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IMPACT OF RELAY NODES ON VEHICULAR DELAY TOLERANT NETWORK

Anand Mulasavalgi[1] and Anand Unnibhavi[2]

[1,2]Department of Electronics and Communication Engineering,
Basaveshwar Engineering College, Bagalkot, India
E-mail: anand.dm8@gmail.com[1], anandhu.rampur@gmail.com[2]

ABSTRACT

Vehicular Delay Tolerant Networks (VDTNs) are networks in which no simultaneous end-to-end path exists. Typically, message delivery experiences long delays due to the disconnected nature of the network. In this type of network our main goal is to deliver the messages to the destination. In this paper we use stable nodes (relay nodes) at cross roads with different number of mobile nodes. With various simulations it was shown that relay nodes improves the message delivery probability ratio.

Keywords: Vehicular Delay Tolerant Network, Relay Nodes.

1. INTRODUCTION

Delay Tolerant Network (DTN) is intermittently connected mobile wireless networks in which the connectivity between nodes changes frequently due to nodes movement. Typical Examples of DTNs include interplanetary networks, wildlife tracking and habitat monitoring sensor networks, etc. In DTN routing, messages are sent in an extended store-and-forward manner and nodes may cache the messages for considerably long time before getting the opportunity to send them to the next hop nodes [11]. In this paper we exemplify the use of a Vehicular DTN to provide asynchronous communication between mobile nodes and relay nodes, on some part of a city (Fig.1). Mobile nodes physically carry the data, exchanging information with one another. They can move along the roads randomly. Relay nodes are stationary devices located at crossroads, with store-and-forward capabilities. They allow mobile nodes passing by to pickup and deposit data on them. We can also envision the possibility for the relay nodes to be able to exchange data with each other, and at least one of them may have a direct access to the internet.

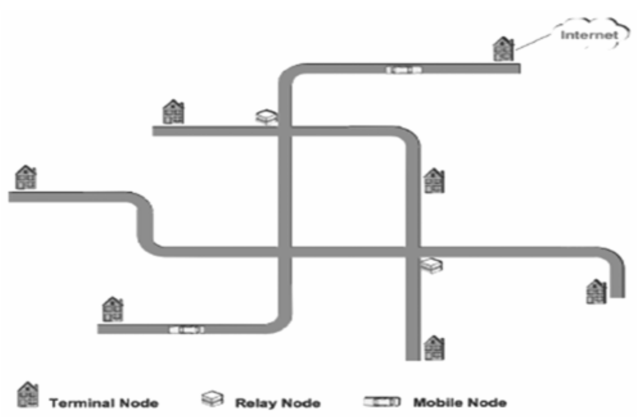

Figure 1: VDTN Example

The use of relay nodes should create a greater number of connectivity opportunities, improving the performance of the VDTN network in terms of message delivery probability. The key contribution of this paper is the evaluation of the impact of the number of relay nodes on DTN routing protocol, in scenarios with different numbers of mobile nodes. The remainder of this paper is organized as follows. Section 2 briefly reviews the related work. Section 3 presents the simulation scenario and discusses the results. Section 4 concludes the paper.

2. RELATED WORK

This paper [2] deals with exploiting mobility for energy efficient non real time data collection in sparse sensor networks as an alternative to forming an ad-hoc network. The key idea is to exploit the presence of mobile nodes in the environment by using them as forwarding agents. Paper [3] deals with the use of throw boxes to enhance network capacity in mobile DTNs. By relaying data, throw boxes increase the transmission opportunities and throughput between nodes. It is evaluated by different routing and deployment approaches using *ns* simulations. The ONE simulator can incorporate real-world traces and feeds from other mobility generators as well as generate mobility traces for use by other simulators [4]. Spray and Wait [5, 6] that manages to overcome the shortcomings of epidemic routing and other flooding-based schemes, and avoids the performance dilemma inherent in utility-based schemes. SMART uses travel companions of the destinations to increase the delivery opportunities [1]. ANBR [7] uses nodes among a local sub-graph formed by including all neighbors of two meeting nodes. Average delivery predictabilities are used in advanced PROPHET to avoid routing jitter Furthermore, evaluate it through simulations versus PROPHET routing protocol [8]. This paper [9] proposes a Bayesian classifier based DTN routing framework that adopts a methodical approach for computing the routing metrics by utilizing the network parameters that capture the periodic behavior of DTN nodes. In Fair-Route, a routing message are preferably forwarded to users that have a stronger social relation with the target of the message and assortativity, that limits the exchange of messages to those users with similar social status [10].

3. PERFORMANCE EVALUATION

To demonstrate how relay nodes improve the performance of a VDTN network, we run several simulations using the MATLAB Simulator. In the networks scenario, the number of mobile nodes, and the number of deployed relay nodes on the network was changed. The overall message delivery ratio and the message delivery delay were analyzed for the epidemic DTN routing. For the simulation we use the map-based model of a part of the city of Bagalkot (Fig. 2). We simulate using MATLAB simulator and measure the differences in performance, when 0, 2, 4, 6, 8, or 10 relay nodes are deployed in network scenarios with 25 and 50 mobile nodes.

