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Misbehavior Node In VDTN(Vehicular Delay Tolerant Network)

Heena S. Kapadia

Electronics & Communication Engineering Department, Dr. S & S.S. Ghandhy Government Engineering College, Surat, Gujarat, India

Abstract
Vehicular delay-tolerant networks (VDTNs) are based on the delay-tolerant network (DTN) concept applied to vehicular networks, where vehicles mobility is used for connectivity. VDTNs appear as an alternative to provide low cost asynchronous internet access on developing countries or isolated regions, enabling non-real time services, such as e-mail, web access, telemedicine, environmental monitoring and other data collection applications. However, there are some misbehaving nodes that consume the network resources and decrease its performance so the bundle cannot be delivered to the intended destination. In this paper, we introduce the concept of misbehavior of nodes and punish them to improve the performance of VDTN.
Keywords: *Delay Tolerant Network, Misbehavior of nodes, Routing, Vehicular Delay Tolerant Network.*

1. Introduction.

Vehicle communication is important for future life. Imagine a day when vehicles are able to communicate with one another. Imagine a future where drivers would be warned of a potential crash by the vehicle they are driving because of this communication. The technology to make this happen exists today. This technology is nothing but vehicular network.

Routing in vehicular networks presents a particularly challenging problem due to the unique characteristics of these networks. These unique characteristics motivate the use of an opportunistic routing model known as the store-carry-and forward (SCF) paradigm in the context of delay tolerant networking (DTN). The idea behind SCF is to buffer and forward messages (called bundles) hop-by-hop by intermediate nodes until reaching its destination. Researchers have increasingly been interested in applying DTN techniques to vehicular networks. These networks are usually called vehicular delay-tolerant networks (VDTNs). Vehicular delay-tolerant network (VDTN) is a network architecture based on the delay-tolerant network paradigm, which was designed to provide low-cost asynchronous vehicular communications in environments with disruptions, intermittency, variable delays, and network partition. Data communications in vehicular delay-tolerant networks (VDTNs) present new challenges when compared with other kinds of networks. The paper work aims to improve the performance of VDTN by enhancing performance parameters.

2. Delay Tolerant Network

Delay tolerant networks are wireless mobile ad hoc often where a communication path between a source node and destination node does not exist, either directly or through established routes by intermediate nodes. This situation occurs if the network is sparse and partitioned into several areas due to high mobility, low density nodes or when the network extends over long distances. The DTN concept has been applied to various areas including interplanetary networks ,underwater networks ,wildlife tracking sensor networks and networks to benefit developing communities.

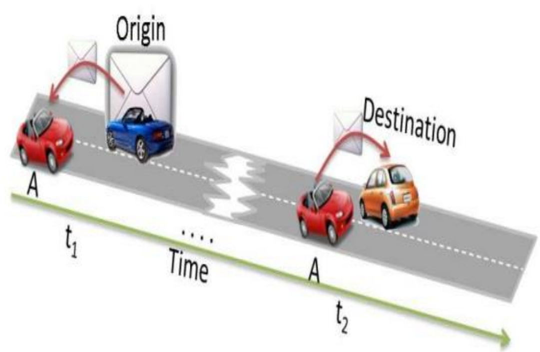

Figure 1 A representation of two communication opportunities in a DTN.

Fall (2003) is one of the first authors to define DTN and discuss its potential. According to his definition, a DTN consists of a sequence of time-dependent opportunistic contacts. During these contacts, messages are forwarded from their source towards their destination. This is illustrated in Figure 1, in the first contact the origin sends the message to A in time t1, then A holds the message until it delivers to the destination in the contact at time t2. Contacts are characterized by their start and end times, capacity, latency, end points and direction. The routing algorithm can use these pieces of information to decide the

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most appropriate route(s) to deliver a message from its source to its destination. However, routing in a network where the edges among the mobile nodes depend on time signifies is not a straightforward task. One needs to find an effective route, both in time and space. All nodes along the path should consider the nodes movement pattern and the possible communication opportunities for message forwarding. Unfortunately, it is not always easy to determine future communication opportunities or even forecast the mobility patterns of the nodes in the network.

