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The optimization of Spray and Wait routing Protocol by prioritizing the message forwarding order

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ABSTRACT: In most of the wireless applications, e.g. military networks, vehicular ad-hoc networks, wild life tracking and sensor network, it is impossible to sustain a complete end-to-end data transmission path from source to destination. Thus, the traditional routing strategies (TCP/IP) cannot work with such environments as they need to establish the uninterrupted path before transmission. The disruption-tolerant network (DTNs) has emerged as technology that enables the communication in highly disrupted environments by intermittently connected mobile nodes. The DTN transmission model follows a store carry and forward mechanism wherein the nodes stores the incoming message , carries it while moving and forward when comes in the transmission range of other contacts. The DTN protocol can be divided as single copy and multi copy. In single copy protocol the node is allowed to generate the unique copy of message and forward it on a unique path. The multi copy protocols generate and transmit the multiple copies of each message and forward it along various paths.
In DTN environment, the communication opportunity exists for short duration and a node cannot transmit all copies of its carried message from its forwarding queue. Hence the order at which the messages are forwarded becomes very important. In this paper, we have proposed a message forwarding order for multi copy Spary&wait routing protocol called as smallest message first. Through simulations, we proved that proposed policy out perform as compared to existing FIFO in context of delivery probability, overhead, latency average and buffer time average.

KEYWORDS: DTN, store-carry-forward, Routing, Buffer management, forwarding order, multi copy protocols, FIFO.

1 INTRODUCTION

In conventional routing schemes Ad Hoc [1] 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 [2], sensor networks biological sensor networks and vehicular networks[3] due to highly unstable path which may change or break while being discovered.

Delay tolerant networks [4] permit the transmission of data by means of intermittently connected mobile nodes. DTN has put forward a store-carry-forward paradigm, where every node acts as a hop in the network and store the incoming message in its buffer, carries the message while moving and forward when it encounter with other nodes.

Foundation on the scheme of message forwarding, routing plan for DTN can be separated in to two main categories, single copy[5] and multi copy[6]. Hence, single copy routing schemes only one copy of message exists in the network, which is forwarded along single path. While in multi copy schemes more than one copy of same message are forwarded to multiple paths. Multi copy routing cases according to have high influence on message delivery probability and robustness at the price of extra bandwidth, energy and memory usage such as epidemic, spray & wait. Some recent work has focused on controlling the resource consumption via efficient buffer scheduling [10-11] and message forwarding polices [12-13].

With extensive delays, restricted bandwidth and limited duration of contact time, a node in DTN multi copy routing cannot exchange all messages from its forwarding queue. Therefore the sequence in which the messages are transmitted becomes very vital [7].

In this paper we studied the impact of packet forwarding order with spray&wait [8] routing protocols and optimize its performance by introducing a new message forwarding scheme (smallest message transmit) SMT as compared to FIFO.

2 Existing Queuing Management Policies

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)" [7].

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(BD)> P(A-D)."

2.1 GRTRMax

"Select messages in descending order of P (B-D) forward the message only if P (B-D)> P (A-D)."

3 Spary&wait

Spary&wait routing algorithm work in two phases In phase one, for each message M, N numbers of copies are sprayed/forwarded by source node over network. If the destination is not found in spraying phase, each node carrying the N copy of message and perform direct transmission.

Spary&wait routing inherit the speed of Epidemic routing and simplicity of direct transmission. It initially spread N number of copies in the network just as epidemic routing, when N numbers of copies are forwarded with high probability that at least one of copy will be delivered to destination, it stop and let each node perform direct transmission.

In binary Spary&wait if node A having N>1 copies encounter with node b with no copies, transmit B->N/2 and hold N/2 by itself, when it left with one copy it performs direct transmission.

The existing message forwarding strategy for Spary&wait is First In First Out (FIFO). In the next section we discuss the metrics which will be used to examine the performance of first in first out (FIFO) with proposed Smallest Message Transmit (SMT).