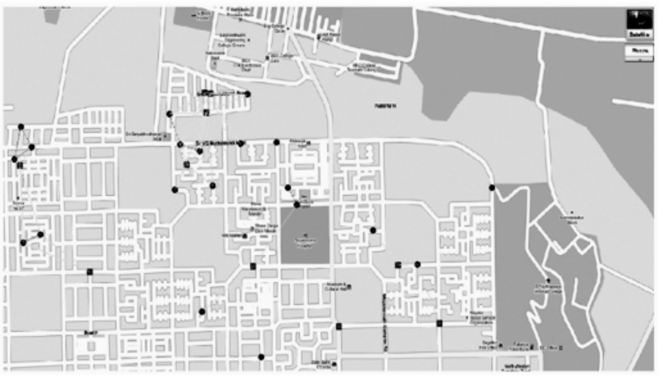

Figure 2: Bagalkot Simulation Area

Mobile nodes move between random map locations. Once a mobile node reaches a destination, it selects a new random map location. The mobile node moves to the new destination using the shortest path available. Each of the mobile nodes has a 150 Mbytes FIFO message buffer. Messages are exchanged between random source and destination mobile nodes. Message size is in the range [500 KB] of uniformly distributed random values. Each of the relay nodes has a 500 Mbytes FIFO message buffer size the transmission range of relay and car is 150 meters. The transmission range of cars is 60 meters. there is a 100 meters separation between two relay nodes. Vehicles exchange data between themselves. We run series of simulations for each combination of the parameters: number of vehicles, and number of relay nodes. We use different random seeds, and report the mean values.

3.1 Simulation Results for 25 Mobile Nodes

We start our evaluation by simulating a scenario with 25 mobile nodes. Deploying relay nodes augments the number of contact opportunities increases. Introducing 10 relay nodes increase the number of contacts. This suggests that relay nodes will contribute to increase the number of messages exchanged between vehicles (Fig. 3).

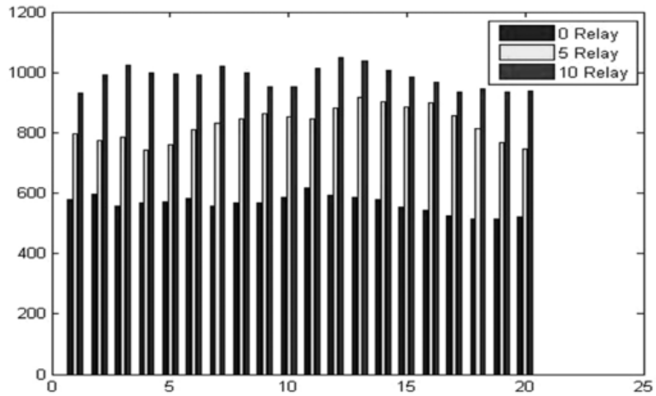

Figure 3: Number of Contacts with 25 Mobile Nodes

Figure 4 shows that epidemic routing increase message delivery ratio when relay nodes are deployed. When analyzing the simulation results with the introduction of 0, 2,4,6,8 and 10 relay nodes, we observe that Epidemic increases 2% from 0 to 2 relay nodes, 21% from 2 to 4 relay nodes, 17% from 4 to 6 relay nodes and 26% from 8 to 10 relay nodes.

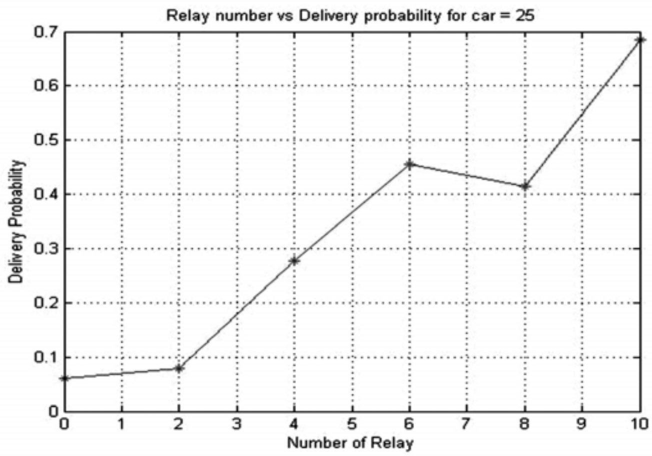

Figure 4: Message Delivery Probability

The message average delay is an interesting metric, since minimizing it reduces the time that messages spend in the network and reduces the contention for resources in the network. We can mainly focus on message delivery probability as the main performance metric. Fig. 5 shows