3. Vehicular Delay Tolerant Network

Vehicular Delay-Tolerant Network (VDTN) is a particular application of a mobile DTN, where vehicles are opportunistically exploited to offer a message relaying service. VDTN architecture also adopts a store-carry-and-forward paradigm from DTNs. Nonetheless, VDTN distinguishes itself from the DTN architecture by positioning the bundle layer between the network and data link layers, introducing a clear separation between control and data planes using out-of-band signaling.

3.1 VDTN Architecture Model

VDTN architecture model is based on the three node types presented on Figure 2: terminal nodes, mobile nodes, and relay nodes.

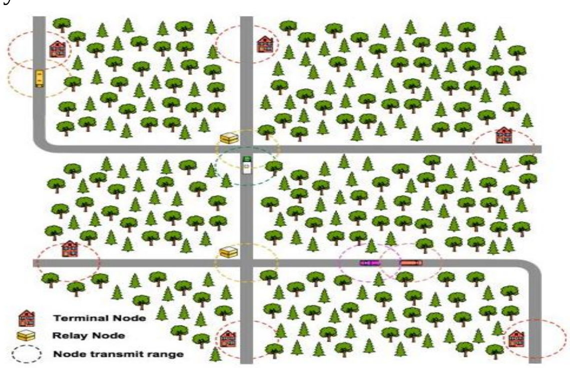

Figure 2 Example of Vehicular Delay Tolerant Network Nodes.

Terminal nodes are located in isolated villages and provide network connection to end-users. They are usually placed at the edge of the VDTN network and are responsible for the heavy data processing and interaction with other networks (such as, the Internet). Terminal nodes are the VDTN access points providing several application services such as exchanging emails, documents, voice mails, movies, music, images, among others.

Mobile nodes (e.g., vehicles) act as the communication infrastructure for the network, collecting and disseminating data. They can move along the roads randomly (e.g. cars), or following predefined routes (e.g. buses and trams) roads and carry data between terminal nodes (figure 2).

Relay nodes are store-and-forward stationary devices located at crossroads. They are placed at road intersections increasing the number of network contacts and storing a higher number of bundles that can be picked by any passing-by vehicle. They allow mobile nodes that pass by to collect and leave data on them, thus improving the overall message delivery probability. When mobile nodes meet, they can exchange data with one another. Relay nodes can be audio signal traffic lights, placed in the crossroads of the smart city streets.

3.2 VDTN Architecture Working

The principle of VDTN architecture working is illustrated in Figure 3. At the time t+t0 , a mobile node and a relay node detect each other and start exchanging signaling messages through the control plane link connection. Both nodes use routing information to determine which bundles should be forwarded. Then, based on this information, the data plane connection is configured and activated on both nodes at the time t + t1. Then, The data bundles are exchanged until the time t + t2. The data plane connection is deactivated after that time instant, since the nodes are no longer in the data plane link range of each other.

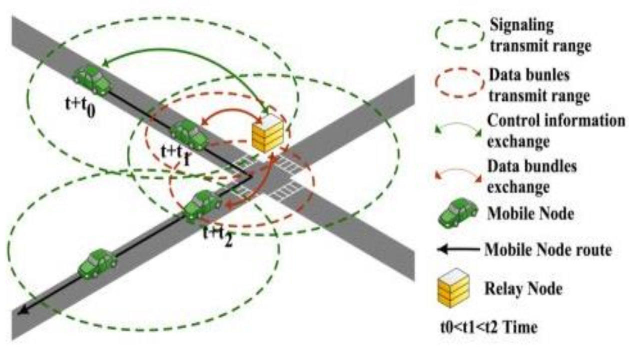

Figure 3 Illustration of the VDTN control information and data bundles exchange

3.3 VDTN Application

VDTN is used to provide a low cost solution to connect villages located in a vast geographical area with a sparse population density, and where a telecommunications infrastructure is not available. In such a scenario, incurred delays are high and unpredictable, intermittent connectivity is common and data paths exist over time. Some of the potential non-real time applications for this scenario are: notification of blocked roads, accident warnings, free parking spots, advertisements, and also gathering information collected by vehicles such as road pavement defects.

