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ANALYSIS OF SELFISH NODE BEHAVIOR IN DELAY TOLERANT NETWORKS ROUTING PROTOCOLS

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ABSTRACT

Delay Tolerant Network (DTN) is a class of networks in which number of nodes that help to transmitting message even with connectivity issue. The connectivity issue betweens mobile nodes are due to transmission range of nodes, energy constrained, mobility of nodes or due to some other channel impairment. To make contact possible peer nodes take custody of the message being transferred and transmit it as the opportunity arises i.e. message delivery is implemented through store-carry-and-forward manner by use of short message transmission technologies such as Bluetooth or Wi-Fi. This paper focuses on the impact of selfish nodes which drops message upon message reception on DTN routing protocols using One simulator simulation.

***Keywords*: *Delay Tolerant Networks, Routing, Selfish nodes, ONE Simulator*.**

I. INTRODUCTION

Delay Tolerant Networks (DTNs) enable data transfer when mobile nodes are only intermittently connected. Due to lack of consistent connectivity, DTN routing usually follows store-carry-and-forward; i.e. after receiving some packets, a node carries them around until it contacts another node and then forwards the packets [1, 2, 3]. Since DTN routing relies on mobile nodes to forward packets for each other, the routing performance depends on if nodes are willing to forward for others. In order to overcome the lack of end-to-end paths, the protocols can replicate messages in each contact, if necessary. When node meets the next node it tries to forward the message to next node. Message in DTN are also called bundle. A bundle consists of three types of data: i) source application user data ii) control information provided by source for the destination iii) A bundle header inserted by bundle layer. Bundle layer is new protocol layer which ties together the region specific lower layers3, so that application programs can communicate across multiple regions. DTN are resource constrained network, so it may possible that the next node may have selfish behavior. It may try to maximize its own benefit by dropping the packet from other nodes and will forward only its own message. Such node in the network will degrade the network performance as this behavior will increase the message dropping rate and reduce the probability of message delivery. The contribution of this paper is a study of the impact of selfish nodes on a set of delay tolerant networks routing protocols that are representative in terms of the number of copies created –

single-, n-unlimited-copy as well as if estimation metric is used (estimation-based). This paper focuses on specific case of node selfishness: the case of nodes that defer the forwarding of messages, reducing the probability of their delivery to the final destination.

II. ROUTING PROTOCOLS IN DTN

Direct Delivery [4] and First Contact [5] are single-copy DTN routing protocols: only one copy of each message exists in the network at each moment. In Direct Delivery (DD), the message is kept in the source until it comes in contact with the destination. In First Contact, the message is delivered to the first node encountered and deleted, being forwarded until it reaches the destination.

Epidemic routing [6] is an unlimited-copy routing protocol or flooding-based in nature its tries to send each message to all nodes in the network. In this router when two nodes encounter, they exchange only the message they do not have in their memory buffer. Overhead gets high due to more utilization of buffer space but delivery probability gives good value.

PRoPHET (Probabilistic routing protocol using history of encounters and Transitivity) [7] is an unlimited-copy routing protocol or flooding-based in nature. It estimates probabilistic metric called delivery predictability. This routing protocol based on the probability of node's contact with another node. The message is delivered to another node if the other node has a better probability of delivering it to the destination.

MaxProp [8] is an unlimited-copy routing protocol. When all node are in communication range it transfer all the messages not held by other node. The protocol puts priority order on the queue of messages. Message that should be dropped and those that need to be transmitted are then classified in this priority queue. The priority includes the ratio of successful path establishments to nodes or the number of acknowledgements. These methods increase the message delivery ratio.

Spray and Wait [9] is an n-copy routing protocol. There are two phases of spray and wait routing protocol: the spray phase and wait phase. In the spray phase when new message is created at the source node, n copies of that message are initially spread by the source and possibly received by other nodes. In wait phase, every node containing a copy of message and simply holds that particular message until the destination is encountered directly. There are two versions of Spray and Wait: normal mode, a node gives one copy of the message to each node encountered that does not have same copy. In Spray and Wait Binary mode (SaWBinary), half of the n copies to the first node encountered and that node transmits half of the copies to the one it encounters first this process is continue until one copy is left with the node.

III. TYPE OF SELFISH NODE BEHAVIOR

In this paper we studied the node selfishness behavior in delay tolerant networks. Selfish nodes are those nodes which received the message from the other nodes but not transmitting the message to next nodes. Whenever, the message is transmitting to other node which is in the transmission range of the sender node. If the message receiving node is selfish node then it does not send the message to next node within the defined time and drops message upon message reception in the network.

