

Analysis of Delay Tolerant Network Routers by Implementing Selfish Node Detection Algorithm with an Incentive Strategy

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Abstract: *Delay-Tolerant networks (DTNs) provide solution to applications where end to end connectivity is weak and not available so to support these applications DTN has characteristics like delay tolerance capacity in packet delivery, intermittent connectivity, scheduled contacts, high error rate and long or variable propagation delays. In DTN, to overcome weak end to end connectivity DTN nodes uses store-carry and forward protocol to relay messages from source to destination node. In DTN in-transit packet we call it as bundle and bundle is opportunistically forwarded to the destination through intermediate nodes. In opportunistic routing, DTN use hypothesis of each node in DTN is cooperative with other nodes and willing to forward in-transit bundle to the destination nodes through intermediate nodes, with this hypothesis DTN perform well in routing but in real time applications of DTN, entities using DTN behaves rational and will not participate in bundle relaying to destination to reserve it's resources like buffer space and energy. This behaviour of a entity or node is called as selfish behaviour of DTN node. Such selfish behaviour of node causes very large impact on bundle routing and decreases the performance of bundle delivery due to packet dropping by selfish node so single selfish node can jeopardise whole network and causes violation of DNT hypothesis. Hence, to overcome selfish behaviour of node we can use basic incentive scheme to promote selfish nodes to take part in bundle forwarding and selfish node detection algorithm to detect selfish node and ban and punish them in bundle routing protocol. We have implemented selfish node detection algorithm with incentive scheme and analysed it with different DTN routers for packet delivery ratio and number of selfish nodes detected.*

Keywords: Delay Tolerant Network, Selfish Node, Selfishness

1. Introduction

A Delay Tolerant Network is a network of regional networks and DTN has characteristics like opportunistic and scheduled contacts, long propagation delay, asymmetric data rate and high error rate. DTNs support interoperability of the networks which covers it by including long delays between and within regional networks, and by translating between regional network communications characteristics. DakNet project of India is a typical example of DTN [1]. In providing with these functions, DTNs accommodate limited energy resource and the mobility of evolving wireless communication devices. The DTN technology has the wider scope; it includes radio frequency (RF), ultra wide band (UWB), and free space optical and ultrasonic technologies [1]. Several networks including the internet also may not have assumptions which Delay Tolerant Network has. Characteristic of Delay Tolerant Networks [4] are Opportunistic contact- connectivity between peer to peer is not always persists and nodes gets connected with each other on opportunity mean when they are in range of each other. Traditional network doesn't support this, it requires guaranteed connectivity.

Intermittent connectivity-DTN supports intermittent connectivity means connections are available at irregular intervals and not continuous or steady because of this intermittent connectivity traditional TCP/IP protocol doesn't work.

Long or variable Delay- bundles in DTN would be a live for long delays due to store-carry and forward protocol but in TCP/IP protocol packet will not survive for long delay and

causes packet dropping in the routing path. Scheduled Contacts-in this characteristics of DTN nodes are get in contact with each other on scheduled moment like in planetary network where satellite gets in contact with each other on particular scheduled moment.

2. Selfishness of Node in DTN

In real time application of DTN entities used in are resource constraint battery operated hand held devices like mobile cell phones, personal digital assistances and laptops. These devices are portable to use in DTN and carry out but are energy and buffer constraint. These resource constraint entities sometimes will not participate in bundle routing and drop the bundle, this behaviour of node is called selfish behaviour. Node is forced to behave selfish because of the limited power, the buffer and so on. A lot of bundle routing algorithms are existing for DTN based on the assumption of each node in DTN is willing to take participation in bundle forwarding but in real time application entities are rational and behaves selfish to reserve their resources and ignores the bundle forwarding. The selfish behaviour causes catastrophic damage. Xin Jiang and Xiang-Yu Bai [2] have discussed various types of incentive strategies and emphasize on the selfishness problem of nodes in the DTN network.

In DTN, there are four types of nodes in context to the bundle forwarding. These are as follow,

Type1-In this type of nodes, they help in bundle forwarding and follow the DTN message relaying assumption. These nodes earn more reputation and credit values from the TAs

in Incentive Schemes. In DTN these nodes have highest priority in bundle forwarding as they are wealthier than other nodes in the network and have greater cooperation probability ($P_c=1$) as compare to other nodes in the network.

Type 2-These types of nodes do not support in bundle forwarding and will not follow the DTN assumption. These nodes earn less reputation and credit values from TAs in Incentive Schemes as they are not helping in bundle forwarding in the network. These nodes have the lowest priority in bundle forwarding as they disobey the message relaying Assumption in DTN. Type 2 nodes have cooperation probability as $P_c=0$ and it is less than other types of nodes in DTN.

Type 3-These types of Nodes helps in bundle forwarding but has moderate cooperation in it. Type 3 nodes earn average reputation and credit values from TAs in incentive schemes and are the fair choice in bundle relaying process. These nodes have in between priority of type 1 and type 2 nodes in the network so these nodes have moderate demand in bundle forwarding. These nodes have cooperation probability between 1 and 0.

Type 4-These nodes do not participate in bundles forwarding which are originated from other nodes in DTN and it results in less earning of credit and reputation from incentive schemes. These nodes have least priority of choice in message relaying in communication and out degree of bundles forwarding is 0 and in degree is equal to the bundles relayed for type 4 nodes in DTN

3. Algorithm for Selfish Node Detection

The basic selfish node detection algorithm [3] is used to detect the misbehaviour nodes.

