Credit-based Cooperation Enforcement Scheme in Delay Tolerant Network

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Credit-based Cooperation Enforcement Scheme in Delay Tolerant Network

Major Project

Submitted in partial fulfillment of the requirements

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Master of Technology in Computer Science and Engineering

Prepared By

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Certificate

This is to certify that the major project report titled **"Credit-based Cooperation Enforcement Scheme in Delay Tolerant Network"** submitted by Vimalkumar Patel (12MCEI25), towards the partial fulfillment of the requirements for the degree of **Master of Technology in Computer Science and Engineering (Information and Network Security)** of Nirma University, Ahmedabad is the record of work carried out by her under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Abstract

Delay tolerant network(DTN) is a network which provide a promising solution to support various applications in the regions where connectivity of end-to-end network is not available. In Delay tolerant networks(DTNs) , the intermediate nodes which are on a communication path between source and destination are expected to store, carry and then forward the bundles which also called in-transit messages in opportunistic way. This is called opportunistic data forwarding . Such kind of forwarding method depend on the assumption that each node in the network is ready to forward bundles for other nodes in the network. This assumption can be violated. Because there may be some selfish or malicious nodes, which may not forward bundles for others and work as bundle relays. Selfish nodes may do this because they do not want to waste their resources to relay bundles of others. To give solution to this problem , we propose credit-based cooperation enforcement scheme. This scheme stimulate selfish nodes to take part in forwarding process. In this scheme some incentives are given in favor of message forwarding by selfish nodes. In this scheme, credits are given to each selfish node lies on forwarding path if bundle is successfully delivered to final destination. In this way, we can achieve better network performance by stimulating selfish nodes to take part in forwarding process.

Key words : Delay tolerant networks(DTN) ,selfish node , incentives , cooperation.

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Chapter 1

Introduction

1.1 Introduction

Delay tolerant networks (DTNs) offer a promising approach to support varied applications in difficult environments wherever an end-to-end path between the communication sources and destinations is inaccessible often. the application of DTN idea advantages various applications that usually suffer from frequent network partitioning, e.g. supporting rural schools in developing countries, affordable net service provision, zebra tracking in Africa, and social networking. In DTNs, because of distributed node density and unpredictable node mobility, bundles, the in-transit messages, are opportunistically routed to the destinations, that follows a store-carry-and-forward paradigm.

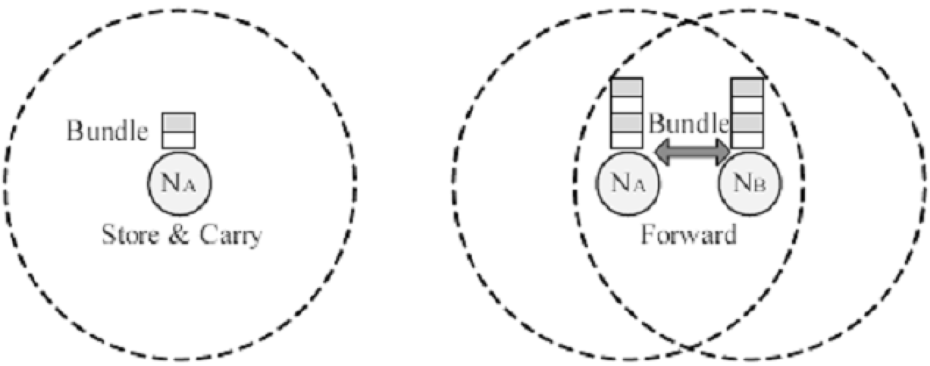

Figure 1.1: Bundle store-carry-and-forward in DTNs [1]

Most of the literature on opportunistic data propagation in DTNs up to now have assumed that every node is willing to cooperate within the dissemination process and forward bundles for others honestly. However, since every DTN node operates below energy and storage resource constraints, some nodes might exhibit numerous degrees of selfishness and be unwilling to serve as bundle relays or custodians on behalf of others to conserve restricted buffer and power. Thus, the hypothesis that every individual node behaves rationally to share its own resources for global connectivity may simply be violated. so as to conserve energy, bandwidth, and process power, selfish nodes might refuse to cooperate and serve as a bundle relay, that dramatically degrades network performance, even results in a nonfunctional network in certain circumstances once opportunistic routes are required. Therefore, the way to restrain selfishness in DTNs has become a difficult issue.

To address the selfishness issue, some credit-based and reputation-based incentive schemes, providing economical and promising solutions, are proposed. Credit-based schemes, e.g. payment schemes, aim at stimulating selfish nodes to collaborate through introducing some kind of virtual currency. Nodes are paid for forwarding, and pay for the forwarding of their own bundles transmitted by others. These schemes create make nodes unwilling to deny forwarding, however, selfish nodes target different forms of misbehavior, e.g. silent route changes. Reputation-based schemes monitor and rate the behavior of neighboring nodes so that nodes will respond according to the opinion on others. These schemes enable nodes to differentiate and exclude selfish nodes. reputation schemes are eligible for dealing with any quite misbehavior as long as it is noticeable.

However, the distinctive characteristics of DTNs create the existing schemes, that are proposed for standard ad hoc networks or P2P networks, not applicable for DTNs. First, due to the intermittent connectivity and network partitioning, the assumption, that is adopted in all existing scheme , that there always end -to end path between source and destination exist which doesn't hold. Second, opportunistic forwarding makes the main approaches to find neighboring nodes behavior, e.g. promiscuous listening mode, inefficient. Third, multiple-copy routing adopted in DTNs to enhance network performance and communication reliability isn't compatible with existing schemes designed for single-copy routing.

To address the issue of selfishness in network ,some barter based approach are also there which provide the solution to the network with selfish behavior very efficiently and promisingly.In barter-based approach , when to nodes which are in range of each other make a connection .Then they will first send complete description of messages those are their in buffer to each other and then they decide which messages they want to take from each other. For fulfillment of fairness there are some constrains that the size of selected subset must be same , messages are transferred in messages by messages pattern ,in priority wise. If any node cheats , the sending and receiving can be disrupted and party which is honest does not lose any major disadvantages because the messages which are downloaded by honest party are at most one less than messages downloaded by selfish or misbehaving node.

In this it is up to nodes that which messages they want to take from eachother.There can be selfishness like only download those messages which are more important for them. However ,the misbehaving will not be more useful in long run. For example , some messages may not be interested for particular node A but those messages may be interesting for any other node like B , and A can use that in protocol which is described above to get messages from B that are already interesting for A. In simple word we can say that , there is also some barter value even if that are not directly interested for node .

There are some limitations for barter-based approach like:

- If two nodes establish a connection, then the lifetime of this connection is sufficiently long such that the two nodes can fully execute their message exchange.
- Every message has approximately the same size, and therefore, the cost of downloading a message over the wireless link is the same for every message.
- The communication cost of a message is much higher than its storage cost. Storage has no cost, and storage space is not limited in the nodes.
- Messages lose their value over time. This is true for the primary value of a message as well as for its barter value.

A reputation scheme is composed of two parts: reputation architecture, which refer to an operation mode including obtaining , storage and communication of reputation between nodes; and a computation model, which refers to some related mathematical equations for the processing of networks' statistics. Up to now, main focus on the computational Models is done in order to acquire more exact reputation ratings. But the designs of robust reputation architecture are in need of more attention. Most of existing reputation schemes adopts source routing and promiscuous listening as the main approach for the detection of nodes' behavior. But as we know in delay tolerant network ,end-to-end path is hardly available so node monitoring is very difficult task.

For credit-based cooperation enforcement scheme , charges or rewards are given based on some models. Those models we can say rewarding models. There are two models. The first one is packet purse model in which the charges are given by the source of packet while second one is packet trade model in which charges are given by destination. We can use both models to provide hybrid model.

The Packet Purse Model (PPM) : In packet purse model , the source will pay for messages forwarded. The charge is given among all intermediate nodes in following way : When source send packets ,first it loads number of nuglets .The nuglets should be sufficient to reach to the destination. Each intermediate node which forward packet takes some nuglets from the packet that include cost of forwarding .The number of nuglets that are charged by intermediate nodes may depend on many things like energy that is used to forward packet , the battery status of intermediate node , and number of nuglets it has.If there are not enough nuglets to forward then packets will be discarded.

