

# TMHF: Transmit Max Hop First forwarding Strategy to optimize the Performance of Epidemic Routing Protocol

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## ABSTRACT

Delay Tolerant Networks vary from conventional networks in that they have reserve constraints, unbalanced mixture traffic, data redundancy, network dynamics, and energy balance. Moreover due to node mobility DTN suffers from unpredictable connectivity and limited transmission duration. A mobile node in DTN routing may not be able to transmit all messages from its forwarding queue; therefore the order in which messages are transmitted becomes very important.

In this paper, we propose forwarding queuing mechanisms named Transmit Max Hop Count first (TMHF) in which when the connection opportunity arises, the node will transmit the message with max hop count.

## General Terms

Algorithm, Routing, Epidemic router.

## Keywords

Store and forward networks; Forwarding strategies, routing, DTN, Queue modes, maximum hop forward

## 1. INTRODUCTION

In conventional routing schemes TCP/IP it is necessary to launch end-to-end path from source to destination previous to the transmission of data. Hence most of wireless applications such as sensor networks for ecological monitoring [16], ocean sensor networks [18], [17], biological sensor networks [7], [11] and vehicular networks [19], [20] due to highly unstable path which may change or break while being discovered.

Delay tolerant networks (DTNs) permit the transmission of data by means of intermittently connected mobile nodes. DTN as [9],[4],[10],[6] put forward as work by via store-carry-forward paradigm, where every node acts as a hop in the network and store the message in buffer, carries the message while moving and forward when it encounter with another node.

Foundation on the scheme of message forwarding, routing plan for DTN can be separated in to two main categories, single copy and multi copy [12]. Here single copy routing schemes only one copy of message exists in the network, which is forwarded along single path [5] for example first contact [5], direct delivery [5]. While in multi copy schemes more than one copy of same message are forwarded to multiple paths for example Epidemic router[8], spray & wait[14], prophet[3], MaxProp [20], probabilistic forwarding[3]. Multi copy routing cases

according to [13] have high influence on message delivery probability and robustness at the price of extra bandwidth, energy and memory usage such as epidemic, spray & wait.

Extensive delays, restricted bandwidth and limited duration of contact time, a node in epidemic router [8] can not be able to exchange all messages from its forwarding queue. Therefore the sequence in which the messages are transmitted becomes very vital. Additional by apply efficient buffer management policies and forwarding strategies we can optimized the performance of routing protocols. A small number of recently work [1], [21],[2], [24], [23], [22]and [15] have proposed few forwarding and buffer management strategies.

In this paper we have propose the forwarding strategy TMHF with existing forwarding queue FIFO to obtain the quality of service optimization in the performance of DTN routing in terms of delivery probability, overhead ratio and Hop count average.

The remaining paper is prearranged as follows. Section 2 elaborates existing forwarding strategies. Section 3 is about protocol under observation, Section 4 is performance metrics, Section 5, 6 are regarding approach and Algorithms. Simulation and results simulates in section 7 by a conclusion at section 8.

## 2. EXISTING FORWARDING STRATEGIES

### 2.1 First in First out (FIFO)

In FIFO queue mode all messages are arranged according to arrival time and the message which has oldest arrival time will be transmitted first.

### 2.2 Random Queue Mode (RND)

The message is randomly selected for the transmission.

### 2.3 GRTR

“Assume A, B are nodes that meet while the destination is D,  $P_{(X, Y)}$  denote the delivery predictability that a node X has for Destination Y. GRTR forward the message to node only if  $P_{(B, D)} > P_{(A, D)}$ ” [1].

### 2.4 GRTRSort

“GRTRSort looks at difference  $P_{(B, D)} - P_{(A, D)}$  values for each message between the nodes and forward the message only if  $P_{(B, D)} > P_{(A, D)}$ .” [1]

### 2.5 GRTRMax

“Select messages in descending order of  $P_{(B-D)}$  forward the message only if  $P_{(B-D)} > P_{(A-D)}$ .” [1]

### 2.6 TSMF

In TSMF the forwarding queue the message with small size is placed on top of queue [2].