Let,
 B=Bundle in DTN
 BFR=Set of bundle forwarding requests
 BF=set of bundle forwarded
 CN=set of contacted nodes
 NHC=Set of next hop node chosen for bundle forwarding.
 Procedure Selfish_node_detection

```

for each B ∈ BFR do
    if B ∉ BF && CN!=0 then
        return 1
    else if B ∈ BF && NHC ∉ CN then
        return 1
end if
end for
return 0
end procedure
    
```

4. Simulation setup and results

Here performance evaluation of selfish node detection in terms of packet delivery ratio and number of selfish node detected is proposed to analyse various routers of DTN. For simulation we have used ONE (opportunistic networking environment) simulator [7]. Simulation setup and results are mentioned as below:

Table 1: ONE Simulation Parameters

Parameters	Values
Simulation Area	7,000m * 7,000m
Number of DTN Nodes	80
Duration of Simulation	1000ms-10000ms
Router	Maxprop/Epidemic/Prophet/Direct Delivery/Spray and Wait etc.
Speed of DTN nodes	20m/s
Transmission range	100 meter
Buffer Size	5 Mb
Holding time to wait next node	0-240min
Bundle Size	500Kb-1Mb
Bundle TTL	360min

For the performance evaluation we have taken MaxProp router, Epidemic router, Spray and Wait router, Direct delivery router and prophet router. For each router we have simulation time from 1000ms to 10,000ms and results are noted to calculate packet delivery ratio and number of selfish nodes detecteds. Packet Delivery Ratio is the ratio of a total number of selfish nodes present in DTN to the number of DTN nodes used to carry out simulation.

Table 2: Simulation time and Number of selfish nodes detected

Simulation Time (ms)	Number of selfish nodes detected				
	Spray and Wait Router	Epidemic Router	Direct Delivery Router	Prophet Router	MaxProp Router
1000	2	3	1	2	5
2000	6	2	2	5	7
3000	8	6	0	6	7
4000	11	4	1	9	6
5000	12	5	3	7	7
6000	8	7	2	8	4
7000	7	3	0	13	5
8000	10	5	1	5	8
9000	13	6	2	4	3
10000	12	7	4	9	6

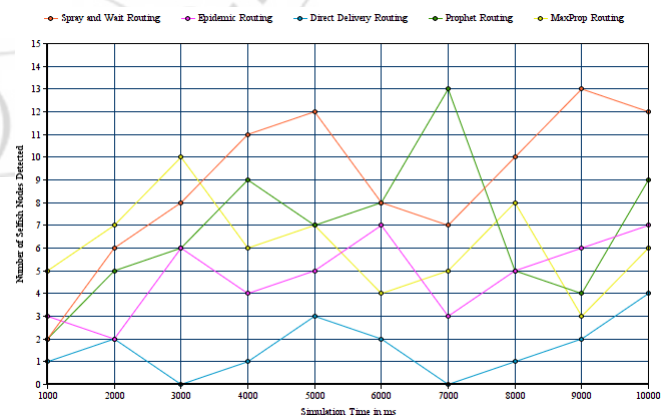


Figure 1: Comparison of DTN routers with basic selfish node detection strategy

Table 3: Simulation Time and Packet Delivery Ratio

Simulation Time (ms)	Packet Delivery Ratio (PDR) (%)				
	Spray and Wait Routing	Epidemic Routing	Direct Delivery Routing	Prophet Routing	MaxProp Routing
1000	5.25	7.67	3.85	1.95	9.40
2000	8.95	9.24	1.95	3.70	6.70
3000	8.67	6.95	2.63	7.82	9.60
4000	15.00	15.78	8.90	15.96	19.7
5000	19.00	17.47	11.75	18.23	20.33
6000	21.05	18.6	14.21	19.23	23.03
7000	24.05	15.8	17.80	21.00	22.42
8000	26.1	21.95	16.54	20.69	21.89
9000	27.5	18.67	18.93	21.89	24.91
10000	29.05	22.3	16.57	23.48	25.75

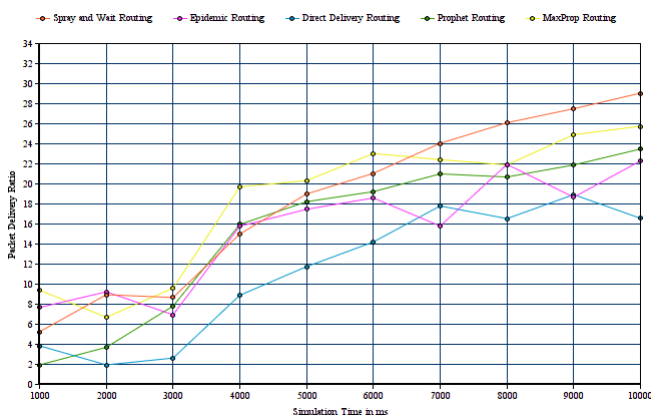


Figure 2: Comparative of DTN routers by Packet Delivery Ratio with basic selfish node detection strategy

Graph and result tables shows that Spary and Wait router has good performance over other routers for selfish node detection algorithm and has highest packet delivery ratio and highest number of selfish nodes detected in simulation.

5. Conclusion

We have implemented basic incentive scheme with selfish node detection algorithm in DTN to analyze various routers in DTN. For simulation we considered four types of nodes based on cooperation probability and selfish detection algorithm is applied to different routers and compared these in terms of packet delivery ratio and number of selfish nodes detected. Finally, analyzed and concluded that Spray and Wait router has highest packet delivery ratio and highest number of selfish nodes detected as compared to other routers used for simulation.

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