Packet forwarding in the Packet Purse Model is illustrated in Figure 1.2. Let us assume that originally each terminode has 7 nuglets (1). Furthermore, let us assume that A wants to send a packet to D. In order to do so, A loads, say, 5 nuglets in the packet and sends it to the next hop (2). B takes out 1 nugget from the packet, and forwards it with the remaining 4 nuglets to C (3). C takes out 2 nuglets from the packet and forwards it with the remaining 2 nuglets to the final destination D (4). Note that terminodes B and C , which forwarded the packet, increased their stock of nuglets, whereas terminode A , which originated the packet, decreased its stock of nuglets.

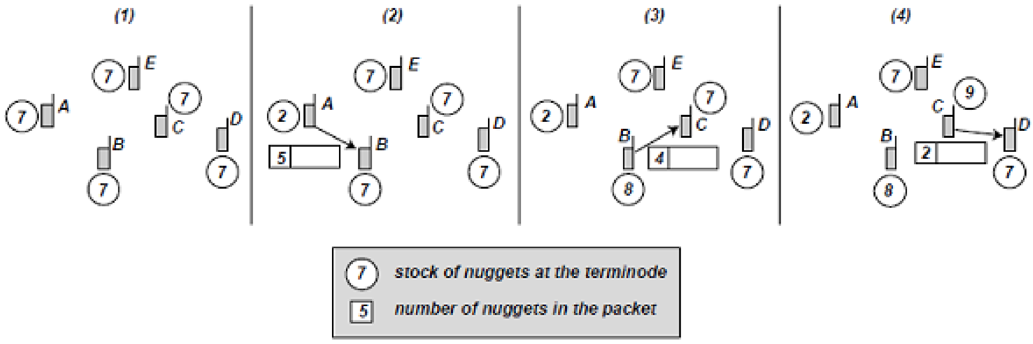

Figure 1.2: The Packet Purse Model(PPM)

The main advantage of the PPM is that even if stimulating selfish nodes , this can also stop nodes from sending data which are not useful and can deter from overloading network. Overloading prevention is an important issue because the bandwidth available is decreased when nodes increase.we assume that traffic do not exhibit local property.The main disadvantages of PPM is that the estimation of number of nuglets which are required to reach destination is very difficult. If source of the packet less estimate this number ,packet can not be reach to destination and will be discarded and source will lose its investment in packet. Therefor the source must overestimate the nuglets number .The nuglets which are left even after reached to destination may be taken by destination or if the destination has provided some services that can be used for pay for that. However source should make attention in over estimation , because packets which holds nuglets can be dropped during transmission because of several reasons like buffer overflow etc.

The Packet Trade Model (PTM) : In Packet Trade Model , there is no need to load nuglets in packet but packets are traded by intermediate nodes for some nuglets. In this approach , each intermediate node buys packet from previous node for some nuglets. If the previous node is source node then it buys for free from source node. Then it sells that packet to next node or it can be destination also for more nuglets. In this way ,each intermediate node which have taken part in forwarding of packet increase nuglets number. The total cost for forwarding the packet is given by the destination node of packet. If the intermediate node next to it do not want to buy packet for that price , then intermediate will try to sell to another intermediate node or try to sell at lower price or it will discard that packet.

Let's consider Fig 1.3 .Let make assumption that initially each node has 7 nuglets.Now assume that Node A wants to forward packet to D. A will send packet to the hop B without any charge.B will then forward it to C for 1 nuglet.And then at end ,C forward it to destination D for 2 nuglets.In this case note one thing that ,each intermediate (B and C) who forward the packet increase the nuglets number while D decrease the nuglets number.

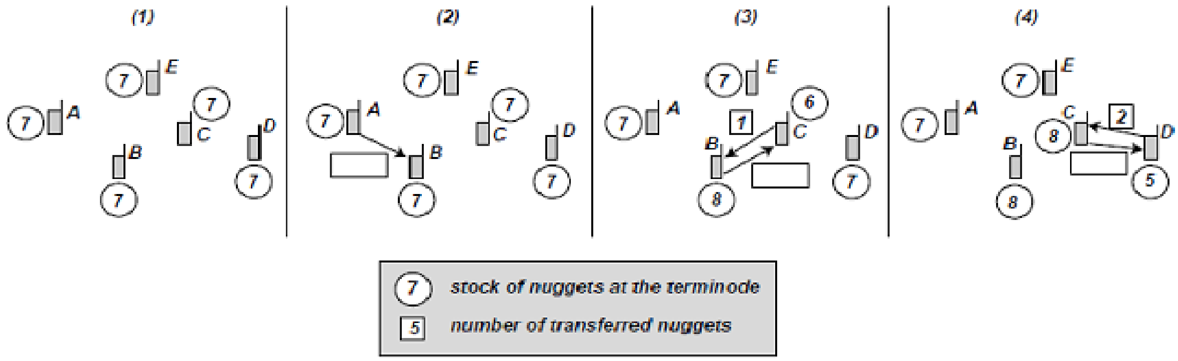

Figure 1.3: The Packet Trade Model(PTM) [10]

An advantage of Packet Trade Model is that the source of packet doesn't need to know in advance that how much nuglets are required to deliver a packet.Here destination of packet pays for forwarding which makes this model suitable in case of multicasting packet as well. A disadvantage of this model is that this approach does not stop nodes from overloading the network.

A hybrid model : The models which we have discussed can be together in following way : The source first load nuglets in the packet before sending. The packet is forwarded according to PPM till it has no nuglets remaining.Then it is forwarded according to PTM till it reaches to destination. In this approach ,the advantages of both models are combined. First because the source have to pay yet , it will not send useless data in the network and overload network. Another , source can also underestimate nuglets number which it puts in packet because even if there are no nuglets in packet they will not be discarded.

In this project, in order to enhance the performance of the DTNs in terms of high delivery ratio and low average delay,we propose a Credit-based incentive scheme to handle the selfishness problem in DTNs. in the proposed scheme, the scheme stimulate selfish nodes to take part in forwarding process. In this scheme some incentives are given in favor of message forwarding by selfish nodes. In this scheme ,credits are given to each selfish node lies on forwarding path if bundle is successfully delivered to final destination. In this way, we can achieve better network performance by stimulating selfish nodes to take part in forwarding process.

1.2 Problem Definition

In this project we are implementing credit-based cooperation enforcement scheme in Delay Tolerant network to protect network from the effect of selfish behavior of nodes. To do so, we first add selfish behavior to certain percentage of nodes in the network and analyses the effect of that selfish nodes using performance metrics like delivery ratio, average delay and overhead.

After analyses the effect of selfish behavior to network we found that performance of network decrease as percentage of selfish nodes increase. So we implement credit-based cooperation enforcement scheme to give some incentive to selfish nodes to stimulate those selfish nodes to take part in forwarding process of bundles. For simulation we use ONE(Opportunistic Network Environment) simulator which is specially designed for evaluating DTN routing and application protocols.

1.3 Scope

The assumption and the scope of the project as as following.

- We assume that there exist a virtual bank(VB) in the network which takes charge of credit clearance.
- We have one more assumption that each intermediate node contain the tamper resistent security module like a special chip or a smart card kind of thing that is used for preventing attack by attacker like modification of behavior of node.

1.4 Objectives of Study

- The study focus on performance of spray and wait routing protocol and its consequences.
- Finding out the performance of SNW protocol under presence of selfish nodes.
- Comparing the results with and without selfish nodes.
- Proposed credit-based cooperation enforcement scheme to stimulate selfish nodes to take part in packet forwarding.
- Comparing the results with and without cooperation scheme.

