



## Enhanced Spray and Wait Routing Scheme for Delay Tolerant Network

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**Abstract**— *One of the major problems of delay tolerant network is the absence of complete path in between the source and destination. The major challenge in opportunistic environment is that the conventional routing scheme can not be directly adopted. To deal with such adversity, routing protocol employs various techniques that come from flooding, forwarding or replication based routing scheme. In this paper, we propose an enhanced spray and wait routing (ESNW) scheme. The simulation result shows that the proposed ESNW routing performs better than other routing schemes in terms of delivery probability, overhead ratio and the average delay.*

**Keywords**— *Resource aware, DTN, Routing, utility values, ONE*

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### I. INTRODUCTION

Delay tolerant network [2] is a special class of wireless network in which complete path from source to destination does not exist. Now a days various challenged or opportunistic networking application are being used such as wildlife monitoring [25], search and rescue system, underwater sensor network, vehicular ad-hoc network [8], data mule [18], packet switched network, underdeveloped region connectivity [26] and many others. The working of these networks is affected by various limiting factors [1] such as High latency & low data rate (10kbps under water), end to end node Disconnection Problem, Long message queuing Times, as well as Limited resources in terms of limited memory and processing capability which leads to the unstable path [3] or connectivity in between two nodes in opportunistic network. As the contact schedules between two nodes are completely opportunistic [4], we cannot accurately predict the meeting probability or the contract schedule of the node.

The routing protocol for challenged network can be divided into three categories i.e. flooding based routing families, replication based routing families and forwarding based routing families. Forwarding based routing protocol makes the use of a single custodian for each message and tries to direct the message towards the destination by making the use of knowledge oracle. Many routing protocol belongs to flooding based routing families in which contact opportunity is being utilized for flooding the message throughout the network. Here the multiple copies of the same message are being injected into the network for the purpose to enhance the packet delivery ratio but this approach leads to high network congestion overhead. And at last replication based routing families are the compromise of forwarding based routing approach as well as flooding based routing approach. This routing family tries to achieve the packet delivery ratio as high as that of some of some of flooding based routing protocols and at the same time reduces the network congestion overhead by limiting the no. of message replicas throughout the network.

The rest of the paper has been organized as follows. Section II gives a brief description of DTN routing scheme. The proposed enhanced spray and wait routing is presented in section III. Performance comparison has been done in section IV. And finally section V includes concluding remarks and future work.

### II. RELATED WORK

The routing in intermittently connected network has been widely discussed in recent years. The traditional ad-hoc network routing protocol do not fit in the opportunistic network environment because of many limitations such as high node mobility, end to end delay etc. Due to this inherent adversity of opportunistic network, most of the delay tolerant routing protocols falls under three categories, based on the number of copies of same message created throughout the network i.e. forwarding based routing protocol, quote or replication based routing protocol and flooding based routing protocol.

Under flooding scheme [7], Epidemic routing protocol [10] was one of the earliest in which encountering node first exchange a summary vector in between them. Here the summary vector contains the metadata regarding the message stored at node's buffer. By comparing a summary vector a node learns about new messages or information stored at the neighbour. The other flooding based routing protocol includes Prophet [11], MaxProp [14], RAPID [22] etc.

Although the flooding based routing protocols are well suited to the opportunistic network environment, it suffers from high congestion overhead because of its policy to replicate as many copies of message as resource permits. To deal with the problem of greedy use of network resources as flooding based routing protocol does, forwarding [9] based routing scheme is introduced. Here, single copy of the message is injected into a network and is forwarded towards

the destination through successive intermediate nodes. Forwarding routing protocol though saves network resources but present low delivery probability unless frequent connectivity is present in the network. The various proposed forwarding routing protocols are MEED [12], SimBet [17] etc. which makes the use of different types of knowledge oracle to forward the packet towards the destination.