4 Approach

Table 1. Symbol and description

Symbol	Description
M	Messages
SM	Size of Message
NM	Number of Copies of Message M
AT	Arrival Time
TTM	Total Transmission Time for NM
DTnT	Delay Tolerance Network Transmission Time
TM	Transmission Time Per Message

Consider a scenario where a source node have to forward M messages such that M ∈ [9]. NM correspond to number of copies of Message M where N={1,2,3,4,5,6,7…20}. SM is the size of message, TTM (Total Transmission Time) represent the net time required to transmit NM copies of message M. When source node starts forwarding then DTnT (DTN Time) is the duration by which two nodes can perform the message exchange. The Time required to transmit the single copy of message M can be calculated from equation [10].

$$\sum_{k=1}^{i} TM_k = \frac{\sum_{k=1}^{i} TTM_k}{\sum_{k=1}^{i} NM_k} \qquad (1)$$

DTnT (Delay Tolerant network Transmission Time) represents the time available for the transmission; we can calculate how many NM can be transmitted.

$$TCT = \frac{DTnT}{\sum_{k=1}^{i} TM_k} \qquad (2)$$

Number of Iterations required to transmit the copies of message with available DTnT can be calculated as

$$Iteration = \frac{\sum_{k=1}^{i} TTM_k}{DTnT} \qquad (3)$$

In the next part we evaluate the performance of existing first in first out FIFO and proposed message Smallest Message Transmit (SMT) forwarding policy.

a. FIFO(First In First Out)

In FIFO scheduling mechanisms message which arrives first is the one to be processed first. In table 02, we have three messages M12, M23, M43 with messages size (M), Number of Copies (NM), Arrival time(AT), Total Transmission time (TTM), Delay Tolerant network Time (DTnT).

Table 2. FIFO Transmission order

M	SM	MN	AT	TTM	DTnT
M12	200MB	6	13ms	12s	8s
M23	133MB	6	14ms	8s	
M43	83MB	6	18ms	5s	

The above table describes the message forwarding sequence according to FIFO. Message M12 of size SM (SM=200MB) holding N (N=6) number of copies have TTM (TTM=12s). Time required to transmit single copy of message can be calculated from equation (1). $TM_{12} = TTM_{12}/NM_{12}$ = 12/6= 2. Hence 2s seconds are required to transmit each copy of M12.

The available DTnT (DTnT=8) by putting values in equation (2) we get total number of copies that can be forwarded with in DTnT.TCT =8/2 =>4 copies. The total of 4 copies will be forwarded to network. Total iteration required to forward all copies can be calculated as Iteration = 12s/8s= 1.5 Iterations. Hence, in 0.50 (4s) more Iteration requires to transmit all copies of Message.

b. The Proposed Algorithm

(1) Get Messages from Router where Number of Message Copies greater then 1.
For each Message IN RouterMessageList
If Message→Copies>1
ADD (MessageLIST, message)
End if
End loop
(2) Sort the MessageLIST according to size in Ascending order (TSMF)
SortedMessageList=SORT(MessageLIST)

Table 3. Transmission order by SMT

M	SM	MN	AT	TTM	DTnT
M43	83MB	6	18ms	5s	8
M23	133MB	6	14ms	8s	
M12	200MB	6	13ms	12s	

The table 3 describes the message forwarding sequence according to SMT. Message M43 of size SM (SM=83MB) holding N (N=6) number of copies have TTM (TTM=5s). Time required to transmit single copy of message can be calculated from equation (1) $TM_{43} = TTM_{43}/NM_{43}$ = 5/6=> 0.83s are required to transmitted single copy of M43. The available DTnT is 8s by putting values in equation (2) we get total number of copies that can be forwarded with in DTnT.TCT =DTnT/TM=>8/0.83=9.63 copies. Total iteration required to forward all copies can be calculated as Iteration = TTMa/DTnT=5/8= 0.62 Iterations. Hence 0.48 Iteration can be allocated to next message. Simulations results have proved that with SMT policy, Delivery Ratio can be increased while minimize the Overhead, Latency Average, and Buffer time average.

5 Performance Metrics

5.1 Delivery Probability

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

$$\text{DeliveryProbability} = \frac{\text{NumberOfMessageRecieve}}{\text{NumberOfMessageSend}}$$

5.2 Latency Average

It is sum of time when message is generated and when it is received. Mathematically can be represented as

Objective of algorithm is to minimize the value of latency average.

$$\text{LatencyAverage} = \text{MessageRecieveTime} - \text{MessageGenerationTime}$$

5.3 OVERHEAD

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. Mathematically it can be represented as

$$\text{Overhead} = \text{NumberOfMessageRelayed} - \text{NumberOfMessageDelivered}$$

Objective of algorithm is to minimize the value of overhead.\

5.4 BUFFER TIME AVERAGE

It is Sum of time spend by a message(s) in buffer divided by message send. Mathematically can be represented as

$$\text{BufferTimeAverage} = \frac{\sum_{k=1}^{i} \text{WaitTimeMessage}_k}{\text{NumberOfMessageBuffered}}$$

6 SIMULATION AND RESULTS

The following sections will provide the performance evaluation of SMT policy as compared to First in First out (FIFO) using DTN ONE simulator. The ONE [6] is a discrete event simulator written in Java. The main objective of simulator is to implement DTN store-carry-forward paradigm where the probability of disconnections and failures is high.