Chapter 2

Literature Survey

There are three kinds of node behavior: 1) Forwarding or cooperative nodes are altruistic:they store and forward messages for others with none restriction. 2) Non forwarding or non cooperative nodes: they originate messages as a source and receive messages destined for them as a sink, however don't accept the other messages that will need forwarding. Such nodes are selfish (free riders) and use others for his or her own good, however don't contribute to the community, minimizing their own resource consumption. 3) partially forwarding or partly cooperative Nodes : they accept messages from different nodes for forwarding, however only deliver them directly to the destination. [2]

In the network, intermediate nodes forward packets for source and destination. It is service provided by them. So, credits should be given by either source or by the destination. So there are two models proposed in which charging methods are described for packet forwarding services. 1) Packet Purse Model(also called PPM) : In this model charges are covered by the source of message. If packet has not enough credits to give for forwarding then they will be discarded.It is very difficult to estimate the nuglets require to reach to given destination. 2) Packet Trade Model(also called PTM): In this model the charges are covered by the destination of the packet. Source doesn't need to know that how much nuglets will require to reach to destination. 3) Hybrid Model :In this model ,both above models are combined, first packet will be handled according to PPM till number of nuglets finish and then it will be handled by PTM till destination.From above models,we can not apply it in DTNs directly because all models assume that there exist end-to-end path between source and destination which is not possible in DTNs.[3]

In barter-based approach , when two nodes which are in range of each other and connection is made between them then at very first them send complete messages descriptions those are their in buffer to each other and then they decide which messages they want to take from each other. For fulfillment of fairness there are some constrains that the size of selected subset must be same , messages are transferred in messages by messages pattern ,in priority wise. If any node cheats , the disruption occur in sending and receiving and party which is honest do not lose any big disadvantages because messages downloaded by that honest party are maximum of one less than messages which are downloaded by selfish or misbehaving node.

In this nodes have to decide that which messages from eachother they want to take.There can be selfishness like only download those messages which are more important for them. However ,the misbehaving will not be more useful in long run. For example , some messages may not be interested for particular node A but those messages might be interesting for node like B , and node A can use that in protocol which is discussed above to get messages from B that are already interesting for A. In simple word we can say that , there is also some barter value even if that are not directly interested for node.[4]

Sprite, a simple, cheat-proof, credit-based system for mobile ad-hoc networks with narcissistic nodes.In this system credits are used to provide incentive to selfish nodes. However, one of the novel and distinctive features is that, system doesn't want any tamper-proof hardware at any node.When a node receives a message, the node keeps a receipt of the message. Later, once the node has a fast connection to a Credit Clearance Service (CCS), it reports to the CCS the messages that it's received/forwarded by uploading its receipts. The CCS then determines the charge and credit to every node involved within the transmission of a message, depending on the reported receipts of a message.The design of system has 2 main problems. First, since there's no tamper-proof hardware at any node and the charge and credit are based on the reports of the selfish nodes, a selfish node (or even a bunch of colluding node) might attempt to cheat the system to maximize its expected welfare. As an example, a selfish node might withhold its receipt, or collude with different nodes to forge receipts, if such actions can maximize its welfare.Second, a node should receive enough credit for forwarding a message for another node, so it can send its own messages with the received credit, unless the resource of the node itself is very low.[5]

A node that belongs to a community is willing to relay messages for the nodes among the same community but refuses to relay messages for the nodes outside its community.Selfish behavior can be classify into 2 categories: individual selfishness and social selfishness. Selfish action can be divided in two categories : 1) Non-forwarding of messages and second is 2) dropping of messages. In non forwarding of messages , packets are not forwarded by nodes to which that node is selfish.While in dropping of message , messages are accepted by node and node are agree on being relay but after receiving message it drops those messages. From above discussion we can say that there are two totally different aspect of classification.Two aspects of the classification are collusion and noncooperation. From the perspective of collusion, selfish behavior can be classified into two categories: individual selfishness and social selfishness. From the perspective of non-cooperation, selfish behavior can be classified into two categories as well: non-forwarding of messages and dropping of messages.[10]

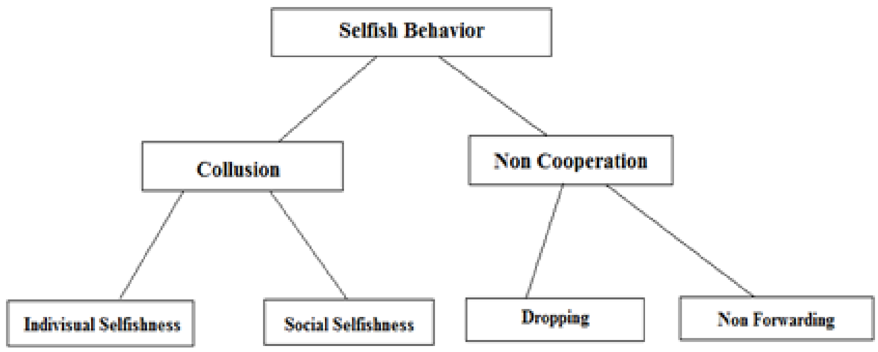

Figure 2.1: The classification of selfish behavior[10]

Xi Zhang et. al. [11], present that the unique characteristics of DTNs make the existing credit and reputation based schemes, which are proposed for conventional ad hoc networks or P2P networks, not applicable for DTNs. First, due to the intermittent connectivity and network partitioning, the hypothesis, adopted in existing schemes, that there is a contemporaneous end-to-end path between the source and destination does not hold. Second, opportunistic forwarding makes the main approaches to detect neighboring nodes behavior, e.g. promiscuous listening mode, inefficient. Third, multiple-copy routing adopted in DTNs to improve network performance and communication reliability is not compatible with existing schemes designed for single-copy routing.

To cope with the selfishness in DTNs, there is a practical reputation-based incentive scheme, named PRI, which enables DTNs to keep functioning and improves network performance even if the presence of selfish nodes. In that scheme, selfish nodes have to behave honestly in the bundle propagation process in order to avoid being isolated from networks.

In order to address the monitoring of nodes behavior, there is a concept of successful forwarding credential (SFC) which serves as a behavior record of successful forwarding. The generation and transmission of this credential is integrated into an observation protocol. A verifiable signature technique is used to guarantee the feasibility and provides authentication and integrity protection in the PRI scheme.

To achieve fairness, a novel reputation model is used. In that model, both the quantity that a node cooperates and the ratio of successful forwarding to total have an impact on reputation values. In order to obtain a good reputation value, nodes need to provide reliable service of forwarding continuously. Furthermore, each DTN node provides service of forwarding for honest nodes in advance, and excludes selfish nodes whose values are below a deterministic reputation threshold, which energetically stimulates all individuals to cooperate in forwarding in order to earn a great reputation. [11]

Xiaofei Wang et. al. [12], present the concept of reputation based scheme.The definition of the agent reputation is given in that.It is observation which is related to its behavior that the other node in the network have for him.It is based on the actions those are taken by that node as well observation and experiences .For example the reputation value is low for a node that means other nodes consider that node as selfish. Suppose the reputation value is high for a given node that means other nodes consider that node as cooperative.In simple term ,we can say that the nodes will send packet of nodes only if those nodes have forwarded the packets which are generated from others. So calculation of reputation value of any node of network in this strategy is very important . Reputation based cooperation scheme can be divided into two different models.In which first is detection-based model and the second one is without detection model. In the first model which is detection-based model, each node of network observe the behavior of the receivers from which it receives message,which is used in detection of selfish nodes and then to stimulate those selfish nodes to cooperate with other nodes. In one scheme, each intermediate node receives a receipt after forwarding a message to another node. The receipt is a proof about the cooperation of the intermediate node. In another scheme similar to previous scheme ,Receiver sends receipt to all nodes in the network means it floods instead of sending to only sender. In another proposed scheme selfish node detection is done in a different way. In this scheme the forwarding records and encountering nodes records are kept by sender which held the message identifier, forwarding time and the message destination. When two nodes come in eachother transmission range, it will check the record of forwarding done earlier and messages received since they have met last time to detect the selfish nodes and cooperative nodes. But it is very difficult to detect selfish behavior in DTNs because end to- end path are rarely available and there are high chance of changes in network topology. So second approach is used , in that approach all nodes reputation is decreased periodically .The reputation of nodes only increase when they have participated in successful delivery of packet. [12]

Chapter 3

Proposed work

In this proposed work we are preventing from the selfish behavior of nodes by providing credit-based cooperation enforcement scheme. There are basically three types of strategies for cooperation enforcement .1)Reputation based. 2) Credit based and 3) Barter based. But in Reputation based and barter based strategies ,there are some assumption and limitation for DTNs .In reputation based scheme , it is very difficult to monitor the behavior of neighboring node in DTNs because of lack of guaranteed connectivity and low frequency of encounters between DTN nodes. So it is not feasible to calculate reputation value for nodes in network. In barter-based scheme ,there are also some assumption like If connection is established between two nodes, then the life-time of that connection should be long enough such that messages of those nodes can fully executed by nodes. Which can generally not possible in DTNs. So we go for credit-based scheme.

