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$M_{in}H_{op}$ (MH) Transmission strategy to optimized performance of epidemic routing protocol

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GJCST Classification: C.2.2, C.2.1

MIN HOP MH TRANSMISSION STRATEGY TO OPTIMIZED PERFORMANCE OF EPIDEMIC ROUTING PROTOCOL

Strictly as per the compliance and regulations of:

$M_{in}H_{op}$ (MH) Transmission strategy to optimized performance of epidemic routing protocol

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Abstract- Delay tolerant network aims to provide the network architecture in environments where end-to-end path may never exist for long duration of time. Furthermore, dynamic topology changes, limited buffer space and non stable connectivity make routing a challenging issue. The research contribution regarding DTN routing protocols can be categorized in to single and multi copy strategies. A single copy strategy makes less use of network resources but suffers from long delay and less delivery probability. Multi copy schemes enjoy better delivery probability and minimum delivery delay at the cost of heavy use of network resource. Moreover, DTN nodes operate under short contact duration and limited transmission bandwidth. Therefore, it is not possible for a node to transmit all messages from its forwarding queue. Hence the order at which the messages are forwarded becomes very vital. In this paper we propose a forwarding queue mode named MinHop. We prove through simulations that the proposed policy performs better then FIFO in terms of delivery probability, overhead, message drop and relay.

Keywords- Store and carry networks, Forwarding strategies, routing, DTN, Minimum hop transmission.

I. Introduction

Delay-tolerant networks (DTNs) provide a unique feature of establishing network infrastructure through intermittently connected mobile nodes. This technology [6] have been massively employed in areas like military network[1],wildlife tracking[2], underwater [3][5] and ocean sensor networks[4] where end-to-end path is not stable due to dynamic topology changes, network partitioned, node mobility and long delays.

DTN routing protocol follows three phase store-carry-forward strategy by which a node store arriving message in its buffer, carries the message while moving around and forward it when comes under the transmission range of other node. Moreover low band width, buffer space and limited contact time make routing most challenging part of this rebellion technology.

Depending on resource consumption, routing for DTN can be divided in to two classes. First class of routing minimizes the resource expenditure by controlling the replication of message like single copy [7], first contact [7], and direct delivery [7]. Furthermore, these strategies produce long delay and less delivery probability. The second class of router forwards the multiple copies of each message across network like Epidemic routing [9], Prioritized epidemic [13,]Spray&wait [11], Prophet [8], MaxProp [10], Probabilistic forwarding [12]. Multi copy algorithms results in less delay while elevates the delivery probability.

Despite the effort on improvising the new routing protocols for DTN environment, one area which has not been deeply investigated is the use of message forwarding strategies.

Since moving nodes set up end-to-end contact for very short time, therefore it is not possible for a node to transmit all buffered messages from its forwarding queue to encounter node. Hence the order at which the messages are forward can provide a significant optimization.

Previous work [19, 12, 21], and [29] addressed the forwarding strategies to optimize DTN protocols for resource constraint environments. In addition the combination of forwarding and drop polices [14, 15, 16, 17, 18, 20, 22, 23, and 24] provide better results and gives a motivation towards further investigation in this dilemma.

In this paper we proposed a forwarding strategy named $M_{in}H_{op}$ which utilize the local knowledge of router and transmit the message with minimum value of hop count. Simulation results have proved that the proposed policy performs better then FIFO in terms of message relayed message drop, delivery probability and overhead ratio.

Rest of paper have been organized as follows, Section II present existing forwarded polices, Section III router under observation, performance metrics are in Section IV, Section V depicts approach and $M_{in}H_{op}$ algorithm in section VI .while section VII is about simulation setup and results with conclusion in section VIII.

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II. Existing Forwarding Strategies

a) *First in First out (FIFO)*

In FIFO queue mode all messages are arranged according to in coming arrival time. When forwarding opportunity arises the oldest messages will be transmitted first.

b) *Random Queue Mode (RND)*

The message is arbitrarily selected for the transmission. Here all the messages have equal likely turn to transmit.

c) *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 $P_{(B\text{-}D)} > P_{(A\text{-}D)}$" [12].

d) *GRTRSort*

"GRTRSort looks at difference $P_{(B\text{-}D)} - P_{(A\text{-}D)}$ values for each message between the nodes and forward the message only if $P_{(B\text{-}D)} > P_{(A\text{-}D)}$." [12]

e) *GRTRMax*

"Select messages in descending order of $P_{(B\text{-}D)}$ forward the message only if $P_{(B\text{-}D)} > P_{(A\text{-}D)}$." [12]

f) *Transmit Smallest message first (TSMF)*

According to TSMF forwarding strategy the message with small sizes are placed on top of forwarding queue [21].

