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An Encounter Based Routing in Delay Tolerant Network (DTN): A Hybrid Approach

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ABSTRACT: Background: Delay Tolerant Network (DTN) is a new type of Mobile Ad hoc Networks(MANETs). Unlike MANETs, it is difficult to maintain stability in end to end networks due to DTN characteristics like long communication delay and high mobility of network etc. The Store and Carry mechanism used for the network, node can store and receive the messages in the buffer and wait for the opportunity to transmit them. Therefore, it is very important to define a new reliable and efficient routing strategy in DTN. **Method/Statistical Analysis:** In this paper, we propose a hybrid routing algorithm Spray and Wait with EBR (S&W with EBR) combination of both Encounter Based Routing (EBR) protocol and Spray and Wait Routing (S&W) protocol and compare with that of Source S&W and Binary S&W under different network size. **Findings:** Simulation results show that proposed routing scheme achieves better performance with respect to Delivery Probability, Overhead Ratio, Dropping Packets and Goodput.

KEYWORDS: DTN, MANET, Routing Protocol, Encounter Based Routing (EBR), Spray and Wait (S&W).

I. INTRODUCTION

There are networks the nodes may be totally disconnected and may rely on some other means for message transfer (e.g. mobility). In some other networks, connectivity may exist, but only occasionally or intermittently. Such intermittent connectivity leads to periodic partitioning of the networks. These networks are called delay or disruption tolerant networks (DTNs). DTN is defined as a class of challenged networks, which may violate one or more of the assumptions of the Internet. In such networks where no end-to-end path is guaranteed between any two nodes[1] –[3]. There are many real networks that fall into this paradigm example include wildlife tracking[4], nomadic communities networks[5], underwater sensor networks[6] and satellite networks[7] etc. In this paper, propose a hybrid routing algorithm Spray and Wait with EBR (S&W with EBR) which is combination of Encounter Based Routing (EBR) protocol [1] and Spray and Wait Routing (S&W) protocol [2].

This paper is structured as follows: In section II, we discuss some of the routing protocols used in the DTN and related work. Section III provides complete understanding of our proposed Spray and Wait with EBR "S&W-EBR". Section IV and V provide the simulation set up and result analysis respectively. We have concluded this paper in section VI followed by the references.

II. ROUTING PROTOCOLS IN DTN

2.1 Encounter Based Routing[1]

In EBR every node maintains their past rate of encounter average, which is used to predict the future encounter rates. When two nodes meet, the number of message replicas the node should exchange is depends on the relative ratio of the nodes rates of encounter.

The rate of encounter is used to decide how many replicas of a message a node should send during a contact opportunity.

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Every node maintains two pieces of local information to track a node's rate of encounter: an encounter value (EV), and a current window counter (CWC). EV represents the node's past rate of encounters as an exponentially weighted moving average, while CWC is used to obtain information about the number of encounters in the current time interval. EV is periodically updated to account for the most recent CWC in which rate of encounter information was obtained. Updates to EV are computed through following equation 1 :

$$EV \leftarrow \alpha \cdot CWC + (1 - \alpha) \cdot EV. \qquad \text{Eq. (1)}$$

This exponentially weighed moving average places an emphasis proportional to α on the most recent CWC. Updating CWC is implemented : for every encounter, the CWC is incremented. When the current window update interval has expired, the encounter value is updated and the CWC is reset to zero.

Since EV represents a prediction of the future rate of encounters for each node per time interval, the node with the highest EV represents a higher probability of successful message delivery. Therefore, when two nodes meet, they compare their EVs. The number of replicas of a message transferred during a contact opportunity is proportional to the ratio of the EVs of the nodes. For two nodes A and B, for every message Mi, node A sends

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2.2. Spray and Wait Routing

Spray and wait routing consist of two phases:

1) Spray Phase: For every message originating at a source node, L message copies are initially spread – forwarded from the source and possibly other nodes receiving a copy – to L distinct "relays" till message meets to the destination.

2) Wait Phase: If the destination is not found in the spraying phase, each of the L nodes carrying a message copy performs direct transmission (i.e. will forward the message only to its destination).

Its goal is to reduce transmissions significantly by bounding the total no. of copies/transmissions per message.

- Under low traffic: minimal penalty for delay (close to optimal)
- Under high traffic: reduce the delay of existing flooding and utility based schemes thanks to less contention.

Routing Problem is an important aspect in DTN. Many researchers have proposed new routing protocols such as Epidemic [8], Prophet [9], Spray-and-Wait [10], Spray-and-Focus [11], MaxProp [12] and ORWAR [13] to handle this specific problem for DTN.

III. PROPOSED ROUTING SCHEME

In this section, description of our proposed Encounter Based Routing with Spray and Wait (EBR-S&W) is discussed. Encounter based routing with Spray and Wait is performed same as encounter based routing [1] when node has more than one copies of the message. The number of replicas of a message transferred during a contact opportunity is proportional to the ratio of the EVs of the nodes.

