Modified Spray Phase to Improve Performance of Binary Spray and Wait Routing Protocol in Delay Tolerant Network

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ABSTRACT
Delay or Disruption Tolerant Networks (DTN) are a type of wireless network where at the time of message transmission, there may not exist end to end path between source and destination. Node connections in DTN are very intermittent due to sparse node density and mobility. DTNs make use of "Store Carry and Forward" delivery mechanism for message transmission. Thus message delays may be very long in such networks. In this paper we present a variation of Binary Spray and Wait (BSW) routing protocol where spray phase of BSW routing protocol has been modified. The simulation results shows that our modified spray phase version gives better delivery ratio and less overhead ratio as compared to BSW.

General Terms
Routing

Keywords
DTN, spray and wait.

1. INTRODUCTION
Delay Tolerant Networks (DTN) are partitioned networks where long duration of disconnections and large delays in transmissions are acceptable, in such networks when a node is not in a transmission range of other nodes, store the messages in buffer until it find some appropriate node for transmission. Nodes in DTNs are intermittently connected to each other because of limited power, transmission range and mobility. Each node stores the messages in its buffer until a contact opportunity occurs with other node and then forwards these messages to the encountered node; this process continues until the message eventually reaches the destination. In this way DTN deals with message transmissions, when there is no end to end path available between source and destination nodes. DTNs are also known as opportunistic network [1][6] because whenever a node keeps messages and want to transmit it to other nodes in the network, it always tries to search for a transmission opportunity i.e. as soon as two nodes meet they transmit messages to each other. Thus in such disconnected environments the traditional ad-hoc routing protocols like Ad hoc On Demand Vector (AODV) [10], Dynamic Source Routing (DSR) [10] do not work as they require a path between source and destination for successful transmission of data at the time of message transmission. Number of routing protocols has been proposed for literature in this paper, a modified spray phase of binary spray and wait routing protocol which is a controlled replication protocol is being proposed with the aim to achieve improved delivery ratio.

The rest of the paper is structured as follows. Section 2 describes related work. In section 3 our proposed scheme is detailed. Section 4 describes simulation setup. Section 5 describes simulation results and finally section 6 concludes our paper.

2. RELATED WORK
Design a routing algorithm for DTN is difficult due to the challenging network conditions. Routing protocols in DTNs are mainly divided into two categories on the basis of the technique they use for message transmission, first is forwarding based routing protocol [7] and second is replication based routing protocol [6]. In Forwarding based transmission technique only one copy of the message is present in the network, single-copy routing scheme [7] which is an example of forwarding based routing protocol allows to have only one copy of a message in network and hence significantly reduce the resource requirements of flooding-based algorithms. In Replication based transmission technique multiple copies of a message may exist in the network. Replication based routing is further divided as flooding based where unlimited number of copies of message are made in the network like epidemic and quota based like spray and wait. Epidemic routing[5] is a Flooding based routing protocol which allows node in network to replicate message copies to every other nodes which already does not contains the message copy that are present to this node. Flooding based protocol has a high probability of delivery but suffer from congestion which decreases performance. Social based routing protocols [8] are also comes under the category of replication based routing protocol which use different social characteristics [8] for message transmission. Spray and wait works in two phases first is Spray phase and second is wait phase. In Spray phase it replicates L number of message copies in the network then in Wait phase nodes have a copy of the message wait for destination node then use direct transmission.

2.1 Source Spray and Wait
In Source Spray and Wait (SW) [4] [6] routing protocol, source node S initially has L number of message copies. Whenever node S encounters a node B and if B does not already contain a message copy than S transmits only a single copy of message to B; after successful message transmission, B goes into wait phase and S updates the message copy as L-1. S transmits remaining message copies in the same fashion to other encountered nodes until it is left with only one message copy; after which it enters the wait phase. In the wait

phase, nodes having a copy of the message wait for meeting the destination node and on meeting transmit the message copy and delete it from their buffer.

2.2 Binary Spray and Wait

Binary Spray and Wait [4] [6] is the improved version of Source Spray And Wait in which source node S initially has L number of message copies. Whenever S finds a node B which does not already contain a message copy and L >1 then S transmits L/2 message copies to B, after successful message transmission, S keep L/2 for itself. Now both S and B look for other nodes in network for message transmission. On meeting another node C node S now transmits L/4 message copies to C and keeps remaining L/4 for itself. This process continues until each node has only one copy left then nodes go into wait phase.