g) *ARER*

ARER [25] is the forwarded policy which assigned forwarded probability with a metric Replications Density intended for all message in its queue. Moreover, ARER assembles the forwarding chain and the dropping priority based on their allocate weight. The weight is examined by the Replication Density, the delivery predictability, and TTL.

h) *Lifetime DESC (Descending Order)*

Lifetime DESC [26] scheduling policy orders messages based on time-to-live (TTL). Messages with longer TTLs will be scheduled to be sent first.

i) *BUBBLE*

Bubble [27] a novel social-based forwarding algorithm which exploit two social and structural metrics, namely centrality and community, using real human mobility traces.

j) *Transmit Max Hop Count First (TMHF)*

In THMF the forwarding queue sent the message with maximum hop count [29].

III. Epidemic Routing Under Observation

Epidemic routing inspired by [9] replicate the messages across all intermittently connected mobile nodes called carriers. The carrier nodes then become responsible and diffuse the message to further island of nodes.

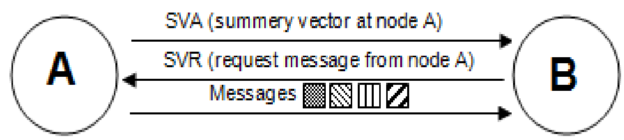

Fig.1 Epidemic routing protocol

Fig 1 depicts the working of epidemic router. When A and B comes in the transmission range of each other, A forwards its summery vector (SV_A) to B. Summery vector is the representation of messages buffered on each node. Node B sends SV_R which is the representation of messages not buffered at B. Finally A sends the message requested in SV_R. Epidemic router proves better delivery probability at the cost excessive network resources.

IV. Performance Metrics

a) *Relayed*

Relay is the hop-by-hop transmission of message. Minimum relay reduce the consumption of network resources. Objective of algorithm is to minimize the relay of messages.

b) *Drop Ratio*

Drop ratio is a measure to count the numbers of messages dropped by a node due to congestion. The objective of algorithm is to minimize the drop ratio.

c) *Delivery Probability*

The ration of message received over message send. Higher value of delivery probability indicates that huge number of messages delivered. The objective is to maximize the delivery probability.

d) *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.

V. Proposed Forwarding Mechanisim

Epidemic routing protocol replicate the each messages across all intermittently connect mobile nodes. This random transmission quickly propagates the message towards destination. However due to short end-to-end connectivity and limited transmission bandwidth the order of message transmission can influence the performance of router. In this section we will provide the theoretical understanding about existing (FIFO forwarding) and proposed (MinHop forwarding) policy. We only consider delivery probability.

$SV_A = \sum_{i=1}^{n} MA_i$ (node A)

Mid	AT	Destination	Hop	TT
M1	20s	D	10	2s
M2	30s	F	8	1
M3	45s	B	4	1
M4	50s	B	1	1

$SV_B = \sum_{i=5}^{n} MB_i$ (node B)

Mid	AT	Destination	Hop	TT
M5	20s	D	10	2s
M6	30s	F	8	1
M8	45s	A	4	1
M9	50s	A	1	1

Fig.2 FIFO order at node A and B

Case 1: Epidemic with FIFO forwarding order

Let A, B are two intermittently connected mobile nodes. Fig.2 represents the messages buffered at each node. Further AT represents Arrival time, TT is transmission time, λ is meeting rate and λ=1/E [U] where E [U] is average meeting time.

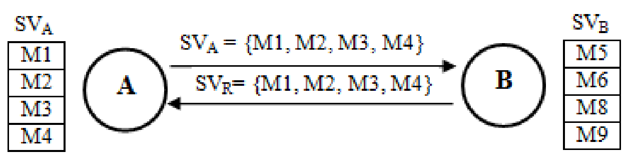

Fig.3 Exchange of summery vectors

Fig 3 depicts the exchange of summery vectors under epidemic routing protocol. For clear understanding we use message id as an alternative to index.

After receiving SV_A node B performs the subtraction with SV_B and transmit SV_R to node A which represents the set messages not buffered at B.

$$SV_{R\,(B\text{-}A)} = \sum_{i=5}^{n} MB_i - \sum_{i=1}^{n} MA_i$$

Fig.4 Summery vector request (SV_R)

Fig 5 represents the transmission of messages from A to B upon receiving (summery vector request) SV_R. The available E [U] transmission time is 3s hence by FIFO forwarding order M1, M2 with destinations D, F will be forwarded to B.