In EBR[1] routing when node has there number of copies after setting the maximum number of replication than using EBR with spray and wait node will divide the copies into the half and it will send to the other encountered node. If node has only one copy of message left than it will directly send to the destination node using direct transmission if the rate of EV of encounter node is higher than the current node. In Direct delivery protocol the node forwards the message to the destination when it is in direct contact with the destination node. So for setting the number of replication we are using the EBR algorithm and for forwarding strategy for message flood the copies using the binary spray and wait. If node have only one copy and by comparing EV values of node, and other node have less EV value than current node than increase the number of copies by one and repeat the process till it reaches to the destination.

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In proposed method first set the Number of replication L with EBR algorithm. then if L > 0 then divide it into the half and then compare the values of both encountered node, if other node's encountered value of EVB >= EVA then that node send to message copies directly to the destination, and if EVB < EVA then wait for the destination node encountered with node. If L=1 then increase the number of copies by 1 and repeat the process. Complete flow chart of the proposed algorithm is shown in figure 1.

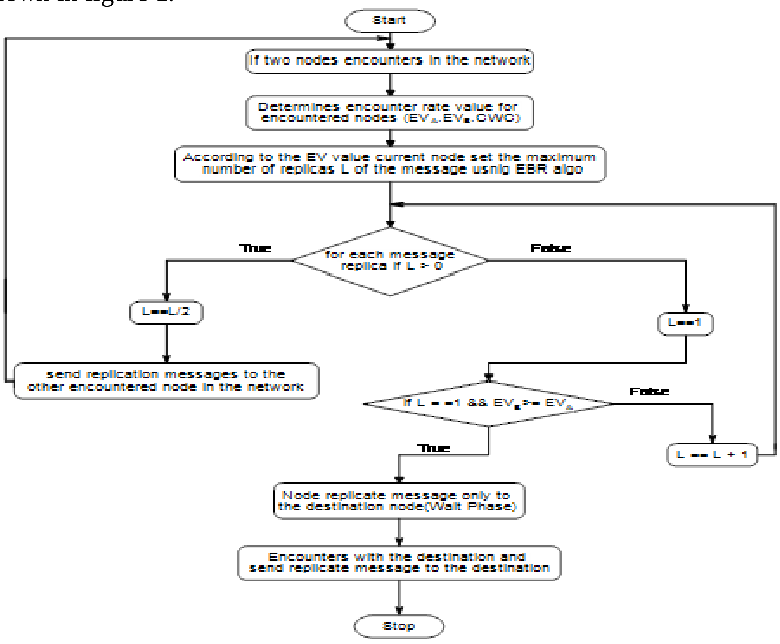

Figure 1. Flow Chart of the Proposed EBR with S&W

IV. SIMULATION SETUP

This section explains the complete evaluation methodology along with simulation environment and performance metric in detail. Simulation was performed using Opportunistic Network Environment(ONE) simulator[14] to measure the performance of our proposed scheme S&W with EBR and to be able to compare it with that of Source S&W and Binary S&W under different network size. In the beginning of the simulations, for every simulation, random seed is used to generate different information, for example, source node, destination node and the speed and waiting time of every node. We run simulations for quite a few times, varying the number of nodes from 10,20,40,80,120. The simulation setup is summarized in Table 1

Table 1.Summary of Simulation Setup

Simulation Parameter	Simulation Value
Scenario.simulateConnections	True
Scenario.updatePOPInterval	30
Scenario.endTime	20000
Group.movementModel	RandomWaypoint
Group.nrofHosts	10,20,40,80,120
Events1.class	MessageEventGenerator
Events1.interval	15-20
Events1.hosts	0,19
Scenario.alpha (when needed)	0.85
btInterface.transmitRange	300
Initial message copies	10

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A. Performance Matrices:

Following are the performance metrics considered to demonstrate the performance of our proposed scheme S&W with EBR and to be able to compare it with that of Source S&W and Binary S&W.

1) **Delivery Probability:**shows message delivery probability that how much of messages are successfully delivered. deliveryProb = (1.0 *this.nrofDelivered) / this.nrofCreated
2) **Overhead Ratio :**Resource cost to deliver one message.overHead = (1.0 * (this.nrofRelayed – this.nrofDelivered)) / this.nrofDelivered
3) **Dropping Packets:**Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. Packet loss is typically caused by network congestion.
4) **Goodput:**Number of userful information or Data successfully delivered/ transferred divided by the total transfer time.

V. SIMULATION RESULT ANALYSIS

The simulation results of compared protocols are discussed in this section. Performance of our proposed S&W with EBR with other routing protocols, including Source S&W and Binary S&W according to the Delivery Probability, Overhead Ratio, Dropping Packets and Goodput under different network sizes is compared. The simulation results are shown in Figure 2, Figure 3, Figure 4 and Figure 5.