In our approach we first simulate the normal scenario without any selfish nodes and cooperation scheme. We then add certain number of selfish nodes to that network. We analyses network performance with selfish nodes and without selfish nodes. From result it is clear that delivery ratio decrease as number of selfish nodes increases. So we then implement credit based cooperation enforcement scheme to stimulate selfish nodes to take part in bundle forwarding process. In this approach we use nuglets(virtual currency) as incentives. In this approach , packet does not carry nuglets , but nuglets are provided by destination if message is successfully forwarded. An advantage of this approach is that the source does not need to know in advance the number of nuglets required to deliver a packet. For simplicity we are giving same number of nuglets for each packet. The total number of nuglets required for complete delivery are paid by destination.

In delay tolerant network, packets are forwarded in store-carry and forward paradigm. So there is no knowledge of full path. So it is very difficult to know in advance the number of nuglets required to reach at destination. So in our approach we use destination for paying which is feasible for DTN. In our scheme nodes will only get nuglets if message is successfully delivered otherwise nuglets are not given even if they have take part in forwarding packet.

SYSTEM MODEL:

A. Network Model :

- We consider a general delay tolerant network consistence of set of mobile devices owned by individual users.
- We also assume that each node has limited transmission capabilities as well as reception capabilities. So that two nodes which are not in transmission range of eachother can communicate only via a sequence of intermediate nodes in multihop manner. There is no guarantee of end-to-end connections and routing is made in opportunistic way.
- We assume that there exist virtual bank(VB) ,which takes charge of credit clearance.

B. Data-Forwarding Strategy :

- We consider generalized multicopy data forwarding architecture.
- Source node S generate bundles and spread then at every intermediate nodes, messages will opportunistically be forwarded to next hops.

C. Rewarding Model :

- In our rewarding model we are paying per packet. That means that ,for each successfully transmitted fixed sized packet , every selfish intermediate node should receive some credits. If message is not delivered successfully then the intermediate selfish nodes will not get reward even if they have taken part in bundles forwarding.

D. Design Goals

- The proposed scheme should be effective in stimulating cooperation among the selfish nodes.
- It should efficiently work without introducing much extra communication and transmission overhead.
- It should be compatible with the most popular DTN routing schemes.

Chapter 4

Implementation

For simulation we use Opportunistic Networking Environment(ONE)(Version -1.5.1) simulator. The ONE has been specifically designed for evaluating DTN routing and application protocols. The ONE contain following some performance factor which makes its very useful.
1) ONE allows user to create scenarios based upon different movement models and real-world traces.
2) ONE allows user to implement routing and application protocols. It also contains six well-known routing protocols.
3) ONE offers simulation framework which support mobility and event generation ,DTN routing and application protocols, a basic of energy consumption ,message exchange , visualization and analysis ,interfaces for importing and exporting mobility traces, entire message and events.

4.1 Simulation Tools

Opportunistic Networking Environment(Version 1.5.1) ,widely known as ONE, is an agent-based discrete event simulator. The ONE is written in Java programming language. Different parts of the programs are divided in different packages. Core components of the simulator are in the core package. GUI-related classes are present in gui package , routing related classes are in routing package and movement models classes are in movement package.

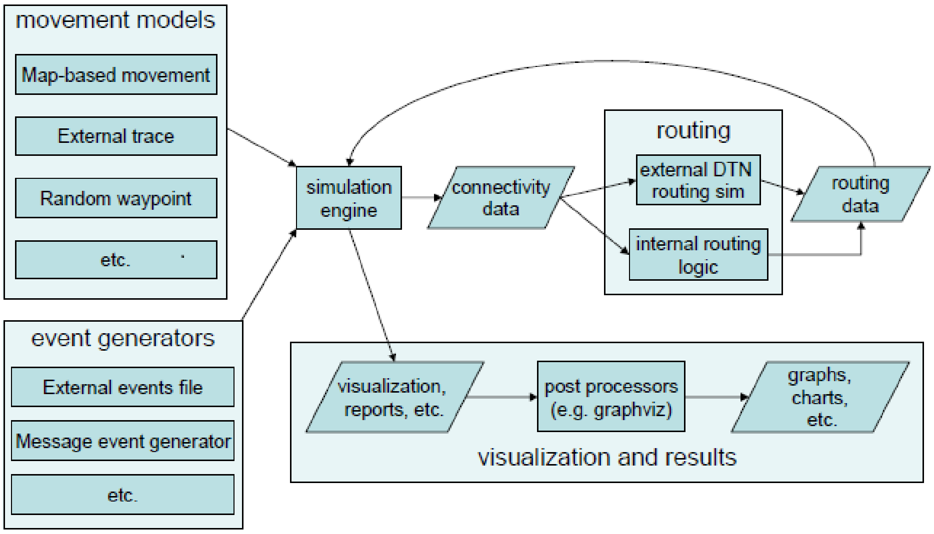

Figure 4.1: Basic Architecture of ONE [9]

Various movement models in the ONE simulator : Mobility models implements the node movement capabilities in the network. In the mobility models there are some algorithms and rules which generate the paths of node movements. There are three types of movement models which are included in ONE :1) random movement 2) map-constrained random movement and 3) human behavior based movement. The ONE also contains the framework in which new movement can be created as well as interface from which external movement data can be loaded. In fig below there are implementations of some popular movement models like Random Walk , Random Waypoint etc are included.