## 3. PROTOCOL UNDER EVALUATION

### 3.1 Epidemic router

In epidemic routing[8] application messages are swamped to the relay nodes called carriers, when carrier nodes while moving comes in contact with another related proton of network, it diffuse the message to further island of nodes. This cyclic forwarding increases the probability of message delivery to its destination.

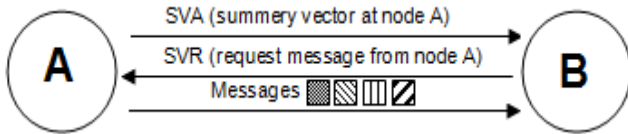


Fig 1 Epidemic Router

Fig 01 illustrates the flow of epidemic router, when Node A, B comes in the transmission range, node A exchanges its summary vector with node B. A summary vector is maintained locally on each node and it represents the buffered messages. After exchange of summary vector Node B by performing a logical AND operation between the negations of its summary vector and filter out messages not buffered at B (SVR). Node B transmits a request summary vector SVR to A. The process prolong as when node B comes in contact with other node as a result increase the delivery probability on the cost of buffer space and transmission time.

## 4. PERFORMANCE METRICS

### 4.1 Delivery probability

It is the ratio of message received over message send. High probability means that more messages are delivered to the destination.

### 4.2 Overhead-ratio

It is the negation of number of messages relayed to number of message delivered. Low value of overhead means less processing required delivering the relayed messages. Objective of algorithm is to minimize the value of overhead.

### 4.3 Hop count average

It is the Mean hops which a message takes to reach its destination.

Table 1. Snapshot of node messages

Node	Message_id	HC	Arrival Time	Destination
A	M4	10	15	B
	M2	8	20	B

	M1	3	4	C
	M51	5	3	D
B	M3	9	45	A
	M5	3	32	D
	M43	5	34	C
C	M18	4	12	D
	M76	7	43	C
	M32	8	76	D

## 5. APPROACH

Assume A, B are two intermittently connected mobile node, M A represents the message buffered at node A where  $MA = \{M4, M2, M1, M51\}$  and Arrival Time  $ATA = \{15, 20, 4, 3\}$ , MB represents the messages buffered at node B where  $MB = \{M3, M5, M43\}$  and Arrival time of messages at B is  $ATB = \{45, 32, 32\}$  while MC represents message buffered at node C. Further destination of buffered messages MA (M2, M4) is B, MA (M1, M51) is (C, D). Similarly the destination of messages stored at MB (M3, M5, and M43) is (A, D, C). We further assume each message transmission time is 1s while total DTN transmission time is 2s.

### CASE 01: Forwarding sequence with FIFO queue mode

Fig 02 depicts the exchange of messages using FIFO under epidemic routing protocol. Fig 02(a) represents the array of messages at node A before the transmission.

From Fig 02(b) we can examine that with available DTN transmission time message M3 and M1 will be forwarded to node B while the destination of messages (M3, M1) is (C, D).

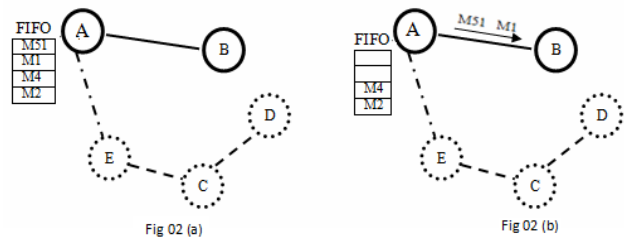


Fig 02 Message Transmission A-B using FIFO

Fig 03(a) demonstrates the string of messages at node B by FIFO forwarding strategy. We can spot in Fig 03(b) that the M5 and M43 will be forwarded to node A; moreover the destination of (M5, M43) is (D, C).

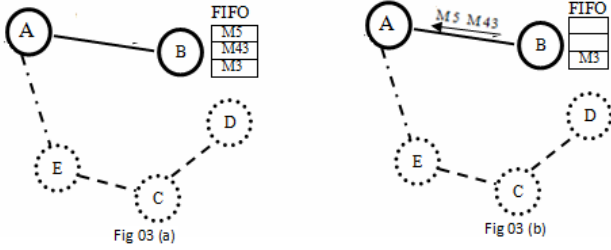


Fig 03 Message Transmission B-A using FIFO

Table 2. FIFO after Transmission

Node	Messages	Destination
A --- B	M51,M1	C,D
B----A	M5,M43	D,C

Table 2 illustrates the result after the transmission involving A and B. After the messages were flooded from A to B (M51, M1) and from B to A (M5, M43), none of them found the destination.