6.1 DELIVERY PROBABILITY W.R.T NO. OF COPIES WITH FIFO AND SMT (SPRAY& WAIT)

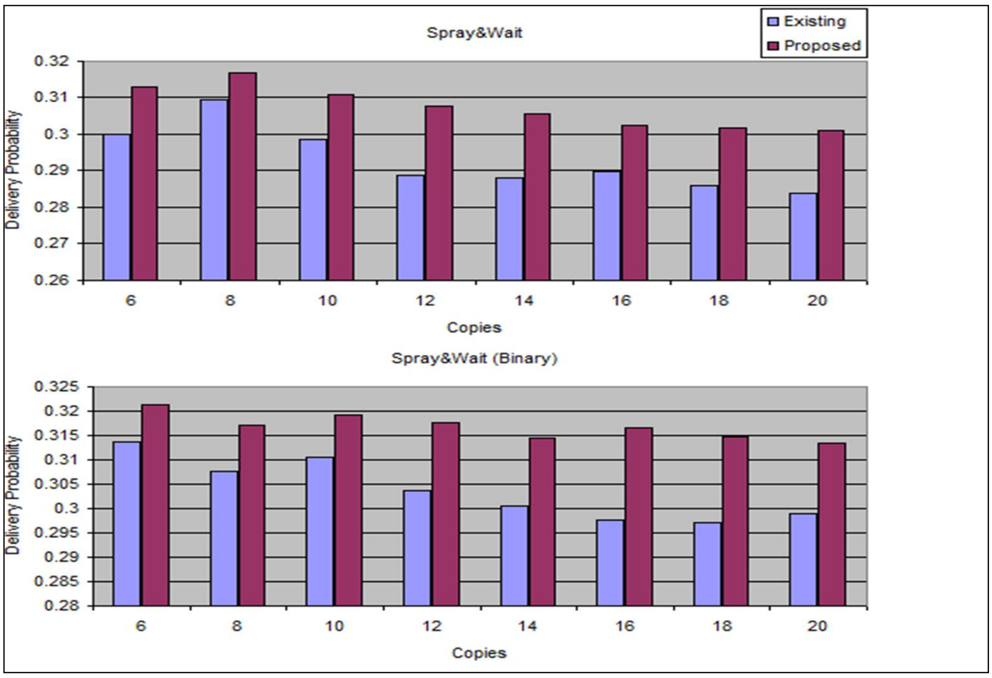

Fig. 1. Delivered Probability w.r.t No. of Copies with FIFO and SMT (Spray& Wait)

As we depict in Fig (1), results has proved that the delivery probability of spray&wait and binary Spray&wait router with proposed scheme (SMT) were performed better as compared to existing FIFO. Moreover by increasing number of copies both routers with SMT scheme performance better but in case of binary spray&wait the delivery probability raises more quickly.

One reason for this is that binary spray&waits forward more copies to relay nodes (N/2), with implementation of SMT small messages gets more opportunity to be transmitted first. In case of spray&wait SMT the average delivery probability is 0.3074 and with existing FIFO 0.2931. In binary spray&wait, average of delivery probability by using SMT is 0.3168 and with FIFO 0.3037. The proposed SMT have optimized the delivery probability.