To mitigate the problem of forwarding and flooding based routing scheme [5], a replication based approach [16] comes into existence. The first routing protocol from replication based routing family was Spray and Wait (Spyropoulos et.al.2005). Spray and Wait routing protocol [13, 15] break routing operation in two phases. In the first phase also known as spray phase identical message copies are disseminated throughout the network and in second phase i.e. wait phase, nodes with single copy of message directly transmit it to the destination when encounters. Further this replication strategy can be classified into two broad categories i.e. one which uses the static quota allocation function for example spray and wait routing protocol which makes the use of binary function to limit the no. of message replicas that has to be injected into the network and the other which makes the use of dynamic characteristics of the network [23] such as requirement and availability of resources or knowledge to decide the no. of message replicas throughout the network.

Another flavour of Replication based routing protocol is also proposed such as EBR [20], Dynamic congestion control based routing [24] etc. Overall, the replication function should aware of the network conditions such as traffic load distribution [21], resource constraints [22] etc. As the network load, Available resources as well as congestion status of the network dynamically changes over time [6].

### III. ENHANCED SPRAY AND WAIT ROUTING

This algorithm is designed to eliminate some deficiencies of Spray and Wait algorithm in some network environments. In Spray and Wait algorithm, once all the copies of the message is spread to some nodes and wait phase is started, but if the mobility of each node is restricted to a small local area, then it may not be possible to deliver one of the copies to the destination. Therefore, this paper proposes a different version of the Spray and Wait algorithm. There are also two phases in this algorithm:

- Spray phase: This phase is actually same with the spray phase of the first algorithm. For every message originating at the source node, L message copies are spread to all L different nodes.
- Relay phase: Once the spraying phase is done, and then nodes start to roam around to find the destination. But different than the wait phase of the first algorithm, in this phase, each copy in a single node is tried to be routed to a closed node via a single-copy utility based scheme (based on a set of timers that record the time since two nodes last saw each other.). Therefore, we can define a utility function, based on these timers, that indicates how “useful” a node might be in delivering a message to another node. That is, if  $UX(Y)$  denotes the utility of node X for destination Y, then a node having a copy of the message destined to node D, forwards its copy to a new node B in its range, if and only if  $UB(D) > UA(D) + U_{th}$ . Here,  $U_{th}$  denotes the utility threshold parameter of the algorithm.

### IV. PERFORMANCE EVALUATION

We have used opportunistic network environment (ONE) simulator [19] in order to evaluate the performance of enhanced spray and wait routing protocol. ONE simulator is an open source simulator, designed by the Helsinki University and is freely available for research and development purpose.

#### A. Simulation Model and Performance Metrics

Here we have considered a scenario with three kinds of nodes that are pedestrians, bicycle and vehicles. The detail of various simulation parameters is listed in table I given below.

Table I Simulation Parameters

Simulation parameters		Simulation parameter values
Map Size		4500m*3400m
Simulation Time		10000s
Buffer Size		30 MB
Packet Transmission Speed		250kBps
Number of Nodes (including all groups)		60, 90, 120, 150, 180, 210, 240, 270, 300
Node Movement		Shortest Path Map Based Movement
Speed	Pedestrians	0.5-1.5m/s
	Bicycle	1.4-4m/s
	Vehicles	2.7-13.9m/s
Transmission Range		10m

Packet Size	500kB-1MB
Message generation interval	25s-35s

Three different types of cost metrics we have used for performance comparison, as given below:

**Delivery Probability:** It is the ratio of Total number of messages delivered to destination to the total number of messages created at the source.

Delivery probability= (Number of messages delivered) / (Number of messages created).

For example, if the total number of message created=93170, and the number of message delivered=91960, then the delivery probability = 91960/93170=.9870.

**Overhead Ratio:** Overhead ratio is used to measure the network congestion status and is calculated as the ratio of difference of total number of successfully relayed messages and the number of delivered messages to the number of delivered messages. We can calculate Overhead ratio as

Overhead Ratio= (Number of relayed messages-Number of delivered messages) /Number of delivered messages.