3.4 Routing Protocols Used In VDTN

Direct Delivery is a simple DTN routing protocol based on single copy strategy where only one copy of each message exists in the network. In direct delivery, the source keeps the message in and transmits it only to the final destination, when they meet each other. The message will be dropped if it has not been sent, when the buffer is full.

First Contact is single copy DTN routing protocol, with one copy of each message in the network. The message is transmitted to the destination along a single path of nodes selected randomly from the available links. The message is forwarded to the first node encountered and deleted. If there is no connection the node having the message, store data, and transmit it to the first contact available.

Epidemic Routing protocol is a flooding based protocol where nodes replicate message unlimited time and transmit it to newly discovered contacts that have not a copy of the message. This strategy minimizes the delivery delay and maximizes the delivery ratio as messages may reach the destination on multiple paths, but spoils storage and bandwidth in comparison with other protocols.

Contrary to epidemic, with spray and wait protocol the source create a limited copies of message. This protocol contains two phases: (1) Spray phase, where the source creates n-copies of message that will be spread the others nodes till the n copies get exhausted. (2) Wait phase, where the nodes that receive the message transfer it to its final destination when they meet it.

The binary spray and wait protocol is a new version of this protocol. With the binary mode, the source of message create a limited number of copies and transfer the half of message copies to each encounter.

Probabilistic Routing Protocol using History of Encounters and Transitivity routing protocol (Prophet). It’s based on the strategy of forwarding. This routing protocol calculates probabilistic metric named delivery predictability that attempts to estimate which node has the higher probability to deliver successfully the message to final destination with the minimal delay. The message is delivered to the node that has a higher delivery predictability based on node encounter history.

MaxProp is a DTN routing protocol that uses several mechanisms to define the order of transmission and deleting packets. It uses a ranked list of the peer’s stored packets based on a cost assigned to each destination which is an estimate of delivery likelihood. Nodes exchange messages depending on the delivery likelihood in order to give the priority to some nodes between others. New packets have a higher priority. Maxprop uses acknowledgments to all peers to delete the remaining copies of the message in the network when received by the destination.

4. Misbehavior Of Node

In VDTNs, the system and its ingredients are not necessarily homogeneous in purpose and capabilities. The mobility of nodes could become predictable depending on the scenario. In such a network, the cooperation between vehicles turns crucial for the functioning of the whole system. The collision would have been avoided if cooperation between the two cars occurred.

However, node behavior has been rarely considered in previous studies. Indeed, besides node mobility, and in the majority of previous works, it has been assumed that the nodes fully cooperate. Sending and receiving data consumes the resources of nodes, especially their energy, which may be the limiting factor, so that cooperation may be perceived expensive and thus unwanted. This may induce users to make their nodes less cooperative (selfish). Thus, the result of selfishness is that nodes cannot count on the help of others. Although, cooperation is required to achieve a certain communication performance to meet the vehicles requirements; therefore and as in the case of Direct Delivery routing, nodes could only deliver messages when they meet the destination.

Authors in [12] develop a unified view of the classification of selfish behavior into two aspects: collusion and non-cooperation. On the first level of collusion, selfish behavior can be classified into two categories: individual selfishness and social selfishness.

This paper is concerned by the non-cooperation which is classified by into three types: cooperative, partly and non-cooperative models. Forwarding or cooperative nodes are altruistic; they store, carry and forward messages for others with no restriction, while non-cooperative nodes do not accept any other messages that would need forwarding. These nodes are selfish and use others for their own interest, but do not contribute to the community, minimizing their own resources.