3. MODIFIED SPRAY PHASE TO IMPROVE PERFORMANCE OF BINARY SPRAY AND WAIT ROUTING PROTOCOL (MBSW)

BSW Routing protocol gives better performance than SW routing protocol because Message spreading is more diversified, faster and instead of transmitting the large number of copies near to source it transmit the message copies more far away from source as shown in figure 1. Thus it increases the delivery probability of a message.

This means that spraying more copy near to destination then source, so that, the delivery probability may increase. Based on this, we modified the Spray phase of BSW as shown in figure 2 and algorithm MBSW is as follows:

Algorithm: MBSW
Variables: int nrofCopies, count;
/*
nrofCopies is the current number of a message copies present at this node.
count keeps the information about, was it first or second transmission of a message from this node.
isFirstTransmission() method return true if it is the first transmission of a message from this node otherwise false.
*/
Step 1: while (nrofCopies !=1) **{**
Step 1.1: No. of copies to be transmitted by a node:

```
If (isFirstTransmission()){
        nrofCopies=Math.ceil( nrofCopies/2);
        count=0;
} else{
        nrofCopies=nrofCopies-1;
        count=1;
}
```

Step 1.2: After successful transmission**:**

```
If (count = = 0){
        nrofCopies= nrofCopies/2;
} else{
        nrofCopies=1;
}
```

}
Step 2: Wait for destination to meet for direct message transmission.

The idea is to transmit L/2 copies to the first encountered node and for the second encountered node transmit L/2-1

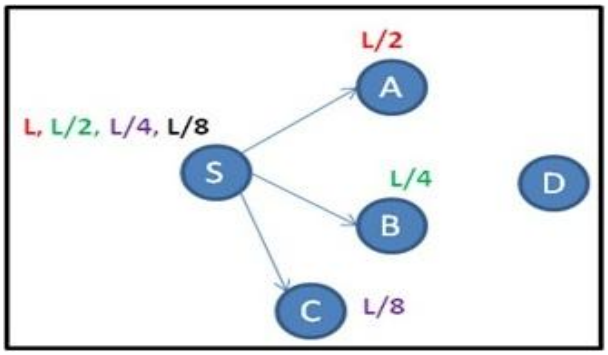

Figure 1: Transmission in BSW

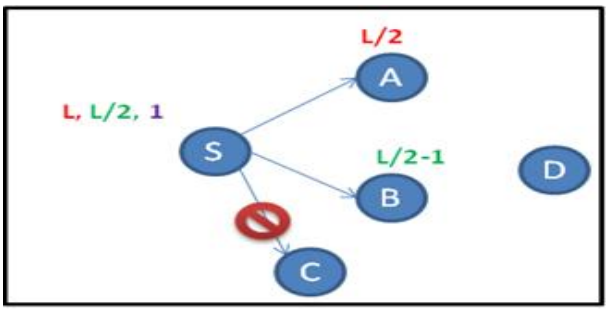

Figure 2: Transmission with modified spray phase of BSW

copies thus after two successive transmissions, source node is left with only one copy for itself. In Spray phase, there will not be more than two transmission of a message allowed by a single node. Finally, in Wait phase only last transmission of a message to direct destination will be done.

Thus, on comparing figure 1 and 2, it may be seen that in MBSW the spreading of message copies is more diversified then in BSW where the distribution is mainly concentrated around source node. Hence, it is expected that delivery ratio of BSW will be improved by using this modified version of spray phase.

4. SIMULATION SETUP

The ONE (Opportunistic Network Environment) [9] simulator provides an environment to implement different routing algorithms that have been proposed for DTN. The setup of this environment is described below.

To compare and evaluate the performance of three protocols, Helskin city scenario has been considered, whose area is 4500 X 3400. There are 6 groups of total 126 nodes. Group1 is pedestrians group which contain 40 nodes, Group2 is automobile group which contain 40 nodes, Group3 is again pedestrians group which also contains 40 nodes, Group 4, 5 and 6 consists of trams which contain 2 nodes each. Nodes of Group 1, 2 and 3 have buffer size of 5MB and those of Group 4, 5 and 6 have buffer size of 50 MB. Pedestrian's nodes have speeds of 0.5 – 1.5 m/s and waiting time of 0 – 120 seconds; automobiles nodes have speeds of 10 – 15 km/h and waiting time of 0 – 120 seconds; and tram nodes have speeds of 7 – 10 km/h and waiting time of 10 – 30 seconds. Message generation interval time is 30 - 40 seconds. Default message TTL (Time To Live) value is taken to be 300 minutes. The Simulation period is taken to be 43200sec which is equal to 12 Hours. In buffer overflow condition, nodes of all groups will not accept any message until some messages are delivered and then deleted from node buffer. Bluetooth and High speed long range interfaces are used for these groups. Bluetooth interface for all groups has bandwidth of 2Mbps and transmission range of 10m. High speed, long range interface for group 4 has bandwidth of 4.5Mbps and transmission range of 30m.

