Performance Evaluation of VANETs under p-persistent Carrier Sensing Protocol

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by

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CERTIFICATE

*This is to certify that the work contained in this thesis entitled "**Performance Evaluation of VANETs under p-persistent Carrier Sensing Protocol**" is a bonafide work of **Praveen Jangid (Roll No. 150101048)**, carried out in the Department of Computer Science and Engineering, Indian Institute of Technology Guwahati under my supervision and that it has not been submitted elsewhere for a degree.*

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I would like to express my gratitude my guide Dr. Moumita Patra for constantly helping me through out my project. Without her guidence this project would not be able to take the face it has right now.

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Chapter 1

Introduction

In today's world where automation has successfully replaced humans at a lot of places, there is no doubt researchers and interested people now want such type of automation in vehicles.[KAE+11] Such type of automation can not only provide assistance to the driver maybe replace drivers but also motivates the need for infotainment and a lot of safety applications.[GLPL14] To bring such a concept onto field it is very important that these moving vehicles which essentially become the nodes of a Wireless Ad Hoc Network have very strict delay constraints to serve with reliability and high efficiency. In order to full fill the very strict constraints of delay IEEE has formulated special set of rules for Vehicular Ad Hoc type networks under IEEE 802.11p. This model adopts a lot of features from it's base model 802.11 but does significant amount of changes in order to serve the tight delay constraints. The base 802.11 model requires every station to go through authentication and association operations when connecting to a Service Access Point(SAP) where as in IEEE 802.11p we avoid this by using Wild card BSSID. The medium is allotted through a carrier sensing mechanism which can have variety of effects on the performance of this special type of network. In this work we try to analyse this aspect i.e. the medium allocation and related affairs to try to improve the delay constraints. This project is aimed at examining the behaviour of WAVE IEEE802.11p under a real time traffic scenario and observe analysis parameters like through put, packet drop and delay under a special type of medium allocation protocol called p persistent CSMA.

1.1 Objective and Need of the work

As explained above the growth in automation technology in VANETs leading to strict delay constraints, constant efforts are made to meet the delay constraints to enable more efficient functioning of VANETs. With traffic congestion becoming the major problem of our metropolitan city around the world and never ending demand to commute at faster times day by day, our objective in this work is to make en effort and try to reduce the delay by bringing a little variation in the MAC of the VANETs. We are introducing the notion of a probability factor to make an effort towards reducing collisions and hence in turn increase the overall performance.

1.2 Wireless Ad Hoc Networks and VANETs

We are enjoying the benefits of Wireless Networks from a long time now. These type of networks rely on a pre-established backbone infrastructure in order to communicate and serve applications. But with the growth in technology and endless increase in demand of applications that these networks should serve sometimes it becomes really inappropriate to trust these backbones for communication as this becomes time taking and less reliable. This motivates what are called Wireless Ad Hoc Networks. These are type of Wireless Networks which do not rely on a prerequisite backbone infrastructure rather form a network in an Ad Hoc way directly communicating with each other.

As discussed above it will be really inappropriate to rely on existing backbone infrastructure to communicate with each other as in Vehicular Ad Hoc Networks(VANETs) applications can be super critical involving human life as stake. When vehicles as node contribute towards formation of a Wireless Ad Hoc Network it is called a Vehicular Ad Hoc Network(VANETs).VANETs are a way of enabling moving cars to act as nodes and establish a mobile network between them. These cars or nodes of the network are also called On Board Units (OBUs). Not only moving cars but this also requires support from what are called Road Side Units (RSUs) for enabling the fast communication.

1.3 Organization of The Report

This chapter provides a background for the topics covered in this report. We have already provided a description of wireless ad hoc networks, and the particular case of VANETs which we will be dealing with in this work. In the next chapter we start by introducing IEEE 802.11 model and give appropriate details about IEEE 802.11p model. We also describe the Carrier Sensing in the next chapter and introduce CSMA and p persistent CSMA. In chapter 3 we introduce SUMO which has been used in this work to generate real time traffic scenarios for the work and also give the apparatus for our work. Chapter 4 includes the results and an explanation for such behaviour of our analysis. In the last chapter we conclude our work and propose a direction to conduct future work related to this work.

Chapter 2

Introduction to WAVE and Prior Work

IEEE formed a team which specifically worked on forming a standard for everyone to follow while communicating in a wireless set up, the proposed accepted model is called IEEE 802.11. The model follows layered protocols which resembles the OSI model.

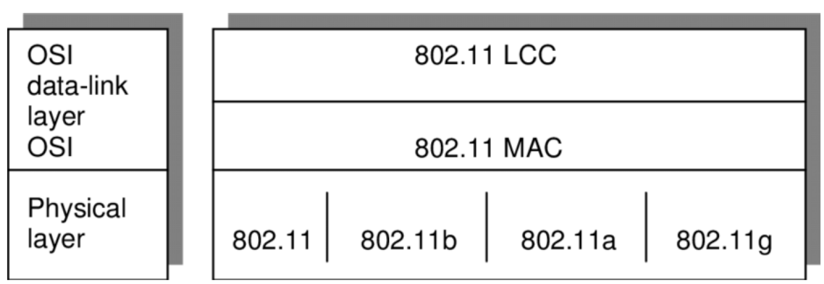

Fig. 2.1 OSI Model and Different Layers

The bottom most part of the both layers is medium through which the packets travel. Above it is the physical layer and data link layer in the OSI model. Correspondingly two divisions of the physical layer as PLCP(Physical Layer Convergence Procedure) and PMD(Physical Medium Dependent) and Logic Link Control(LLC) and Medium Access Control(MAC) layer for Data link control. Above these two layers are the Network and

Application layer which will not be our concern here. PLCP has the job to make the frame format of MPDUs (MAC Protocol Data Units) suitable for transmission and PMD devices the characteristics of the method of transmitting and receiving. Above that MAC take cares about the medium distribution for the data packets and LLC provides an interface to higher layers and perform error control.