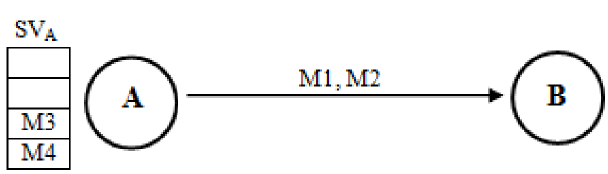

Fig.5 FIFO order at node A and B

SortFIFO ($SV_{R\,(B\text{-}A)}$) = SortFIFO ($SV_B \cap SV_{A)}$ = {M1, M2, M3, M4}

Case 2: Epidemic with $M_{in}H_{op}$ forwarding order

$SV_A = \sum_{i=1}^{n} MA_i$ (node A)

Mid	AT	Destination	Hop	TT
M4	50s	B	1	2s
M3	45s	B	4	1
M2	20s	D	8	1
M1	30s	F	10	1

$SV_B = \sum_{i=5}^{n} MB_i$ (node B)

Mid	AT	Destination	Hop	TT
M9	50s	A	1	2s
M8	45s	A	4	1
M6	30s	F	8	1
M5	20s	D	10	1

Fig.6 MinHop order at node A and B

Sort $M_{in}H_{op}$ ($SV_{R\,(B\text{-}A)}$) = Sort $M_{in}H_{op}$ ($SV_B \cap SV_{A)}$ = {M4, M3, M2, M1}

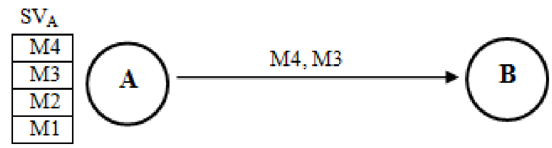

Fig.7 Transmission of messages $M_{in}H_{op}$

From Fig 7 we can see that with available transmission time E [U] M4, M3 with destination B will be forwarded to node B. Hence it increases the delivery probability.

VI. Proposed Algrothem

Step 01:
if (current router not linked with nodes) then
return no message transmission
Step 02:
If (router number of messages are zero) then
return no message transmission
Step 03:
else
Messages = SORT(messages with hop count value)
TrasnimteMessages (Messages)

VII. Simulation and Results

We use opportunistic network environment [ONE] Simulator [28] to check the performance of existing (FIFO) and proposed ($M_{in}H_{op}$). This simulator provides store-carry-forward implementation of DTN routing protocols. It supports various mobility models and customized heterogeneous grouping of nodes facilitates to carry out the experiments in a more practical environment.

We configure epidemic router with random way point movement model on the Helsinki city map of 4500 x 3400m area. The simulation end length was equivalent to 240000s. Messages are created for random source and destinations by varying size between 500K-1MB, with the inter message creation interval [30s, 40s]. Furthermore Bluetooth bandwidth 2Mbps has been uniformly distributed across all nodes with 10m of transmission range. We use FIFO existing forwarding strategy with our $M_{in}H_{op}$ and perform

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experiments by varying the number of nodes from 120 to 360 by an increment of 60 nodes per simulation. We use two homogeneous (pedestrians) and one heterogeneous (car) group with buffer size 2MB and infinite TTL.

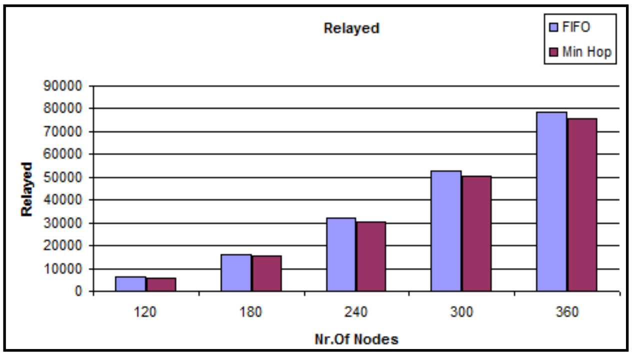

Fig.8 Relayed w.r.t Nr of nodes

Fig 8 depicts the result of epidemic routing protocol in terms of message relay by varying number of nodes per simulation. Since the default behavior of epidemic router is to replicate the message on all encounter nodes which results in high number of transmissions for each message. These redundant transmissions raise router overhead while waste resources like bandwidth, buffer and processing power. Thus minimizing transmissions eventually reduces resource consumption. We can see that the proposed MinHop gradually minimizes the message relays.

$$\text{Relayed improvement} = \left[\frac{\text{FIFO Relayed} - \text{MinHop Relayed}}{\text{FIFORelayed}}\right] \times 100 \quad (1)$$