5. RESULTS

The performance of MBSW has been compared with SW and BSW under different network scenarios generated by varying number of message copies and TTL value of messages. The performance has been studied in terms three metrics namely Delivery Ratio, Overhead Ratio and Average Latency.

The Delivery Ratio (DR) is the ratio of number of messages delivered to number of messages created. Overhead Ratio (OR) is the ratio of number of messages relayed minus number of messages delivered to number of messages created. Average Latency (AL) is the ratio of summation of the latency of number of messages delivered to number of messages created.

5.1 Effect of varying number of Message Copies

The effect of varying number of message copies on different metrics DR, OR and Al is shown in figure 3, 4 and 5 respectively.

Figure 3 shows that MBSW gives better DR in most of the cases as compared to SW and BSW on varying number of message copies. The reason being MBSW sprays more message copies far away from the source and probably near to destination. On increasing number of message copies there will be more congestion in the network and messages will occupy overall more buffer space in nodes. Thus after a certain point DR starts decreasing even after increase in number of message copies.

Figure 4 shows that varying number of message copies MBSW has less OR over BSW but more over SW, as because in MBSW a node in spray phase allows only two transmissions of a message and in wait phase only one transmission of message to direct destination, thus in MBSW a node goes to wait phase earlier then BSW. Probably it may possible that MBSW deliver a message to destination before it sprays all copies in network.

Figure 5 shows MBSW has more AL over BSW but less over SW in most of the cases. This is due to larger number of messages delivered by MBSW as compared to BSW.

5.2 Results on varying TTL

Figure 6 shows that MBSW gives enhanced DR in most of the cases as compared to SW and BSW. As the TTL increases, the messages will stay for longer time in the node buffer and get more transmission opportunities, thus the delivery probability increases. Moreover as message spraying is more diversified in MBSW, it has better performance than SW and BSW in most of the cases.

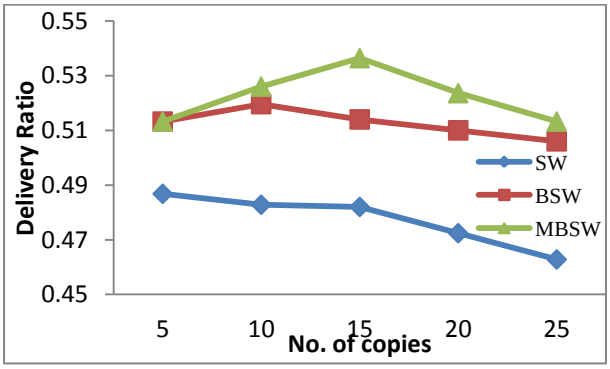

Figure 3: Variation of DR of MBSW over SW and BSW with varying number of message copies

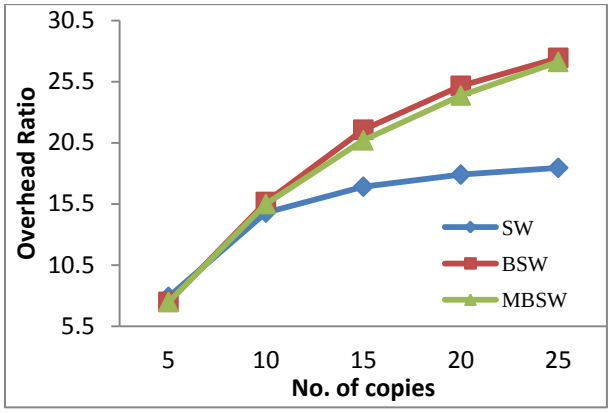

Figure 4: Variation of OR of MBSW over SW and BSW with varying number of message copies

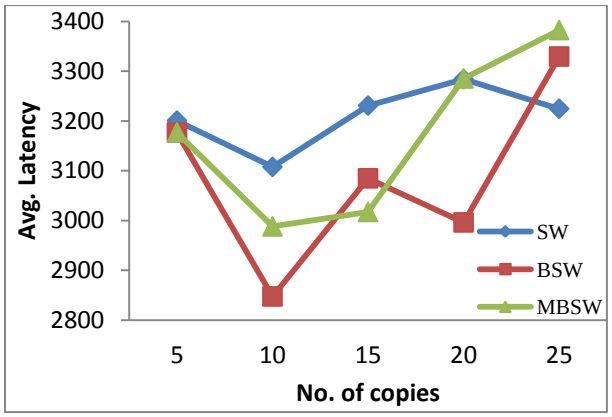

Figure 5: Variation of AL of MBSW over SW and BSW with varying number of message copies

