	Help_me	7	56	1.12
3	I'm_alive	9	72	1.44
4	I_need_doctor	13	104	2.08
5	We_need_food	12	96	1.92
6	We_need_oxygen	14	112	2.24
: :	: :	: :	: :	: :

For an example we select a sms as "help_me". In "help_me" have 7 (seven) characters.So,

7*8KB = 56KB   [1 character = 8KB (guessing)]

56*0.01% = 0.56   [for 8 KB power needed 0.01%(guessing)]

0.56%*2 =1.12%   [multiplied by 2because a device-firstly receives then sends]

So, total power needed ≈ 2%

III.D Graphical Representation of Table 2

Graphical representation of required K.B for each messages character size and required battery powers (as %) for required K.B are given below,

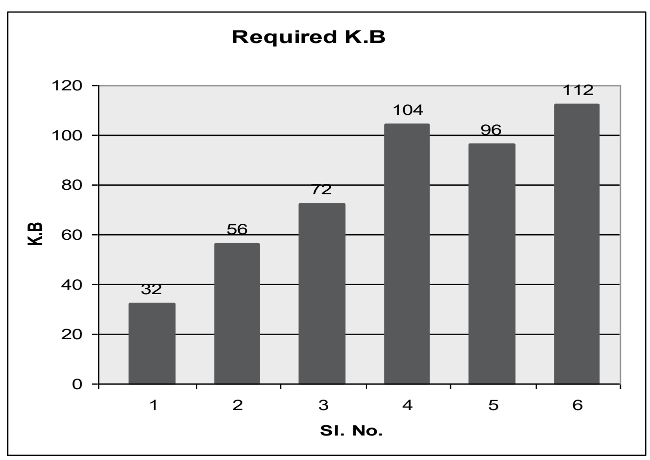

Figure 2: Graphical Representation of table 2 (Sl.Novs. K.B)

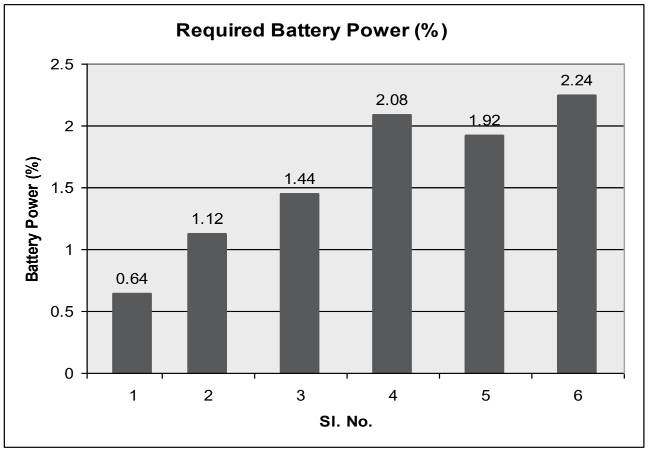

Figure 3: Graphical Representation of table 2 (Sl. No vs. Battery %)

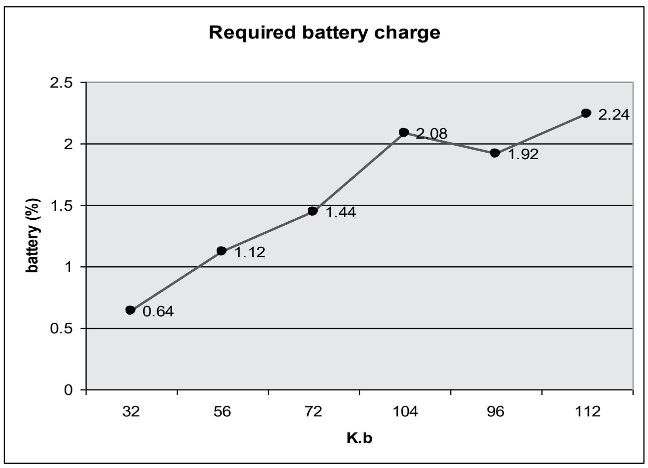

Figure 4: Graphical Representation of table 2 (K.B vs. Battery %)

IV. Simulation Setup

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 (A. Keranen *et al.*, 2009). For simulation purposes the map-based movement model Helsinki City Scenario (HCS) is selected.