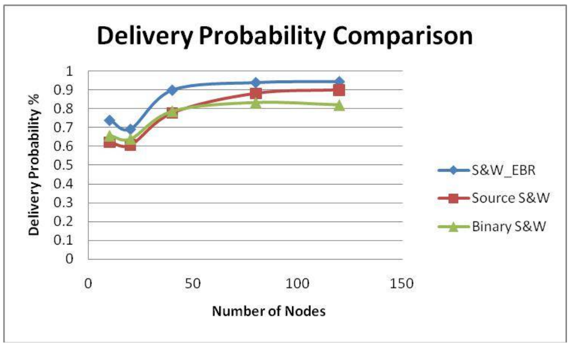

Figure 2. Delivery Probability vs. Network Size

Figure 2 shows the delivery probability ratio as the total network size is varied from 10,20,40,80,120 for Source S&W, Binary S&W and the proposed Spray and Wait with EBR.Among these routing protocols, the performances of proposed Spray and Wait with EBR is better than that of Source S&W and Binary S&W. Based on the simulation result, the proposed scheme gives almost 10 % better delivery probability ratio compared to the other two protocol for the higher network size.

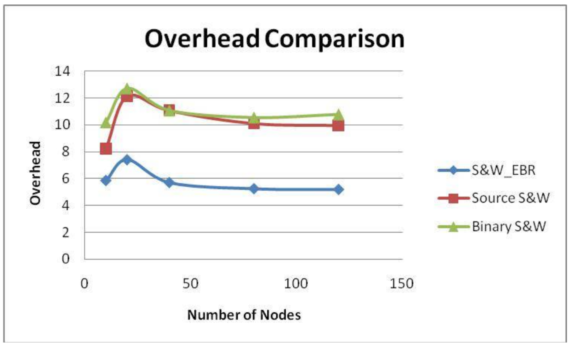

Figure 3. Overhead Ratio vs. Network Size

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Figure 3 describes the overhead as the number of total network nodes varies from 10,20,40,80,120. The overhead of all three routings protocol is constantly decreasing as the number of total network nodes increases. Overheadof our proposed Spray and Wait with EBR is always less and consistently maintained than that of Source S&W and Binary S&W. The figure shows that the network overheads are on the rise when the network size is in less than 40 nodes.

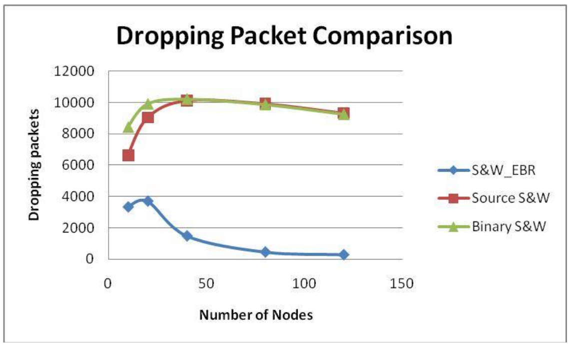

Figure 4. Dropping Packets vs. Network Size

Figure 4 shows the result comparison of dropping packets during the simulation of our proposed Spray and Wait with EBR and that of Source S&W and Binary S&W routing protocol. Numbers of packet drop is very lower in Spray and Wait with EBR compare to rest two other protocols in spite of increasing number of nodes in the network. Source S&W and Binary S&W has almost same result in all scenarios.

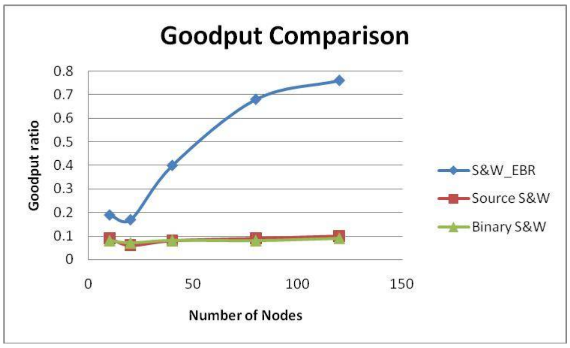

Figure 5. Goodput vs. Network Size

Figure 5 represent Goodput of our proposed Spray and Wait with EBR and that of Source S&W and Binary S&W routing protocol. Goodput of Spray and Wait with EBR is consistently maintained (above .2) while that of Source S&W and Binary S&W falls down drastically and below (.1).

VI. Conclusion

In this paper, we propose a hybrid scheme Spray and Wait with EBR, evaluated the proposed scheme and compared with other two popular routing protocol Source S&W and Binary S&W under the ONE simulator in different scenarios, simulation experiments show that the proposed Spray and Wait with EBR outperforms the other routings Source S&W and Binary S&W in terms of the Delivery Probability, Overhead Ratio, Dropping Packets and Goodput. The analysis shows that the performance of our proposed Spray and Wait with EBR is better than that of the Source S&W and Binary S&W routing protocol with respect to Delivery Probability, Overhead Ratio, Dropping Packets and Goodput. The future study will lie in how to improve the performance by using the efficient buffer strategy.

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