Figure 7 shows that MBSW has less OR over BSW but more over SW, as TTL increases, more messages are transmitted in the network, hence overhead ratio increases; possibly messages are forwarded even after they are delivered to the destination. However in the case of MBSW, probably more message copies are distributed near to destination, hence messages delivered to the destination will be larger. Since MBSW delivers more messages to their destination as compared to BSW its overhead ratio is smaller as compared to BSW but SW routing has less overhead than all because each

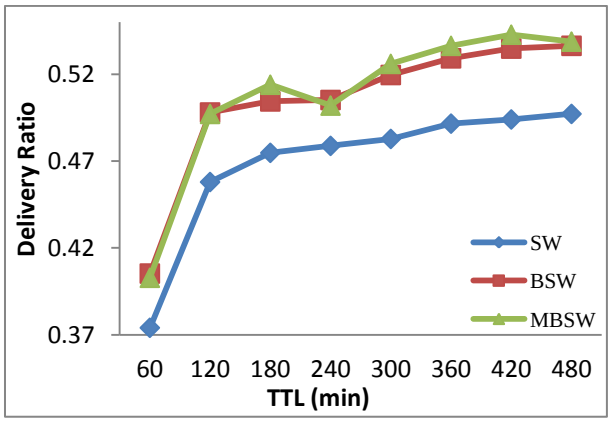

Figure 6: DR of MBSW over SW and BSW with varying message TTL

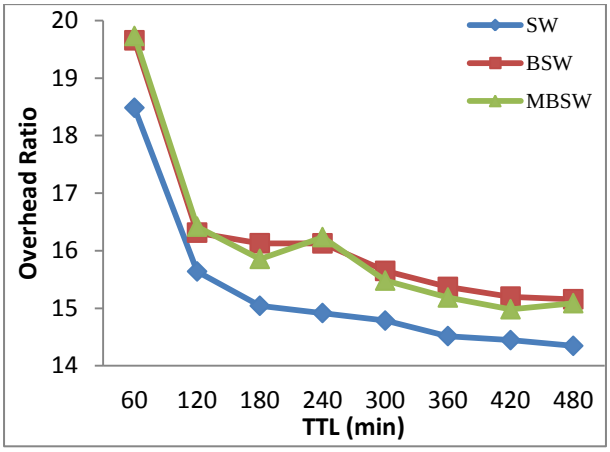

Figure 7: OR of MBSW over SW and BSW with varying message TTL

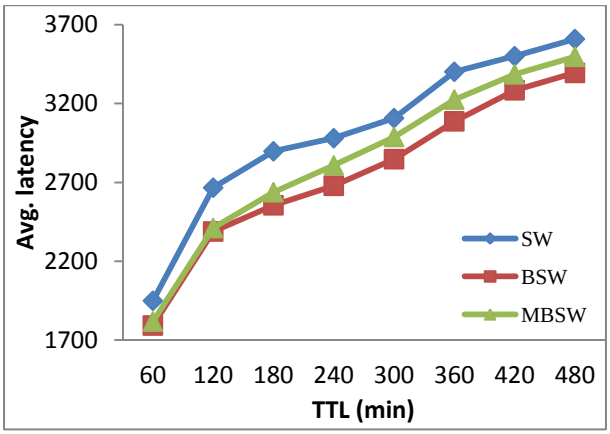

Figure 8: AL of MBSW over SW and BSW with varying message TTL

time nodes only forward a single copy of message to other nodes.

From Figure 8, it may be observed that MBSW has higher AL over BSW in most of the cases but less than SW. It is because MBSW deliver more number of messages to their destination as compared to BSW. However in SW since the spraying is more concentrated near source, messages may be delivered late to their destinations.

6. CONCLUSION

In this paper we propose a modified binary spray and wait routing algorithm with the objective to achieve improved performance. In MBSW, spray phase has been modified so that any node is allowed to transmit message copies to only two nodes which do not already have this copy. In the first transmission of the message, a node transfers half of the copies of the message to the first encountered node and then in second transmission it transmits remaining half copies to the next encountered node and goes into wait phase keeping one copy for itself. Node will keep message copy in its buffer until it find destination node for direct transmission or its TTL expire. The main reason behind this modified spray phase is to achieve more diversified spreading of the message in the network which is far from the source node and probably near to the destination. The simulation results confirm improved performance of MBSW over BSW and SW in terms of delivery ratio and overhead ratio.

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