Let no. of relayed message=99668, no. of delivered message= 91960, then overhead ratio = (99668-91960)/91960=.0838.

**Average Latency:** It is the average delay occurred in between message creation to message delivery.

Here we have compared our proposed routing scheme with well known routing protocols. We have performed extensive simulation work with all these routing protocols in the same scenario setting with the above parameter and compared the performance of these routing protocols in terms of delivery probability, overhead ratio and average latency/delay under different network sizes.

**B. Simulation Result**

We have evaluated the impact of node density by varying the number of participating nodes. TTL is set to 100 minutes and other parameter is same as given in table. Various graphs show the performance as the number of nodes varies from 60 to 300.

**Delivery Probability with different Network size**

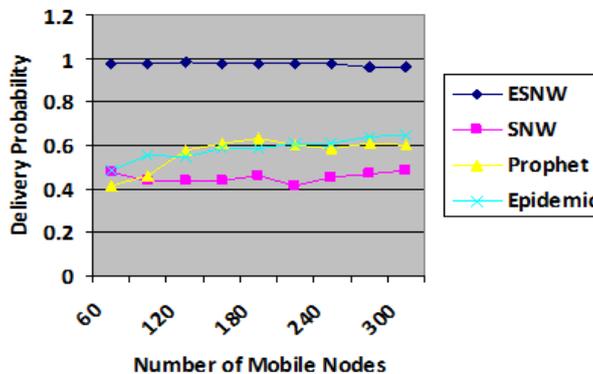


Fig. 1 Delivery probability with different network size

**Average Latency with different Network size**

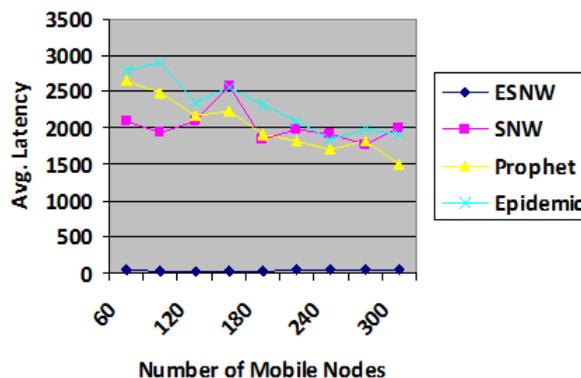


Fig. 2 Average Latency with different network size

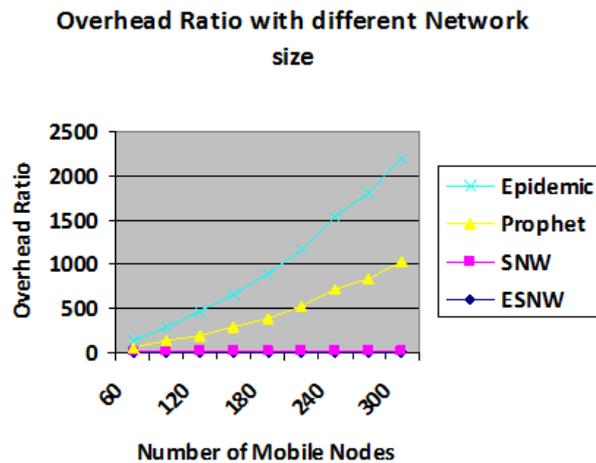


Fig. 3 Overhead ratio with different network size

## V. CONCLUSIONS

The major routing challenge in delay tolerant network is to efficiently route the packets in intermittently connected environment or partition based network where the nodes are sparsely distributed. Our proposed routing protocol makes the use of relay of packets throughout the network. We have evaluated the proposed routing protocol under one simulator with varying network size. The simulation result shows that the proposed routing protocol out performs than other routing scheme. The future work lies on the way to avoid any type of possible node misbehaviours that may degrade the performance of this routing protocol, because in our scheme nodes take the responsibility of distribution of forwarding tokens by showing their available carrying capacity.

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