**CASE 02: forwarding sequence with TMHF queue mode**

Fig 04(a) depicts the organization of messages at node A by TMHF previous to the transmission. Accordingly message M4; M2 will be forward to node B while the destination of (M4, M2) is B which results in raise of delivery ratio Fig-4.0 (b).

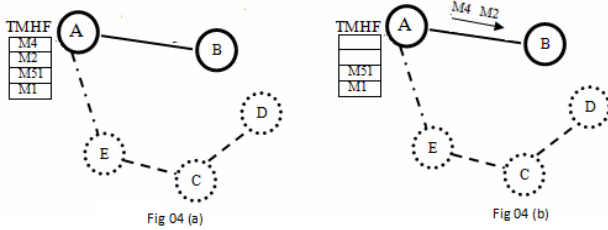


Fig 04 Message transmission A-B using TMHF

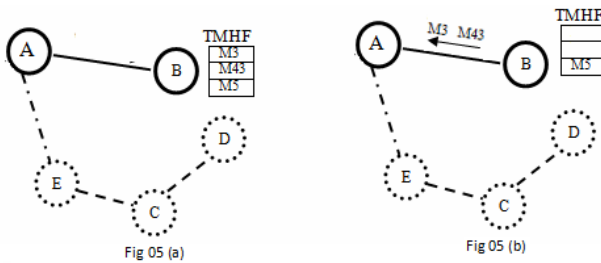


Fig 05 Message Transmission B-A TMHF

Fig 05(a) symbolizes the sequence of messages at node B using TMHF. From fig 05(b) we can see that M3, M43 will be transmitted to node A. While the destination of messages {(M3, M43)} are (A, D).

Table 3. TMHF after Transmission

Node	Messages	Destination
A --- B	M4,M2	B
B----A	M3,M43	A,D

Table 3 represents the result after the transmission of messages by THMF. We can distinguish that M4, M2 were forwarded from A to B. The destination of both messages (TABLE 01) is B. Correspondingly when message replicate from B to A, M3 was delivered.

**6. Algorithm**

Step 01

Get messages from the router in List.

Step 02

Order the messages by placing max hop to top of List.  
OrderMessage (List)

Step 03

Transmit messages.

**7. SIMULATION AND RESULTS**

**7.1 By Varying Time Intervals**

Table 4. Simulation parameters w.r.t Time

Number of Nodes	120
Movement model 1	Random Waypoint
Router	Epidemic
Number of groups	03
Buffer size	2MB
Transmission range	10M
Transmission speed	250 K
Message creation	30-40 (seconds)
Simulations times	80k-560k
Area	4500m x 3400m
TTL	Infinity

In the following section we study the performance of TMHF under epidemic routing protocols, with exiting FIFO.

All the experiments were evaluated by ONE Simulator. The ONE Simulator is a discrete event simulator written in Java. The major aim of simulator is to relate DTN (store-carry-forward) of message for long time, where the probability of disconnections is high.

The Fig 06 depicts the comparison of FIFO and TMHF forwarding policy with respect to delivery probability. We can observe that by increasing simulation time the delivery probability of TMHF perform well then FIFO.