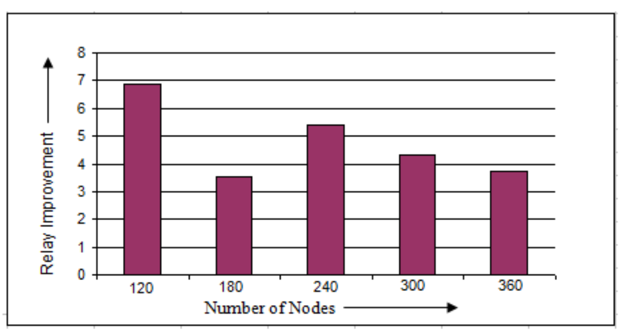

Fig.9 Relayed improvement

From Equation 1 we plot a graph to show relayed improvement of $M_{in}H_{op}$. We can examine in Fig 6 that the proposed policy considerably minimizes transmission of message at 6.8%, 3.5%, 5.4%, 4.3% and 3.7% for 120,180,240, 300 and 360 nodes correspondingly.

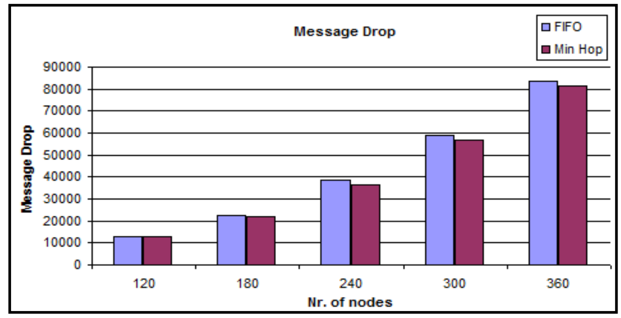

Fig.10 Message Drop w.r.t Nr of nodes

Fig 10 plots the comparisons between existing FIFO and proposed $M_{in}H_{op}$ forwarding policies in terms of message with respect to number of nodes. As DTN is resource constraint network [30] with limited buffer space. Therefore a node must drop a message when its buffer runs out of capacity. Several solutions [20] [22] [23] [24] prove that minimizing message drop can affect the router performance. Moreover dropping a message also squanders all resources consumed by the message during it's strive to destination. On the other hand this drop indirectly gives high opportunity for message relays. Therefore minimizing message drop is considered as positive direction towards improvement. From Fig 04 we can observe that the proposed message forwarding ($M_{in}H_{op}$) limits the message drop as compared to FIFO.

$$\text{Message Drop Improvement} = \left[\frac{\text{FIFO Message Drop} - \text{MinHop Message Drop}}{\text{FIFOMessageDrop}}\right] \times 100 \quad (2)$$

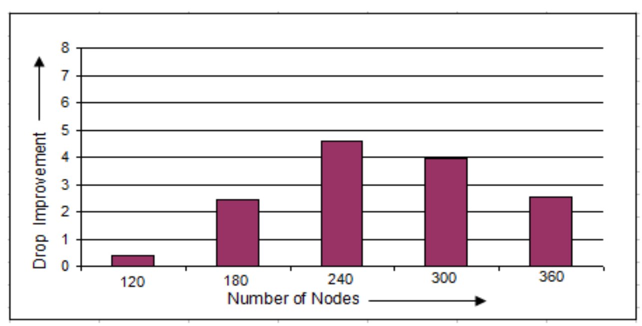

Fig.11 Drop improvement

From Fig 11 we present the effect of $M_{in}H_{op}$ on reducing the message drop by using equation 2. The proposed policy reduces the message drop at 0.3%, 2.4%, 4.6%, 3.9% and 2.5% for 120,180,240, 300 and 360 nodes respectively.

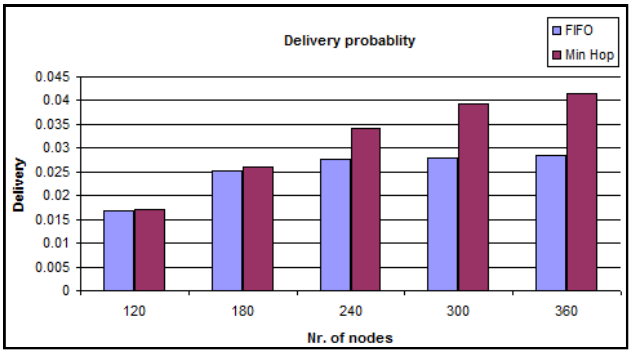

Fig.12 Delivery w.r.t Nr of nodes

Fig 12 compares the delivery probability of $M_{in}H_{op}$ forwarding strategy with FIFO by increasing number of nodes. Delivery probability always is considered the most essential measure in DTN routing. Moreover high value of delivery confirms effective utilization of network resources such as bandwidth, buffer space and processing power. We can easily observe that at each simulation instance proposed policy $M_{in}H_{op}$ shows betters results as compared to FIFO.

$$\text{Delivery Improvement} = \left[\frac{\text{Min Hop Delivery Probability} - \text{FIFO Delivery Probability}}{\text{Min Hop Delivery Probability}}\right] \text{x } 100 \quad (3)$$

Fig 13 clearly shows the improvement in the delivery probability by computing the results from equation 3. The proposed policy raises delivery probability at 1.7%, 2.7%, 19%, 29% and 31% with respect to varying number of nodes.