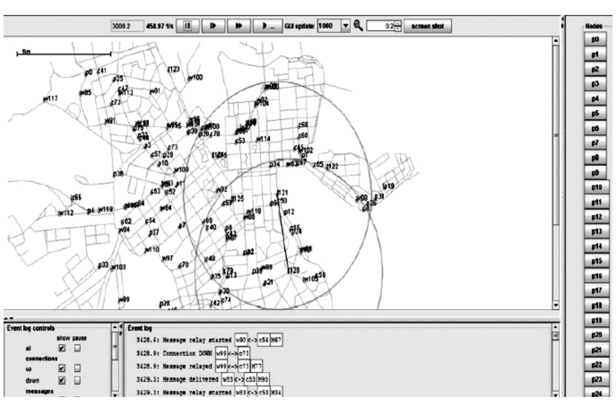

Figure 5: Screenshot of ONE Simulator.

IV.A Simulation Parameters

For this proposed model's performance analysis with other protocols the reference values from Alaoui *et al.* (E. A. A. ALAOUI *et al.*, 2015) for different parameters as given in Table 3.

Table 3: Simulation Parameters Table

Parameters	Value setting
Simulation Time	300 min (5 Hours)
No. of Nodes	125
Buffer size	5Mb
Interface	Bluetooth
Routing Protocols(With Power Priority Model)	Epidemic, Spray and Wait, Prophet, MaxProp
Transmit Speed	2 Mbps
Transmit Range	10 meters
Message TTL	60 min (1 Hour)
Message Size	50 KB to 1 Mb
Character Size	8 KB

IV.B. Simulation 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 ratio:

It is the ratio of the total number of messages delivered to the destination and the total number of messages created at the source node (E. A. A. ALAOUI *et al.*, 2015).

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

Here,

D: Number of messages delivered to the destination.

C: Number of messages created at the source.

ii. Overhead Ratio:

This metric will allow evaluating the effectiveness of the bandwidth and interpreting the number of copies created by a delivered message (it simply reflects the cost of transmission in a network). In other words, the number of replication required performing a successful delivery (E. A. A. ALAOUI *et al.*, 2015).

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

Here,

D: Number of messages delivered to the destination.

R: Number of successful transmission between nodes.

iii. Average Latency:

The average latency is the time that elapses between the creation of a message and its delivery to the destination.

iv. Hop Count:

Number of hops is a metric in DTN assessments which denotes the number of nodes by means of which the message must pass between the source and the destination node, it helps to understand how messages; along a path must pass from the source to the destination (E. A. A. ALAOUI *et al.*, 2015).

V. Result Analysis

From the simulated environment the predicted comparative result for different routing protocols over Power Priority Model is described in the following session.

V.A Delivery Probability

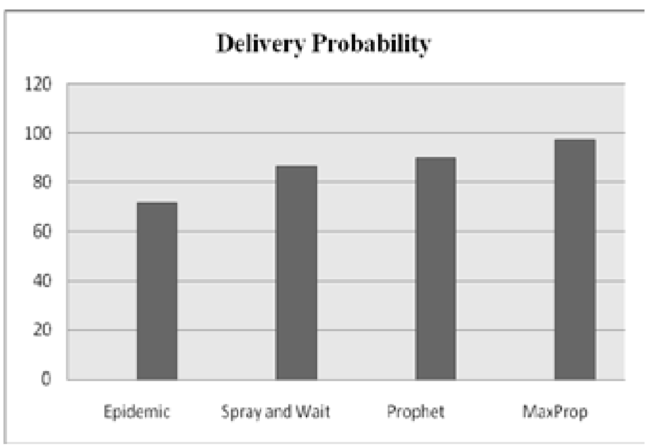

Figure 6: Comparision of Delivery Probability

Fig.6 shows that the massage delivery probability (A. Mehto *et al.*, 2013) of MaxProp with power priority model is higher than all other protocols. Because, delivery probability depends on the message generation and the delivery of that messages correctly. In Spray and Wait with power priority it's lower than Prophet but higher than Epidemic for permissible copies of messages. So MaxProp and Spray and Wait with power priority, they delivers the message to the destination by checking the power level.

V.B. Average Latency

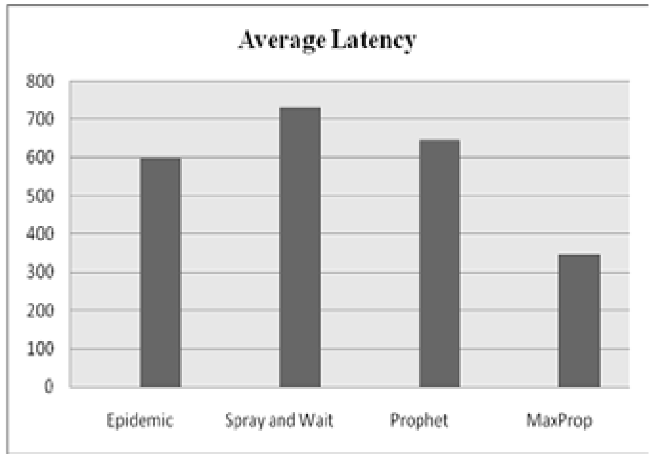

Figure 7: Comparision of Average Latency

Fig.7 shows that the Average Latency (E. A. A. ALAOUI *et al.*, 2015) of MaxProp with power priority is lower than all other. Because Average Latency depends on the average time between the messages generated and accepted by the destination node. MaxProp requires time for calculating and sorting the lowest path cost before delivering the message with the power level calculation. Rather Spray and Wait with power priority is higher than all other because before sending it checks the power level with the spray phase and wait phase mechanism.