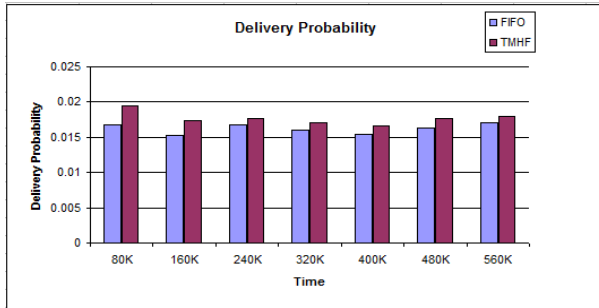


Fig 06 Delivery Probability w.r.t Time

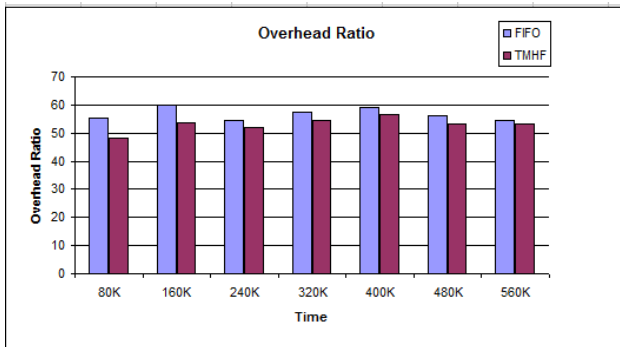


Fig 07 Overhead ratio w.r.t Time

Fig 07 simulates the effect of overhead ratio of FIFO and TMHF by varying the time interval from 80K-160K under epidemic router. Overhead metric can be used to calculate the consumption of resources, operational instructions during the message transmission.

The objective of algorithm must be to minimize the Overhead. We can see that overhead of proposed TMHF is lower then the FIFO.

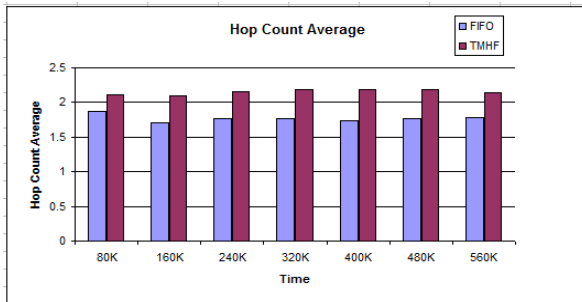


Fig 08 Hop count average w.r.t Time

In fig 08 we find the effect of hop count for FIFO and proposed TMHF under epidemic router. It can see clearly that at various time intervals the hop-count average of TMHF is higher then FIFO. High value of hop count reflects the fact that message is moving around the network work for long time. This reason of keeping message alive is that transmitting the message with greater hop already consumes the network resource; by forwarding such message (TMHF) may have the higher probability of it delivery as proved by fig.

## 7.2 By Varying Area (Sparse)

Table 5. Simulation parameters w.r.t Area

Number of Nodes	120
Movement model 1	Random Waypoint
Router	Epidemic
Number of groups	03
Buffer size	2MB
Transmission range	10M
Transmission speed	250 K
Message creation	30-40 (seconds)
Simulations times	200k
Area	4500m x 3400m -- 8500m x 7400m
TTL	Infinity

In the Second scenario we compare the results of FIFO and TMHF by varying the simulation area from 4500 x 3400 to 8500 x 7400 with the increment of 1000 m.

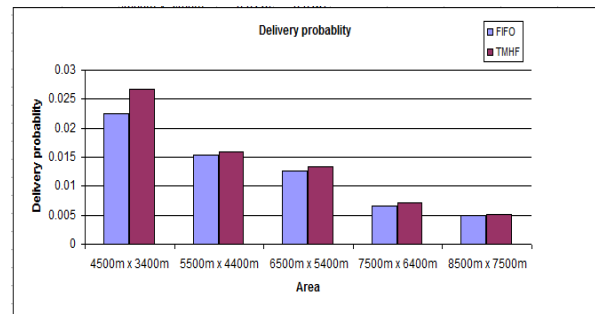


Fig 09 Delivery probability w.r.t Simulation area

From fig 9 shows the comparison of FIFO and TMHF queue modes in terms of delivery probability. We can analyze the results of TMHF proves better delivery probability as the area of simulation wider in terms of meters and nodes goes sparse with the PWP mobility models.

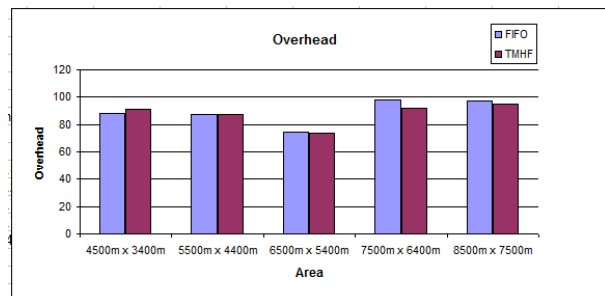


Fig 10 Overhead w.r.t Simulation area

Fig 10 measure the overhead of FIFO and TMHF strategies. We can study that overhead gradually goes down by increasing the simulation area.