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3.1 Algorithm

N number of nodes in the DTN networks

Node A transmitting message M to Node B

If (Node B ∈ Selfish node)

{

Message M drop by Node B

}

Else

{

Message M delivered to Node B

}

IV. PERFORMANCE EVALUATION

This section studies the impact of selfish behavior of nodes on DTN routing protocols in MDTN. The simulation tool used in this study is ONE (Opportunistic Network Environment) simulator [10] which provides a powerful tool for generating mobility traces, running DTN messaging simulations with different routing protocols, and visualization both simulation interactively in real-time and results after their completion. This single simulation framework is Java based tool. It creates a GUI main window (as shown in fig 1.) which is divided into three parts. The main part contains the playfield view (where node movement is displayed) and simulation and GUI control and information. The right part is used to select nodes and the lower part is for logging and breakpoints.

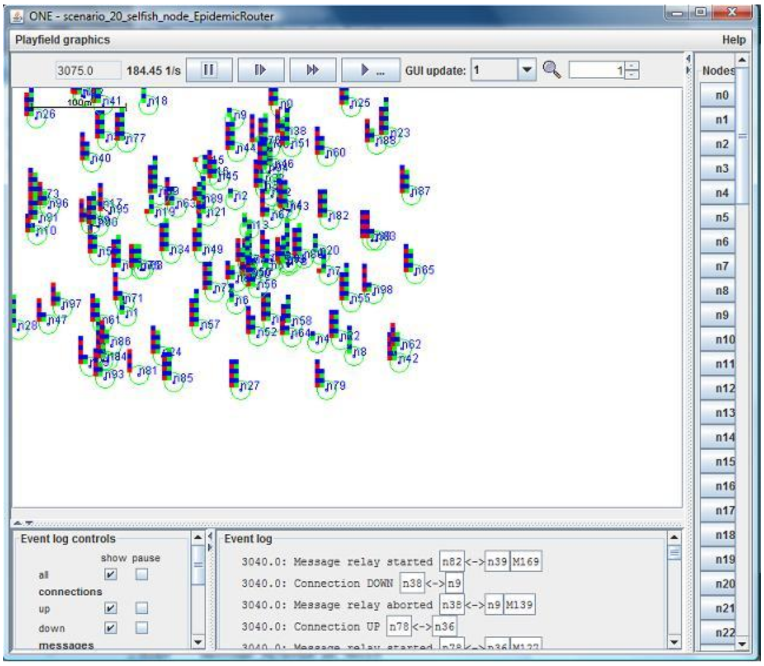

Fig. 1

V. SIMULATION SETUP

Simulating environment consists of total 150 hosts belonging to single group. Simulation is checked with 20 selfish nodes proceeding with 40, 60 and 80. The TABLE 1.1 lists the details of simulation parameters.

Table 1

Parameter Name	Value
Simulation Time	43200 sec
Routing Protocols	Direct Delivery Router, Epidemic Router, Spray and Wait, Prophet Router, MaxProp Router
Mobility Model	Random WayPoint (RWP)
Number of mobile nodes	150
Number of groups	1
Transmission range	10m
Node speed	Min=0.5m/sec Max=1.5m/sec
Message creation interval	One message per 5 – 10 sec
Node Buffer size	20M
Time-To-Live (TTL)	60 min

VI. EVALUATION CRITERIA

In order to compare routing protocols, we must define the some metrics for evaluating their performance.

- **Delivery Probability:** Delivery probability is the fraction of generated messages that are correctly delivered to the final destination.
- **Overhead Ratio:** The overhead ratio measures how many transfers were needed for each message delivery.
- **Latency Average:** the average message delay between when message is generated and when it is received.
- **Hop Count Average:** The average number of hop count between the source and destination node of message.
- **Buffer Time Average:** it is an average time the message stayed in the buffer of each node.

VII. RESULTS AND ANALYSIS

The results given below indicate the comparative study between selfish nodes and different metrics like Delivery probability, Overhead ratio, Latency average, Hop count and Buffer time of routing protocols in DTN.

7.1 Performance Evaluation on Message Delivery Ratio

Fig. 2 shows that average message delivery probability for all protocols with the impact of selfish behavior. The MaxProp and SaWBinary routing protocol have best delivery probability as compared to other routing protocol without including the selfish node. Selfish nodes cause a reduction of the number of message copies circulating in the network (congestion) as they drop them. DTN Protocols like DD, Epidemic, MaxProp, Prophet and SaWBinary their delivery probabilities decreases with the increasing of selfish nodes in network. Protocols, like MaxProp and DD, are barely affected by selfish nodes.