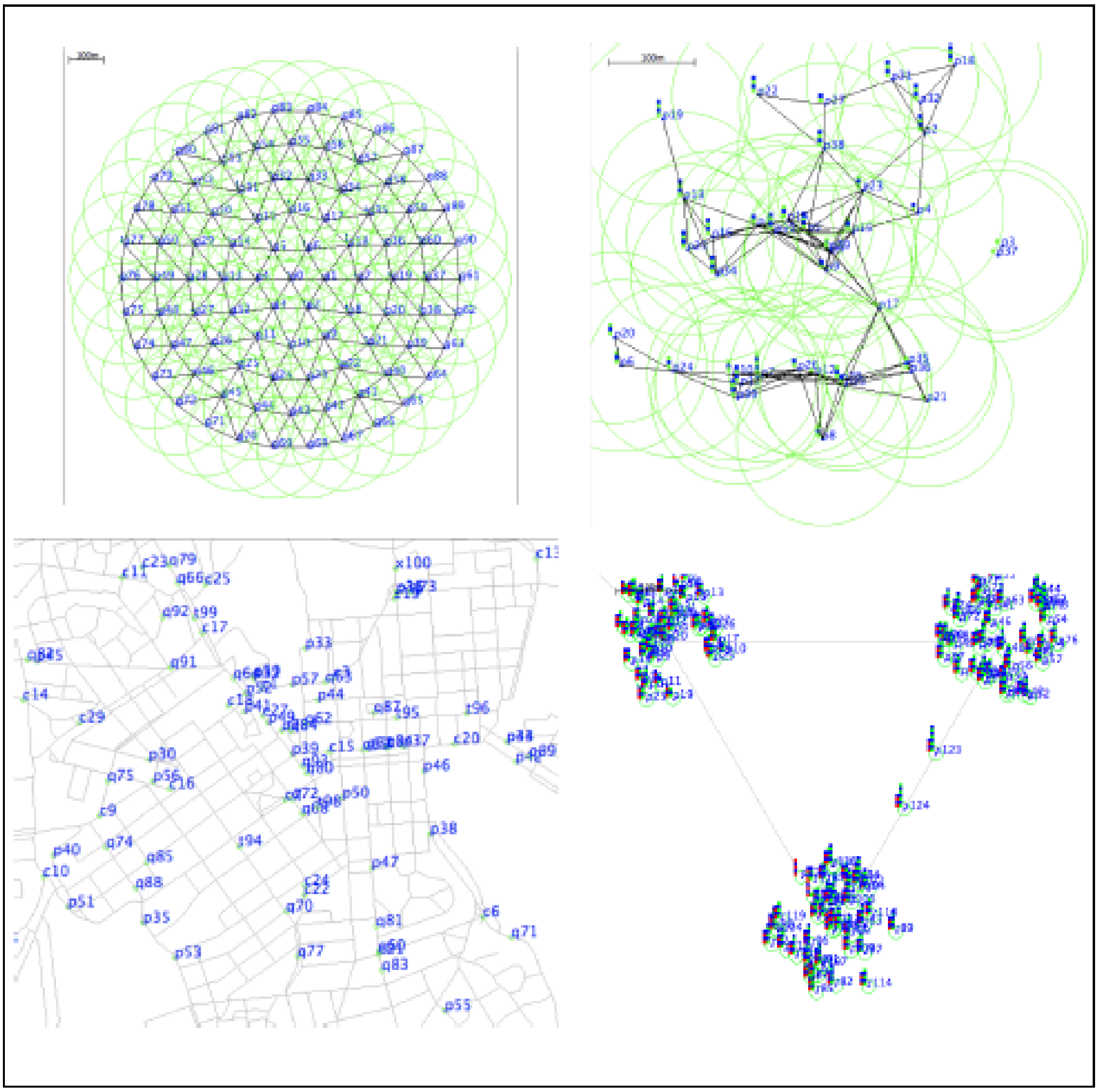

Figure 4.2: Various mobility models in ONE

4.2 Simulation Setup

Our scheme is implemented in ONE simulator.In our scenario there are 400 nodes.All nodes have transmission coverage of 10 m and uniformly distributed in area of 4000m 4000 m. The speed of nodes 0.5 km/h to 1.5 km/h. Nodes follows mapbased movement model which makes simulation realistic. Evaluation runs on the top of binary spray and wait routing protocol. The detail of simulation parameters are summarized as follow.

We will simulate our system using two configurations of selfish nodes in network.

1) In first scenario we simulate for the network in which there is not a single selfish node.The network is free of selfish behavior.

Parameter	**Value**
Scenario	
Simulation area	4000 m by 4000 m
Duration	12 hours
DTN nodes	
Number	400
Velocity	0.5 km/h to 1.5 km/h
Routing Protocol	Spray and Wait
Transmission Coverage	10 m
Mobility Model	Map based model
Buffer size	5 Mb
Bundles	
Generation interval	25 sec - 35 sec
TTL	300 Minutes
Number of forwarding copies	6

2)While in second scenario the network is mixed with normal nodes and selfish nodes.We increase the number of selfish nodes from 0 to 40 percentage of total nodes.

Parameter	**Value**
Scenario	
Simulation area	4000 m by 4000 m
Duration	12 hours
DTN nodes	
Normal nodes	400
Selfish nodes	0 to 40 percentage
Velocity	0.5 km/h to 1.5 km/h
Routing Protocol	Spray and Wait
Transmission Coverage	10 m
Mobility Model	Map based model
Buffer size	5 Mb
Bundles	
Generation interval	25 sec - 35 sec
TTL	300 Minutes
Number of forwarding copies	6

The performance metrics chosen for evaluation of effect of selfish node and cooperation scheme are packet delivery ratio, average delay and overhead.

Packet Delivery Ratio: The ratio between the number of generated bundles that are successfully delivered to destination node within timetolive(ttl)

The average delay: which is the average time between when a bundle is generated from the source node and when it is delivered to its destination

Overhead :which is the ratio of bundles that relayed in intermediate nodes to bundles that arrives at destination.

Chapter 5

Simulation Results

After performing proposed system using ONE with required tools and environment we have screen like below which performs all completed work.

5.1 Simulation Performance

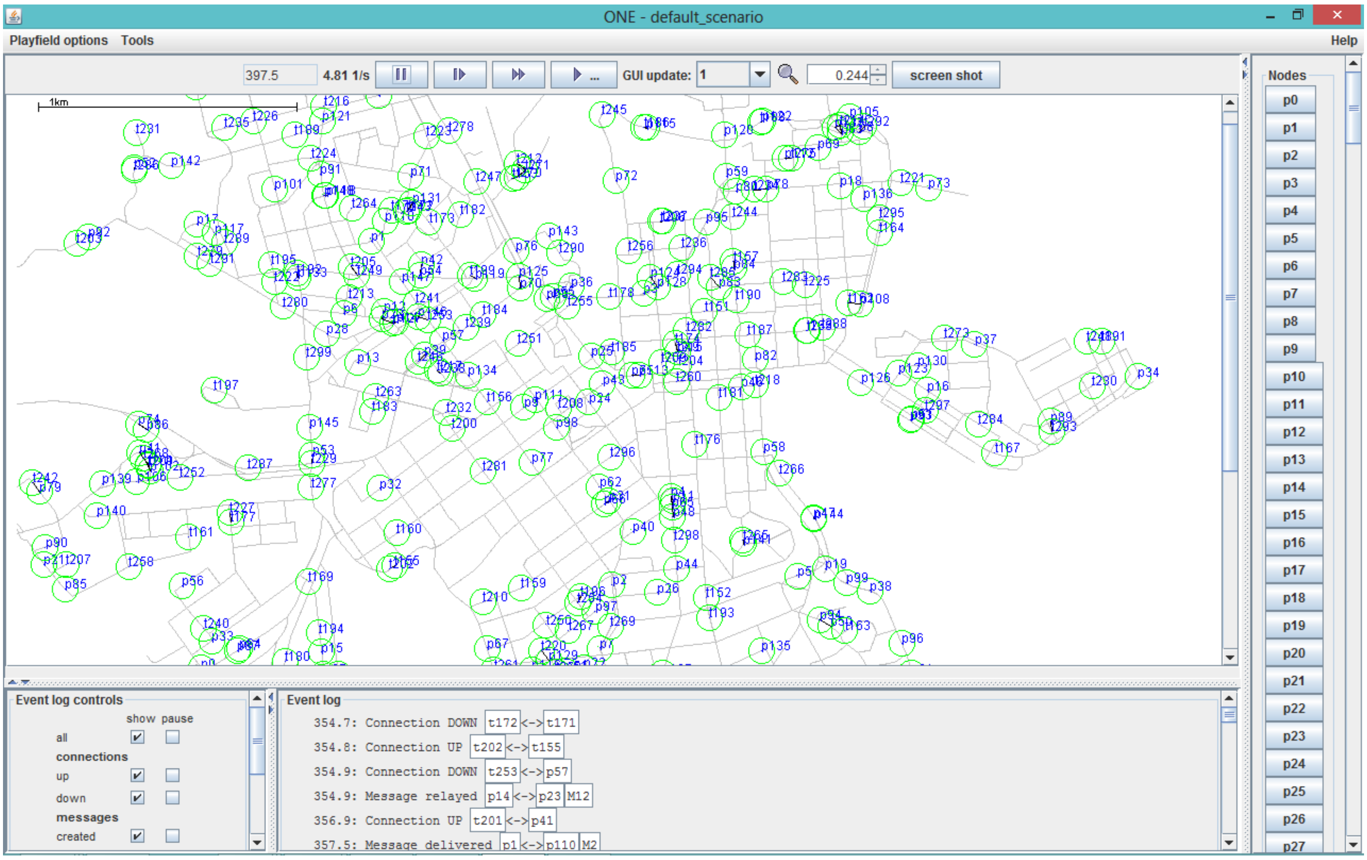

Figure 5.1: Execution of ONE with 300 nodes

The results were collected as comparison of Delivery Ratio for selfish nodes and normal nodes.As well as dropped messages and overhead ration is also compared for selfish nodes and normal nodes.The results for different scenario are as follows:

Scenario 1 Impact of selfish nodes on the network performance : To evaluate the impact of selfish nodes on the network performance , we analyses system performance at different percentage of selfish nodes.