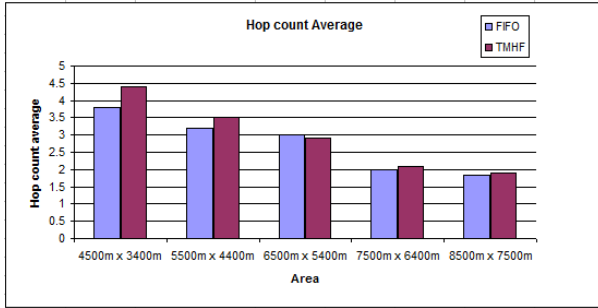


Fig 11 Hop count Average w.r.t Simulation area

Fig 11 demonstrates the impact of simulation area on hop count. As expected that the hop count in proposed TMHF is higher than FIFO.

### 7.3 By Varying Transmission range

Table 5. Simulation Time by varying time interval

Number of Nodes	120
Movement model 1	Random Waypoint
Router	Epidemic
Number of groups	03
Buffer size	2MB
Transmission range	10M -- 120M
Transmission speed	250 K
Message creation interval	30-40 (seconds)
Simulations times varies	160k

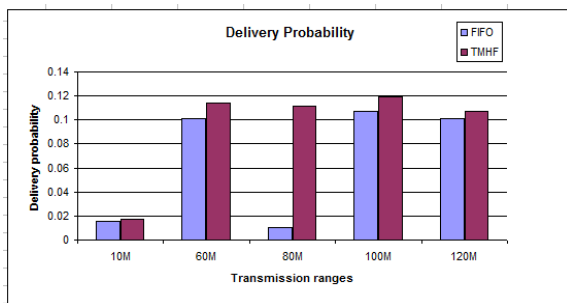


Fig 12 Delivery probability w.r.t Transmission range

Fig 12 determines the statistics of THMF and FIFO in terms of delivery probability. We can see that by increasing the transmission range THMF proves better delivery probability than FIFO. As the transmission range increases the nodes frequently encounters each other, hence by forwarding greater hop message prove high delivery probability.

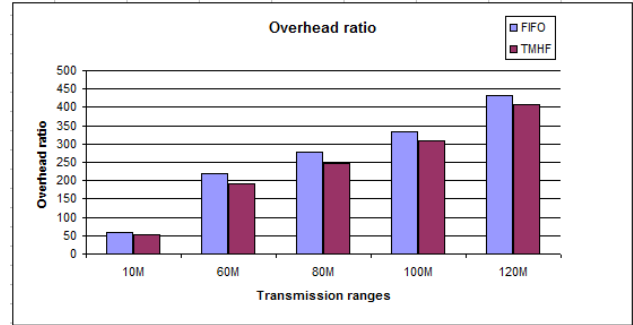


Fig 13 Overhead w.r.t Transmission range

In fig 13 we manipulate the results of overhead with FIFO and proposed TMHF strategies. Fig 13 we can see that at all transmission ranges the overhead of THMF is lower.

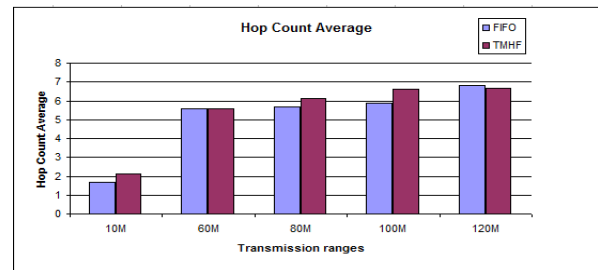


Fig 14 hop count Average w.r.t Transmission range

Fig 14 shows that TMHF have greater value of Hop count as compared to FIFO.

## 8. CONCLUSION

In this paper, we propose a forwarding strategy called as TMHF that optimizes the DTN epidemic routing protocol. The proposed policy reduce overhead and raise the delivery probability as compared to FIFO. The aim was to effectively utilize the network resources by giving priority to messages having higher value of hop count.

In order to check the accuracy of TMHF several experiments were performed at various time intervals by varying node transmission range and simulation area.

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