6.2 LATENCY AVERAGE W.R.T NO. OF COPIES WITH FIFO AND SMT (SPRAY& WAIT)

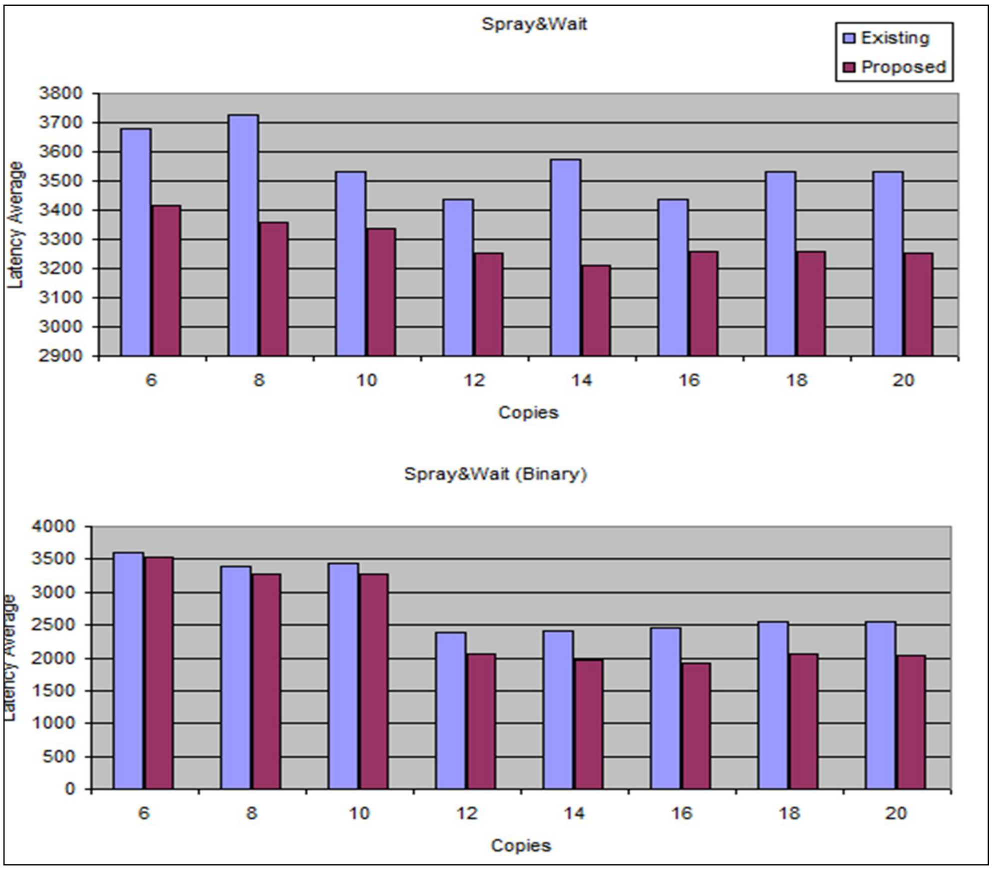

Fig. 2. Latency Average w.r.t No. of Copies with FIFO and SMT (Spray& Wait)

Fig (2) shows the result of latency average by increasing no of copies in spray&wait and binary spray&wait router with existing FIFO and proposed SMT. The objective of algorithm is to minimize the value of latency average. In case of spray&wait with SMT the latency average is 3293.56 and with FIFO 3556.23. In binary spray&wait the SMT the average of latency is 3204.86 and with FIFO 3492.83. The proposed SMT optimize the latency average.

6.3 BUFFER TIME AVERAGE W.R.T NO. OF COPIES WITH FIFO AND SMT (SPRAY& WAIT)

The Fig(3) shows the impact of buffer over Spray & wait and Binary spray & wait with existing (FIFO) and proposed SMT. By increasing number of copies of message the buffer time average drops with a constant ratio. One reason for this is that by increasing number of copies with SMT give high probability of small messages to be forwarded in the network so message spend less time in the buffer. In case of spray&wait SMT the average of buffer time is 2413.69 and with existing FIFO 2429.83. In binary spray&wait the SMT the average buffer time is 1998.60 and with FIFO 1997. The proposed SMT optimize the buffer time average.