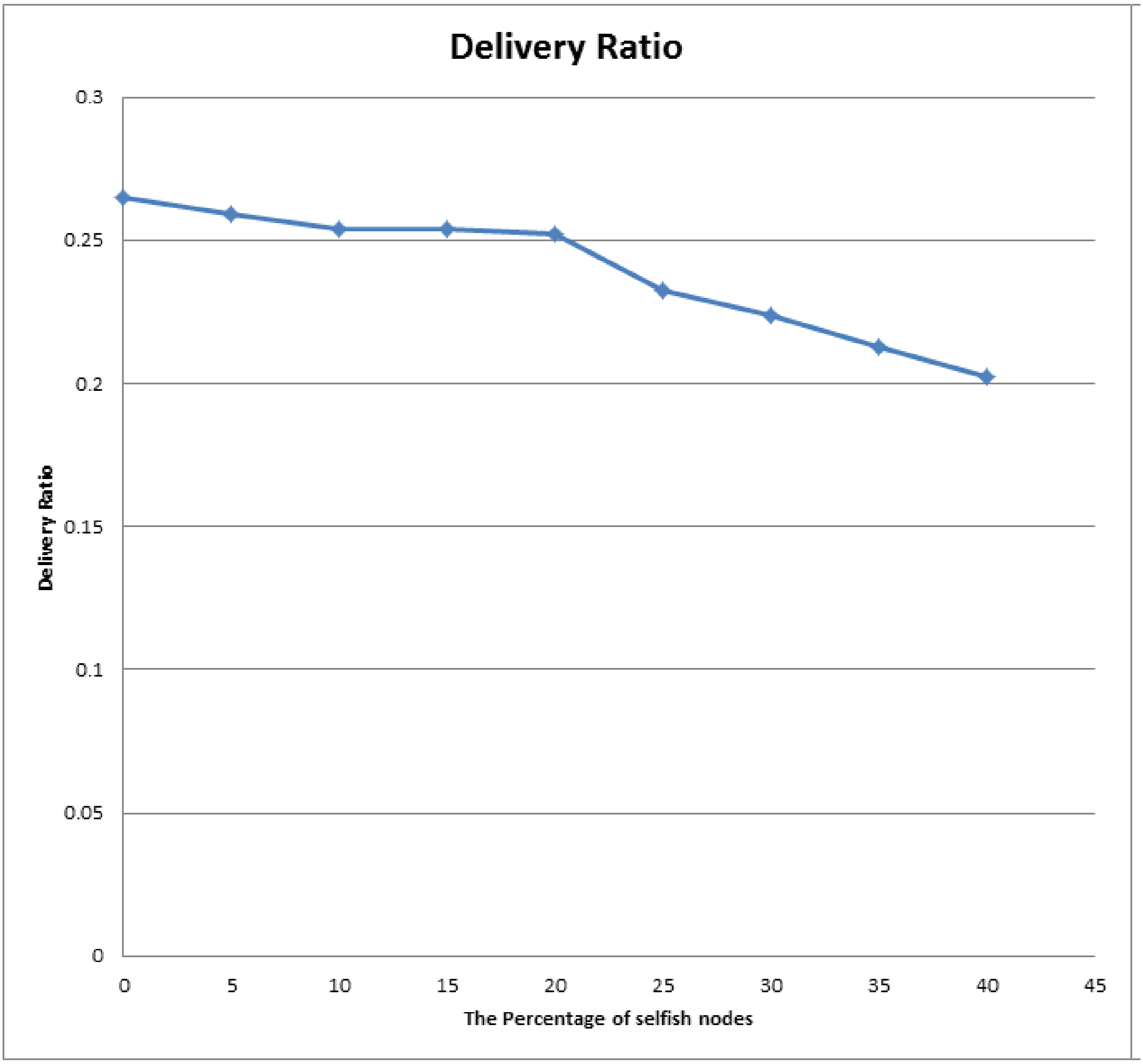

Figure 5.2: Successful Delivery Ratio

As shown in Fig.5.2 ,when percentage of selfish nodes increase from 0 to 40 percentage,the delivery ratio decrease from 0.2647 to 0.2023.

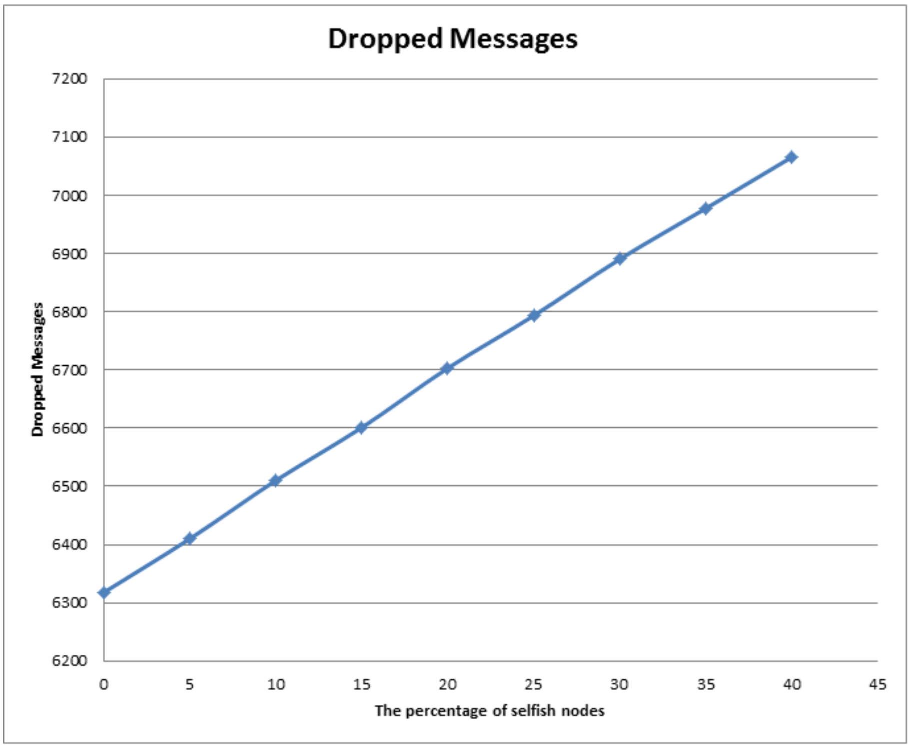

Figure 5.3: The number of dropped messages

As shown in Fig.5.3, when percentage of selfish nodes increase from 0 to 40 percentage, the dropped messages count increase from 6247 to 7065.