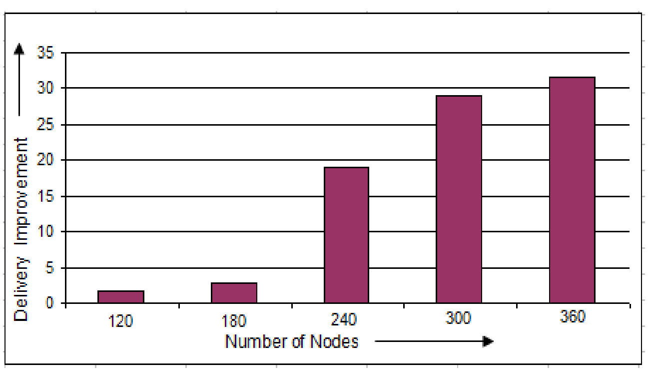

Fig.13 Delivery Improvement

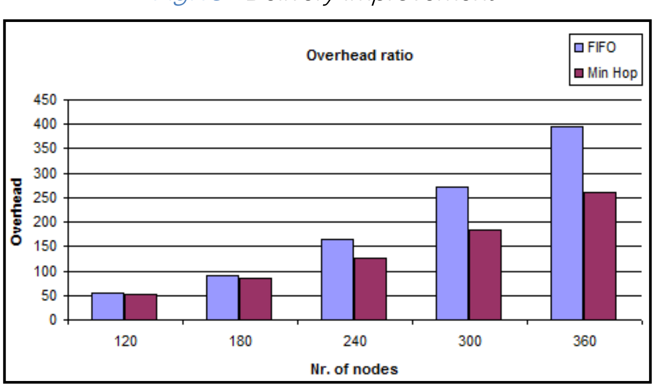

Fig.14 Overhead w.r.t Nr. of nodes

Fig 14 examines the significance of proposed $M_{in}H_{op}$ Forwarding as compared to FIFO in terms of reducing the overhead. Overhead gives the estimated value to measure consumption of processing power and other network resource. Therefore minimum overhead proves effective use of network resources. From Fig 14 we can see that proposed $M_{in}H_{op}$ reduces the overhead as compare to FIFO.

$$\text{Overhead Improvement} = \left[\frac{\text{FIFO Overhead Ratio} - \text{Min Hop Overhead Ratio}}{\text{FIFO Overhead Ratio}}\right] \text{x } 100 \quad (4)$$

Fig 15 provides a boarder view in reducing the overhead. The proposed policy $M_{in}H_{op}$ minimizes the overhead at 2.38%, 6.3%, 23%, 32% and 34% for all node configurations.

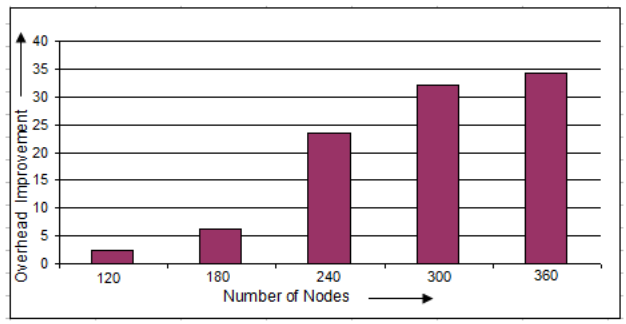

Fig.15 Overhead improvement

VIII. Conclusion

In this paper, we have investigated the problem of efficient message forwarding mechanism in Disruption Tolerant Networks. We proposed a local knowledge based forwarding scheme $M_{in}H_{op}$ for Epidemic Routing. The algorithm solves shortcomings of epidemic router under limited buffer and bandwidth. Simulation results have shown that $M_{in}H_{op}$ optimized Epidemic routing in term of improved relayed, overhead, message drop and delivery by a significant margin.

The future work is to combine the existing forwarding strategies with new one and explore the different routing algorithms performances under spare and congestion DTN environments.

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