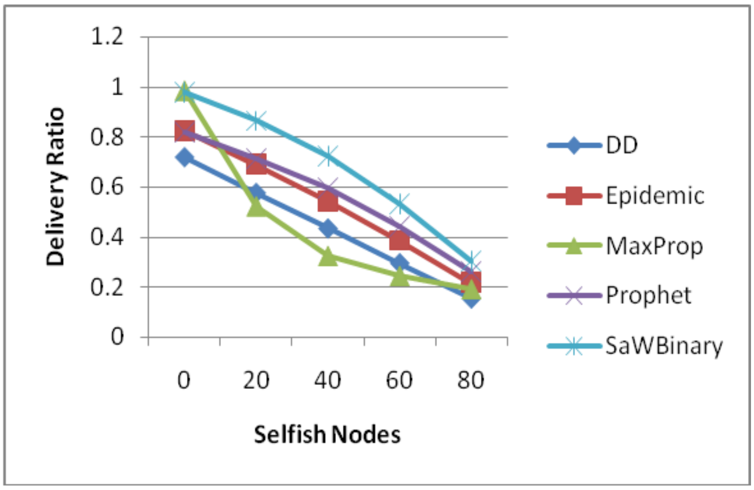

Fig. 2 Delivery Ratio Vs Selfish Nodes

7.2 Performance Evaluation on Message Overhead Ratio

Fig. 3 shows that Epidemic and MaxProp protocol have the highest values of overhead ratio. This happens because of the similarities between these DTN routing protocols. Prophet only has smaller overhead because it uses a probabilistic metric that decides if it is worth replicating a message to a connected node. The protocol DD and SaWBinary have similarities due to which, DD has zero overhead and SaWBinary has smaller values of overhead ratio in comparison with other DTN routing protocols.

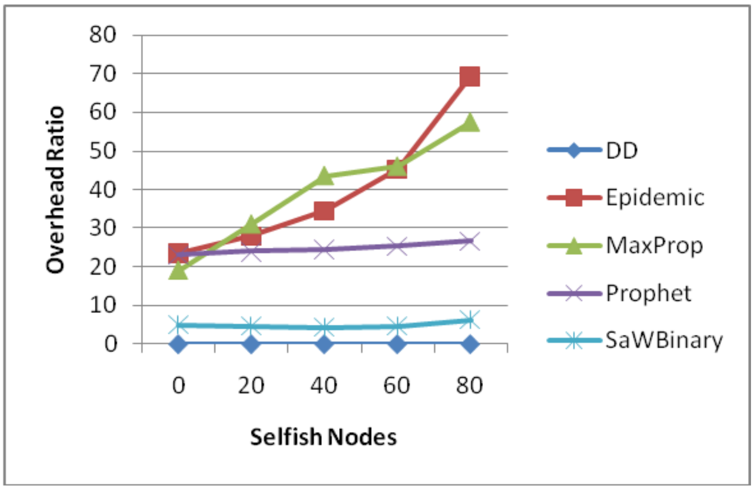

Fig. 3 Overhead Ratio Vs Selfish Nodes

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7.3 Performance Evaluation on Message Latency

Fig. 4 depicts that DD routing protocol presents high values of latency without selfish node in the network. DD routing protocol is also the only protocol in which there is a slightly reduction of latency with the increase of selfish nodes. This happens because undelivered messages do not contribute to the latency statistics and fewer messages are delivered as more selfish nodes drop them. Epidemic, Prophet, SaWBinary and MaxProp routing protocols latencies increased with the increase of the percentage misbehaving nodes. Since messages travel on average a similar number of hops, the increase of selfish nodes caused an increase in network latency. This happens because messages with small latency values are dropped more and more by the increasing number of selfish nodes.