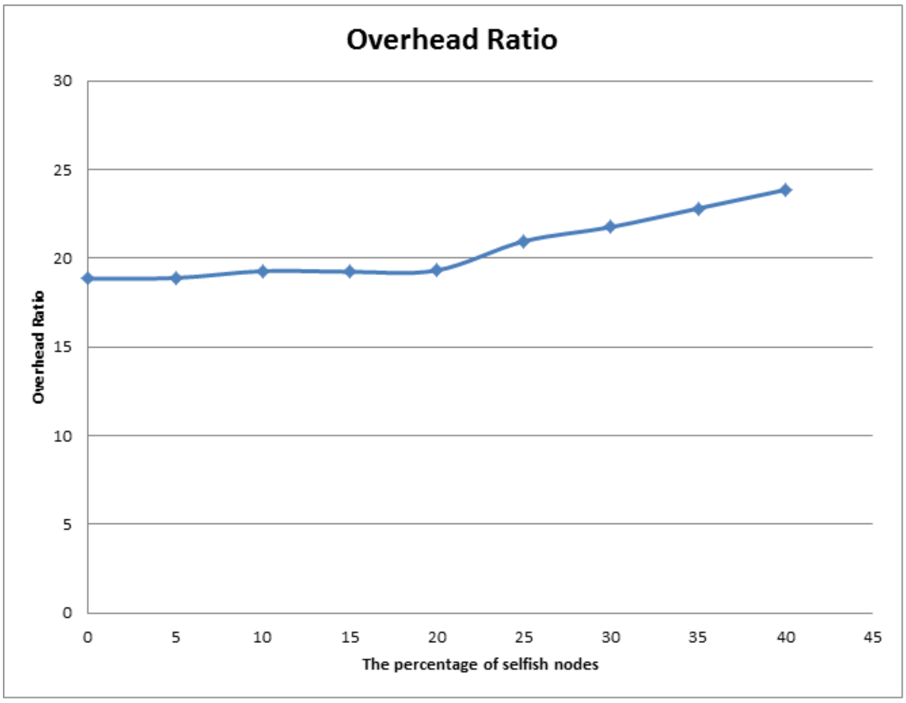

Figure 5.4: The overhead ratio

As shown in Fig.5.4 , when percentage of selfish nodes increase from 0 to 40 percentage, the overhead ratio increase from 18.52 to 23.86.

From above three results ,we can say that network performance decrease when number of selfish nodes increase in netwok.

Scenario 2 : Impact of forwarding copy number : There are two types of forwarding in DTN. single copy and multycopy data forwarding.In this section we will check the impact of forwarding copy number on the system performance and find optimal forwarding copy number in normal scenario.

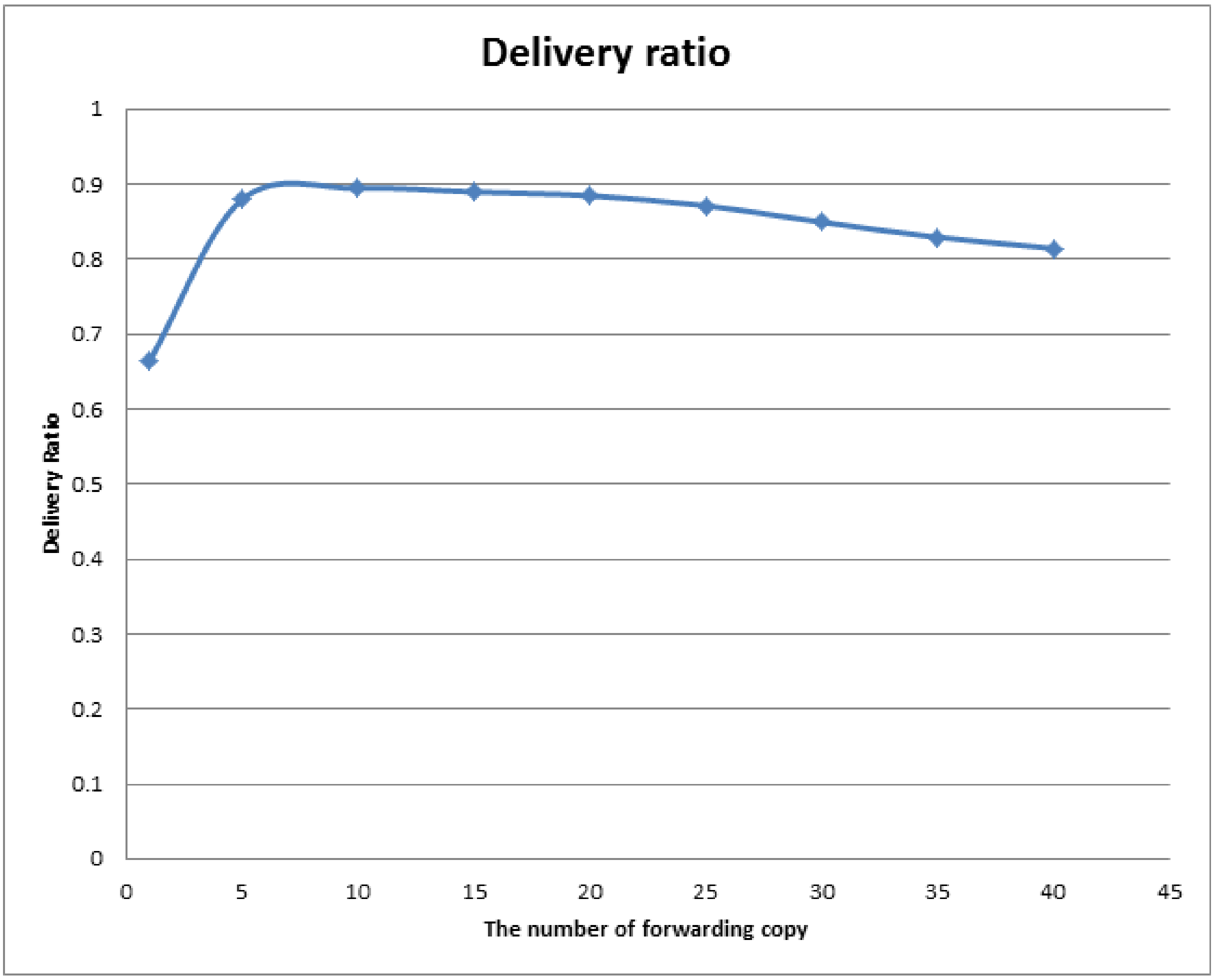

Figure 5.5: The Delivery ratio

In Fig.5.5 ,the forwarding copy number is initially set to 1 and then increase by 5.from fig ,we can say that delivery rate will increase very fast in earlier time and thenafter a specific threshold it decrease. This shows that there exist optimal forwarding copy number to obtain highest delivery rate.