V.C. Overhead Ratio

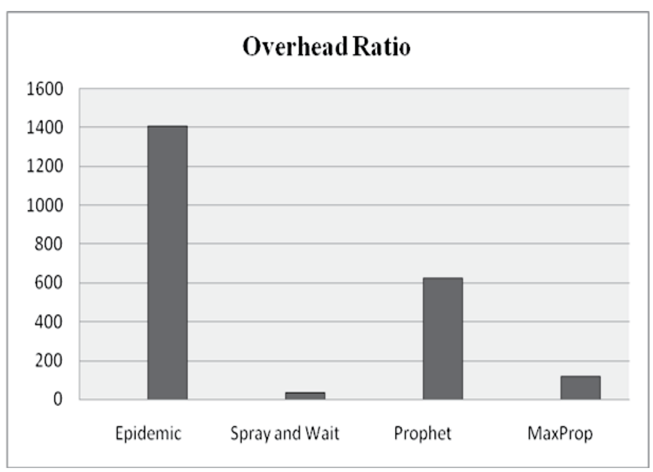

Figure 8: Comparision of Overhead Ratio

Fig.8 shows that the Overhead ratio (A. Mehto *et al.*, 2013) of Spray and Wait with power priority is lower than all other. Rather MaxProp with power priority is lower than epidemic and prophet protocols. Because Overhead ratio depends on the number of the message transmission for each messages. In Spray and Wait with power priority transmission cost is lower because before sending the messages it checks the device power level in each time with its' spray phase and wait phase mechanism.

V.D. Hop Count

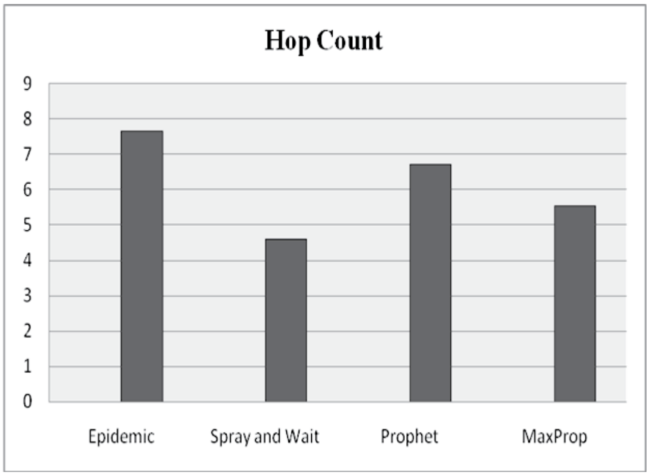

Figure 9: Comparision of Hop Count

Figure 9 shows that the Hop count (E. A. A. Alaoui *et al.*, 2015) of Spray and Wait with power priority is lower than all other protocols. Because Hop count depends on the total number of nodes that message traverse. In Spray and Wait with power priority the numbers of nodes that messages traversed are lower because before sending the messages it checks the power level with the next node except destination node. It doesn't send the message randomly to any node. Rather MaxProp with power priority is lower than Epidemic and Prophet but higher than Spray and Wait. Due to calculate the lowest path cost it requires to visiting the almost every probable node.

VI. Limitations

It (Power Priority Model) works when receiver nodes' power is greater than or equal to sender nodes'. So, there may be a problem arise in a rare case when all the nodes power is same as source nodes' power. On the other hand DTN 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. In spite of these limitations in a post disaster movement when traditional network (TCP/IP) is failed to work beyond all questions only DTN is the light of hope in the wireless communication field.

VII. Conclusion and Future Work

In this paper we have proposed a model which can be integrated with different DTN routing protocols for achieving better performance. DTN routing protocols have different methods to select the delivery performance, paths, transmissions and buffers. This routing looks facing a challenging and rich problem. The developed algorithm focuses on these situations. It has shown that our proposed smart algorithm may provide a significant benefit. Finally, we also believe that in many scenarios communication opportunities may be predictable with this model.

In future, we wish to evaluate this model with other more different parameters by increasing the number of values. We also crave to propose another model which will be included message filtering with power priority at a time for ensuring the best message delivery system over DTN.

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