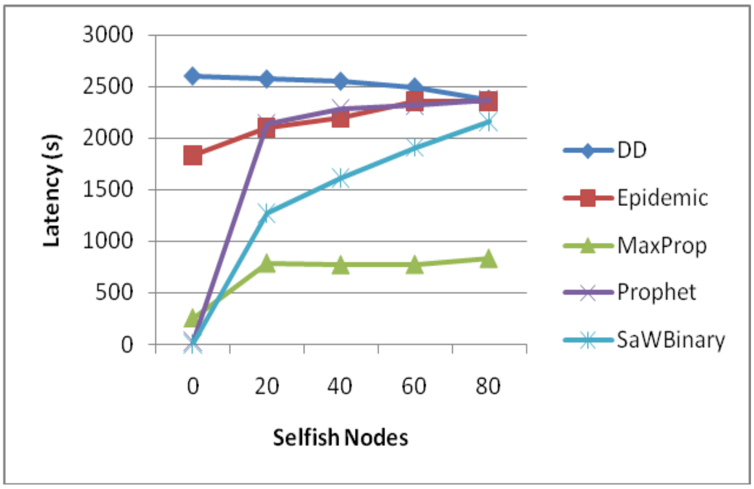

Fig. 4 Latency (s) Vs Selfish Nodes

7.4 Performance Evaluation on Message Buffer Time

Fig. 5 illustrated that DD and SaWBinary routing protocols presents the highest values of buffer time in comparison with other protocols due to using of direct transmission approach. DD presents buffer time values very close to the maximum TTL, as the protocol messages stay in the buffer until it finds the destination nodes or drop them if they expire. SaWBinary protocols suffer more with selfish nodes as the source node replicate messages to selfish nodes that silently drop them. As the outcome, with the increase of selfish nodes, the buffer time decreases.

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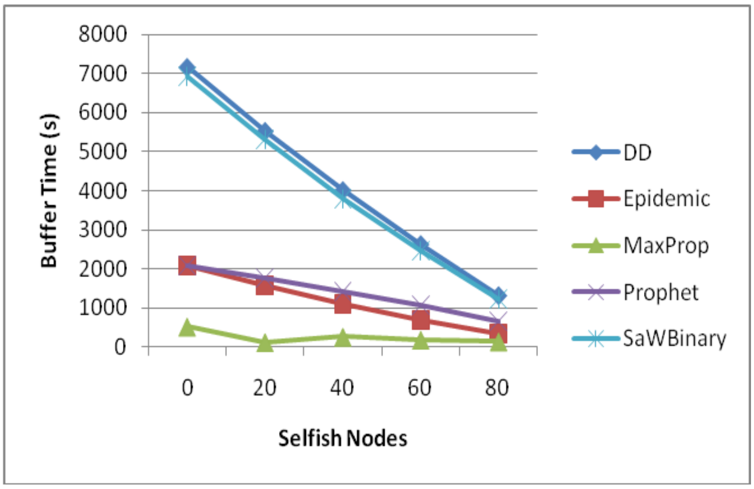

Fig. 5 Buffer Time(s) Vs Selfish Nodes

7.5 Performance Evaluation on Hop Count

Fig. 6 shows that DD has the smallest value of hop count due to the use of a direct transmission approach. Because of the spray phase, SaWBinary has a few more hops. The increase of misbehaving nodes causes a reduction in the number of hops travelled by messages in all routing protocols except MaxProp, for the same reasons as it caused a reduction in the delivery probability.

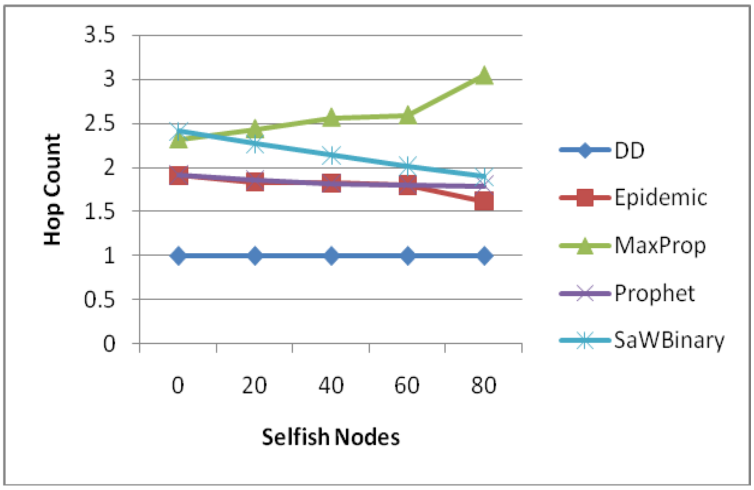

Fig. 6 Hop Count Vs Selfish Nodes

VIII. DISCUSSION AND CONCLUSION

The result and analysis section presents the impact of selfish nodes on different DTN routing protocols. The simulations result in the presence of selfish nodes, Epidemic and Prophet are quite robust as they have unlimited message replication and may even benefit for selfish nodes as they may reduce network congestion. MaxProp and SaWBinary have the highest delivery probability without selfish node. The main conclusion of the paper is that the delivery probability of DTN routing protocols, in the presence of selfish node Prophet, Epidemic and SaWBinary were the best. The delivery probability of all DTN routing protocols are decreased with increasing in selfish nodes.

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