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The authors in [13] define Cooperation by the node's willingness or ability to participate in the message forwarding; a node may be willing but unable to cooperate due to the lack of resources. Two types of cooperation models are considered by the authors: Upon reception of the message copy (type 1), the node either drops it with probability Pdrop or keeps it and follows the rules of the routing algorithm. Upon reception of the message copy(type 2), the node maintains the copy in its buffer but forwards it with a probability Pforward inferior than 1.

5. Simulation Evaluation

In order to evaluate the performance of different routing protocols against non-cooperation of nodes, we use the Opportunistic Network Environment (ONE) simulator[17], which is designed for evaluating and simulating DTN routing protocols and scenarios. We extend the use of ONE to include the simulation of cooperative and non-cooperative nodes. We define groups in a way that allows us to vary their composition with respect to density of network and the three cooperation models: fully cooperative, partly cooperative and non-cooperative. The network scenario is based on a part of the city of Helsinki (Finland). This is the default map in the ONE simulator. The number of mobile nodes is varying from 40 to 100 representing a sparse and dense network in the context of VDTNs. Ten stationary destination nodes and ten stationary source nodes are placed at the map position. Data bundles are originated at stationary source nodes and are destined to stationary terminal nodes. No random transmissions have been used in all simulations. To this end, we have used external event generator to create 1000 messages with sizes varying from 100KB to 1MB.Those messages are created in an interval time between the start of the simulation and 900s.

5.1 Routing Protocols

Four different routing protocols are used for simulations: Epidemic, Spray-and -Wait, MaxProp and Prophet.

5.2 Scenario

Figure 4 shows the localization of all stationary nodes before running the simulation where one can see all nodes participating in the simulations. Source nodes (S) represent sensors used in urban area to collect different types of information and measures whereas destination nodes (D) are gateways connected to Internet. The use of VDTN networks in such a context can be a promising low-cost solution for urban sensing and information/entertainment applications.

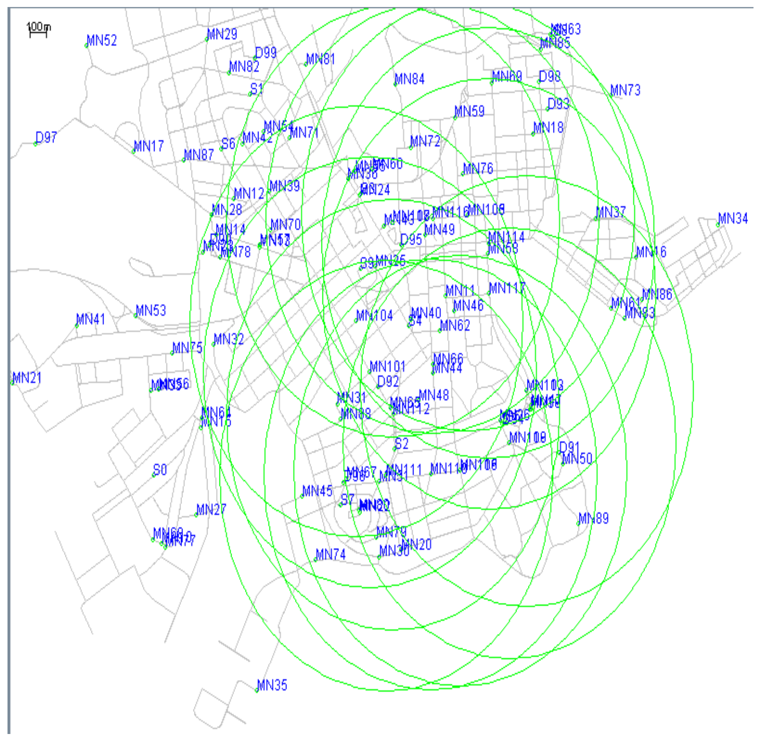


Figure 4 The position of Sources (S), destinations (D) and mobile nodes (MN) in the network