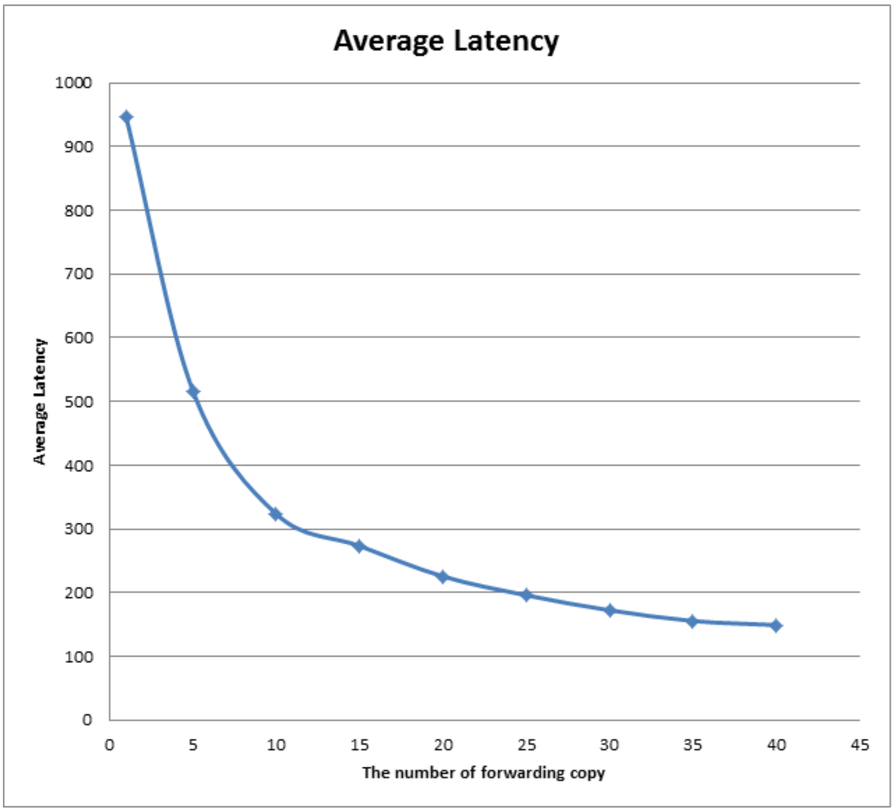

Figure 5.6: Average Latency

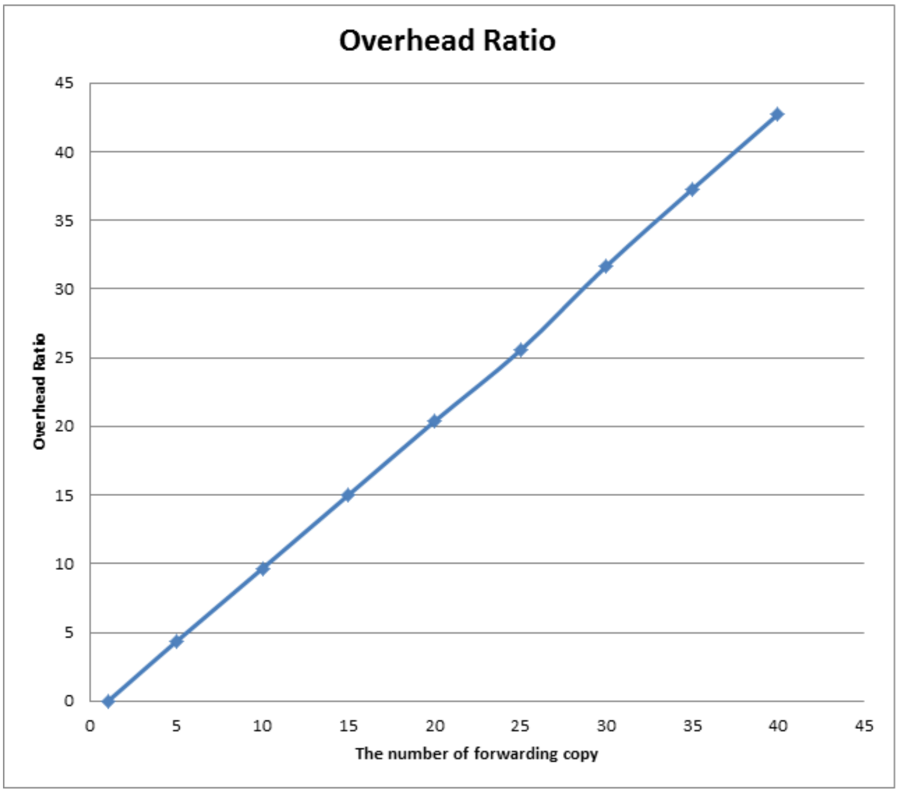

Figure 5.7: The overhead ratio

In Fig.5.6 and Fig.5.7 ,it is seen that average latency will decrease when number of forwarding copy increase and overhead ratio increase when number of forwarding copy increase.

Scenario 3 : Effectiveness of cooperation scheme : To evaluate the effect of cooperation enforcement scheme on the network performance , we analyses system performance at different percentage of selfish nodes. We analyses system performance with the presence of selfish nodes and no cooperation scheme and another scenario in which with presence of selfish nodes and also with cooperation scheme.

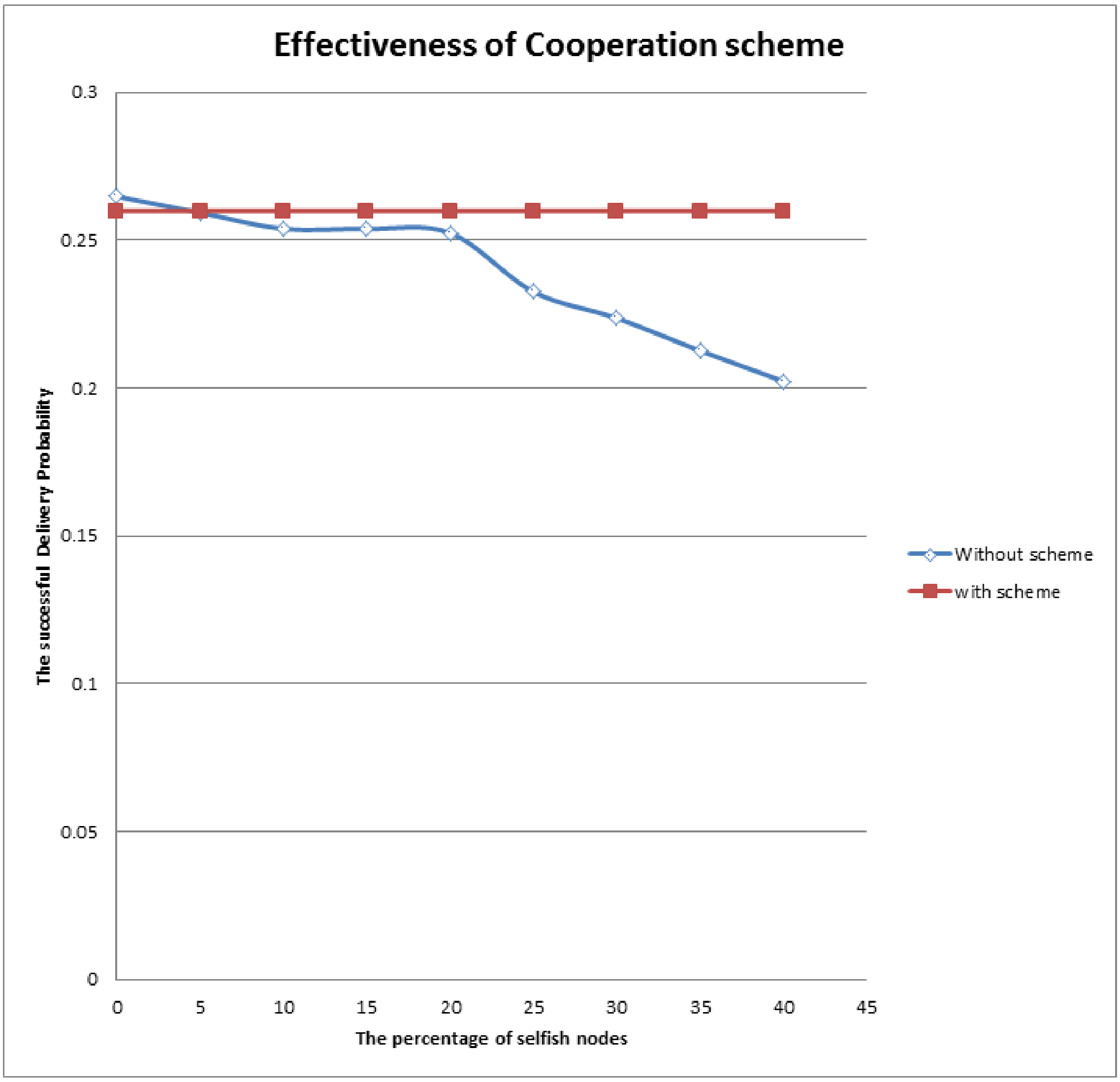

Figure 5.8: The incentive effectiveness of cooperation scheme

From Fig.5.8 ,we can say that when percentage of selfish nodes increase from 0 to 40 percentage,the delivery ratio decrease from 0.2647 to 0.2023.But when cooperation scheme is implemented ,nodes are attracted to participate in bundle forwarding process to earn more and more credits.

Chapter 6

Conclusion and Future Work

6.1 Conclusion

In this work, we proposed and simulated credit-based cooperation enforcement scheme in Delay Tolerant Network to stimulate selfish nodes so that they take part in bundle forwarding process. Selfish nodes refuses to carry out networking tasks for others and decrease the network performance.

The efficiency of credit-based cooperation enforcement scheme through simulations has been also measured.

6.2 Future Work

In this project , selfish nodes only get credits if bundle is successfully delivered to final destination. If bundle is not forwarded to final destination even if selfish nodes have taken part in forwarding process they do not earn credits.

In future , cooperation scheme may be implemented in which even if bundle is not successfully delivered to final destination then also intermediate selfish nodes which have taken part in forwarding process should earn some reputation which would help them in future task.

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