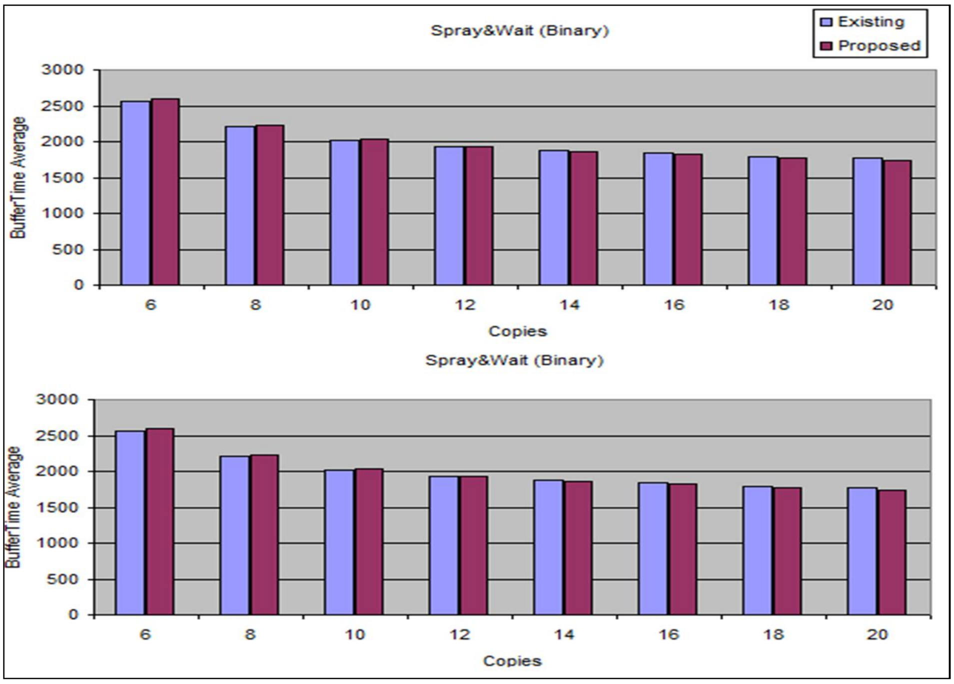

Fig. 3. Buffer Time Average w.r.t No. of Copies with FIFO and SMT (Spray& Wait)

6.4 Overhead Ratio w.r.t No. of Copies with FIFO and SMT (Spray&Wait)

The Fig(4) asserts the of influences of overhead with FIFO and SMT. On average in all cases of no of copies the overhead of proposed (SMT) algorithm is fewer with existing FIFO. In case of spray&wait SMT the average overhead is 16.52 and with existing FIFO 16.62. In binary spray&wait the SMT the average overhead is 20.88 and with FIFO 21.03.

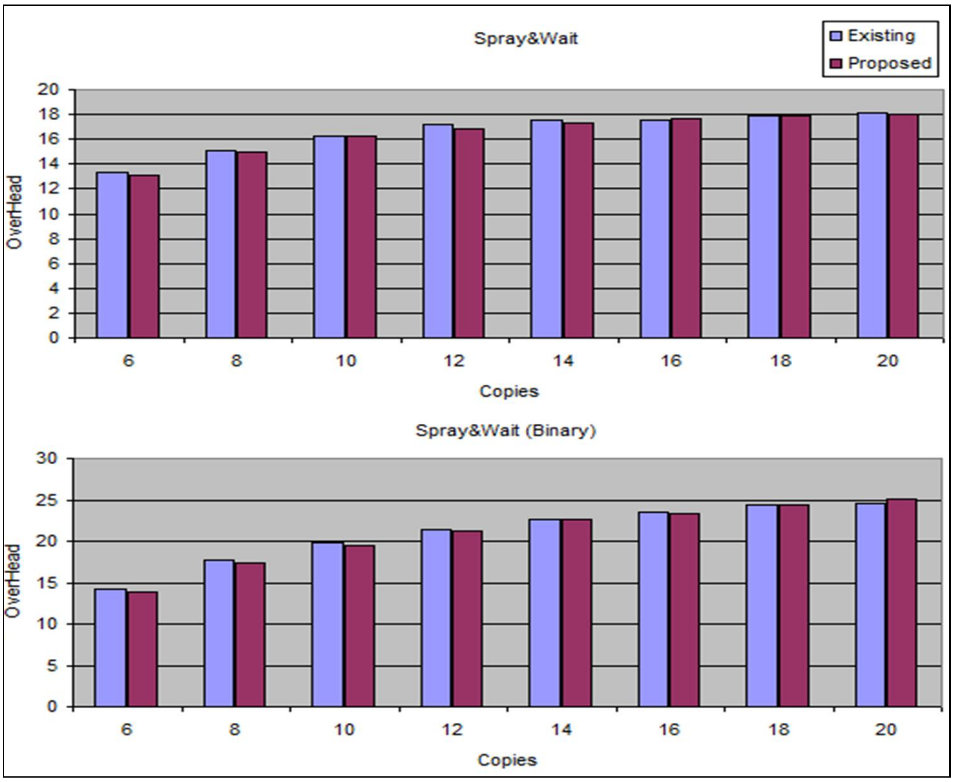

Fig. 4. Overhead ratio w.r.t No. of Copies with FIFO and SMT (Spray& Wait)

7 CONCLUSION

In this paper we have proposed a message forwarding strategy called as Smallest Message First and optimizes the performance of spray&wait routing protocol. The proposed routing method increases the delivery ratio, buffer time average and reduces overhead.

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