TABLE 1 SIMULATION PARAMETERS

Simulation time (seconds)	43,200
Buffer size (bytes)	5 M
Movement Model	Map Based Movement
TTL(min)	50,100,150,200,300,400,500
Routing protocol	Epidemic routing, SnW, MaxProp and Prophet
Interface type	Simple Broadcast Interface
Number of nodes	10 sources, 10 destinations, 20& 80 mobile nodes
Velocity of mobile nodes (m/s)	2.7, 13.9
Size of bundles (kbytes)	100, 1,000
Size of map (m²)	4,500 × 3,400
Transmission range (m)	10
Transmission rate (kbps)	250
Message generation intervals(s)	1900

All nodes in the network have a 5M in their buffer size. During the simulated 43200s period of time, the group of mobile nodes (vehicles) moves along the map roads with a speed ranging from 2.7 to 13.9 m/s, between random locations. Data bundles are originated at specific stationary source nodes and are destined to specific stationary terminal nodes. No random transmissions have been used in all simulations. The update interval defining the time step increment for the simulation time is set to 0.1 s.

5.3 Performance Metrics

We measure the delivery performance of routing protocol under given cooperation constraints by means of three metrics: the delivery probability of the messages the overhead-ratio and their average latency. The Delivery probability, the key performance indicator of the simulations, is measured as the relation of the number of unique delivered bundles to the number of bundles created. The latency is an indicator for the connectivity of the network under a given mobility and cooperation model but also for the network load, it can be defined as the average time needed to finish transmitting messages to their destinations. Overhead ratio is an assessment of bandwidth efficiency, interpreted as the number of created copies per delivered message. That is, the amount of replicas necessary to perform a successful delivery.

5.4 Algorithm

In order to model a cooperation of network, we need to consider:

- The number of cooperatives nodes
- The degree of non-cooperation (D_c) of each node: It's represents the willing to accept or not a message sent by other nodes. In our model, the range of cooperation varies from 0, 50 and 100.
- The function WantToCooperate : This function is called every time a node needs to take a decision
- The function PutToIncomingBuffer : This function put incoming messages in the buffer until the node meet another node.

We Study the impact of the cooperation degree for four routing protocols. Each plotted metric is an average of 1000 messaging events. We present how the percentage of non-cooperative nodes affects the overall routing performance of the network. We vary t he degree of non-cooperation of nodes between D_c= 0 (fully cooperative), 50 (partly cooperative) and 100 (non-cooperative).When the degree of non-cooperation is equal to 0, this means that all nodes cooperate normally. However, when the degree increases, some nodes don't forward the bundle upon message reception. We use a random number (Rnum) generator to obtain values from 1 to 100, and compare it with the D_c of the node, when the Rnum of node is lower than D_c, then the function WantToCooperate and PutToIncomingBuffer are false. The algorithm we propose is represented in TABLE .

TABLE 2 . ALGORITHM OF NON-COOPERATION

Algorithm : Type 1

Begin

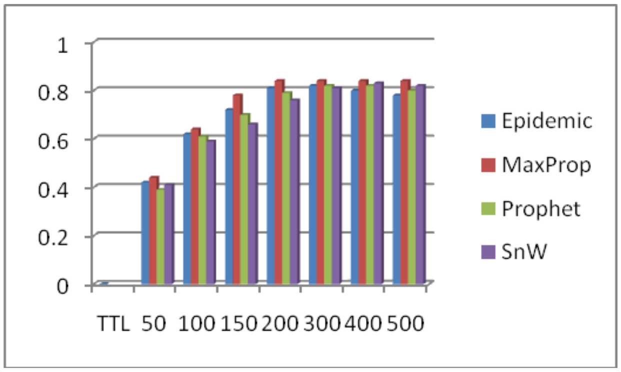
1. Define D_c of nodes between 0, 50 and 100 in network
2. Generate a random number (Rnum) from 1 to 100 in each node
3. Define method WantToCooperate
4. Node is non-cooperative
5. If Rnum of node <D_c
6. Then
7. WantToCooperate = FALSE
8. PutToIncomingBuffer = F ALSE
9. Don't Forward bundle message
10. Else
11. Then
12. WantToCooperate = TRUE
13. PutToIncomingBuffer = TRUE
14. Forward bundle message
15. Endif