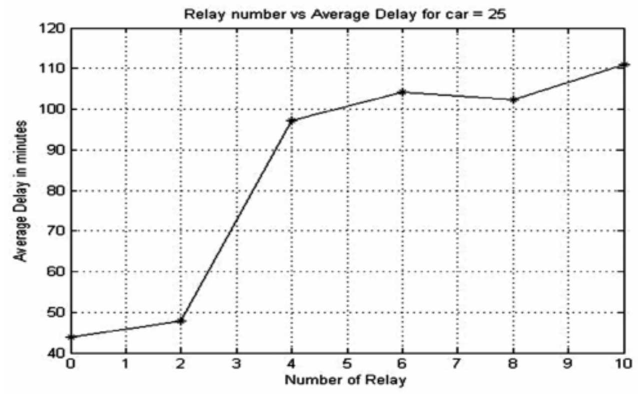

Figure 5: Message Average Delay

that average delay, and that relay nodes do not significantly affect this metric.

3.2 Simulation Results for 50 Mobile Nodes

The second scenario has 50 mobile nodes in the network, therefore the number of contact opportunities increases (Fig. 6). As a result, we observe that epidemic protocol perform better than in the previous scenario. In this new scenario, based on fact that having the double of mobile nodes and, conseqsuluently, a much larger number of opportunistic contacts, it could be expected that relay nodes would not affect the performance of the network considerably. However, in Fig. 7 it may be observed that there is increase of 26% from 0 to 2 relay nodes, 24% from 2 to 4 relay nodes and 16% from 4 to 6 relay nodes.

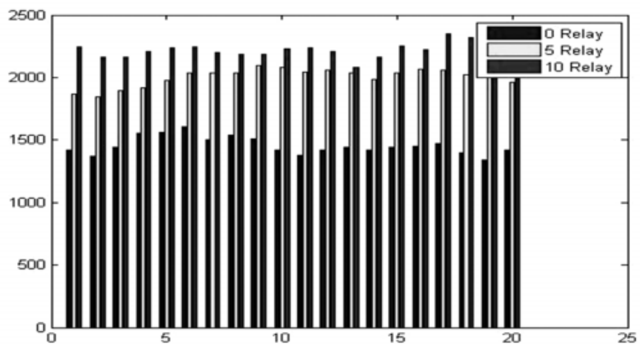

Figure 6: Number of Contacts with 50 Mobile Nodes

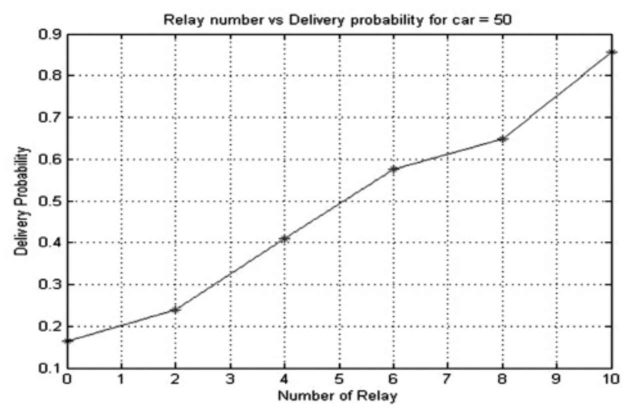

Figure 7: Message Delivery Probability

Epidemic protocol approximately maintains the message average delay across simulations (Fig. 8).

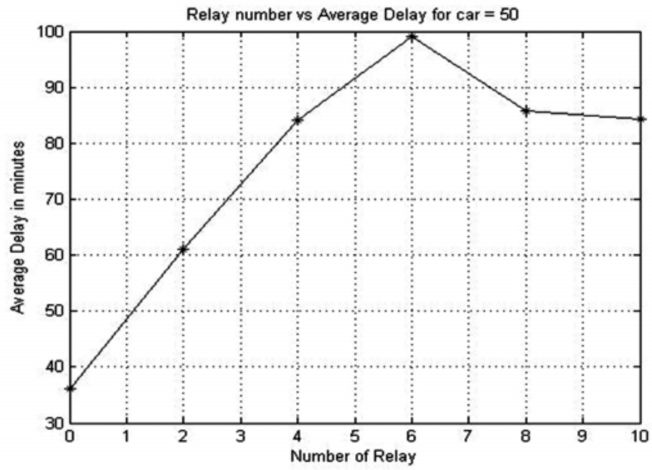

Figure 8: Message Average Delay

4. CONCLUSION

In this paper we studied the performance impact of relay nodes on a VDTN applied to part of city map. It was assumed a cooperative opportunistic environment without knowledge of contact opportunities and traffic matrix. The motivation for this work comes from the idea that placing relay nodes at crossroads allows data deposit and pickup by passing mobile nodes, which will increase the delivered messages to the final destination. Several simulations carried out and finally we conclude that as number of relay nodes increases Number of contacts increases which interm increases message delivery Probability. We are not much concentrated on average delay as we interested only in delivery of messages.

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