End

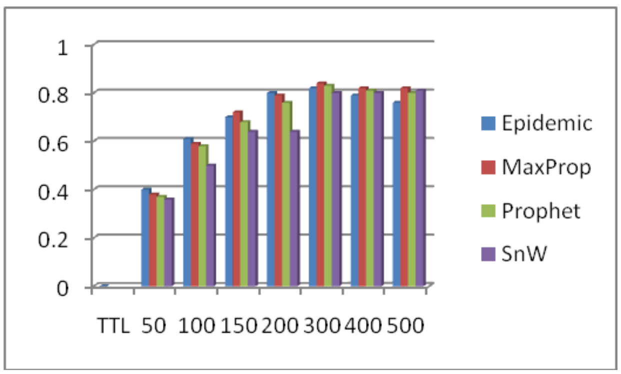
6. Results And Discussion

As shown in Figure 5, the delivery probability decreases as the fraction of non-cooperative nodes in the scenario grows in both sparse and dense network. As it should be expected, the number of mobile nodes in the simulation area has a direct effect on the measurable metrics, as we can notice fro m the comparison between sparse traffic and dense traffic results. Epidemic, Prophet and MaxProp routing proto cols always provides the maximum delivery probability in comparison to Spray and Wait whether in a high or low density of traffics. However, MaxProp gives the best results in dense network especially when the number of TTL increases. This leads to the conclusion that

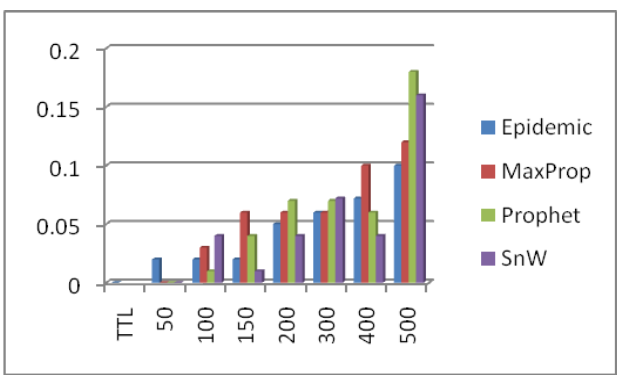
MaxProp could be more suitable in VDTN scenario than other studied routing protocols, especially when the TTL values are high so that the network is more reactive against selfish nodes.



(a). Cooperative_20_Nodes



(b). Partly_ Co-operative_20_Nodes



(c). Non_Co-operative_20_Nodes

Figure 5 Delivery probability as function of TTL for PROPHET, Epidemic, MaxProp and Spray and Wait routing protocols in Sparse network

7. Conclusion

In this paper, Brief introduction of VDTN are also presented. The performances of Epidemic, Spray and Wait, MaxProp and Prophet routing protocols were studied within the framework of a fully, partly and non-cooperative environment. Thus the performance assessment were measured based on metric delivery probability. Our simulation results show that MaxProp routing protocol responds better, in terms of delivery probability, to the non-Cooperation.

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First Author Heena Kapadia, I am Currently Pursuing my Masters Of Engineering From Dr. S. & S.S. Ghandhy Government Engineering College, Surat in an Electronics and Communication Branch. I have completed my Bachelors from Electronics and Communication Branch.