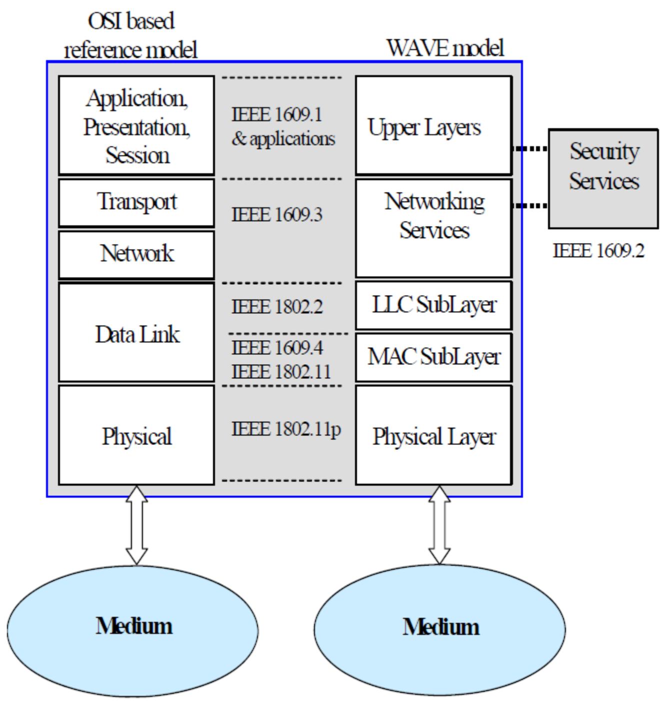

Fig. 2.2 OSI Model and Different IEEE models

2.1 Introduction to 802.11 and 802.11p

The model is divided in service sets each lead by an Access Point(AP) which can be a node itself. This sets of nodes together with the access point are called Basic Service Sets(BSS). One or more such BSSs are connected through a Distributed Sytem(DS) and all of this forms what we call an Extended Service Set(ESS). For instance if packet is to be transported from one node to another node in the same BSS, the packet first goes to the AP and then from their takes it way to the destination node. Similarly if a packet has to go from a node in one BSS to a node in another BSS it travels through the APs of the both BSSs. [JD08]In order to conduct most efficient services between nodes while communicating in IEEE 802.11 formulated nine basic services to every node following 802.11 model. Association, Au- authentication, De authentication, Disassociation, Distribution, Integration, MSDU delivery, Privacy, Re association.

The general 802.11 model is too time consuming in order to meet the strict delay constraints of vehicular networks. Generally a station needs to go through a number of handshakes before establishing the connection to from a BSS(Basic Service Set). A node which is following WAVE(802.11p) standard can send and receive data frames using Wild Card BSSID regardless of the fact that it is a member of a WAVE BSS or not. To initialize a WAVE BSS a station in WAVE mode sends a beacon, which includes all that is required to join a WAVE BSS. It automatically vanishes when there are no stations. A station in WAVE mode cannot be a part of more than one WBSS.

2.2 Carrier Sensing Mechanism

The IEEE 802.11 working group proposed two algorithms for 802.11 MAC. One centralised access where transmission from nodes is controlled in a central fashion and one distributed access protocols which makes more sense for a Ad hoc type of the network using a carrier sensing mechanism (CSMA). The end result 802.11 MAC called DFWMAC (Distributed Foundation Wireless MAC) where centralised access is optionally build on top of distributed. Next we discuss the CSMA protocol in detail.The CSMA process for wireless networks is quite simple. Every node before transmitting anything senses the carrier and waits if its occupied. Now as almost in every scenario we have a competition amongst nodes to transfer, CSMA uses a small delay called as IFS. Any node wanting to transmit a packet, it senses medium and if it is idle it waits for another small amount of time IFS. If the medium is till idle then it transmits else waits until transmission is over. Then again it waits for one IFS and if medium is still idle it backs off for a random amount of time. This is done in order to ensure that multiple nodes do not end up blocking each other every time. If the medium is still idle it transmits else keeps waiting for transmission to end and start again.

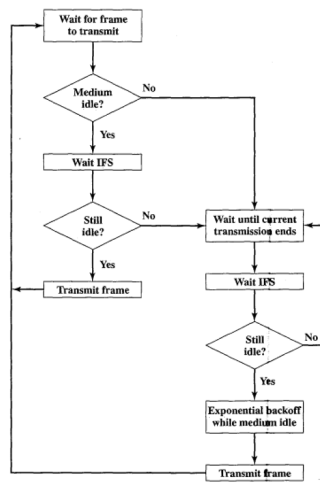

Fig. 2.3 CSMA Protocol Algorithm

2.3 Prior Work and Motivation for this Work

Efforts have been made to try and significantly reduce the delay for VANETs by changing the size of contention window, varying packet size, only trying to send Basic Safety Messages etc. Some works also model the situation as a probabilistic scenario of vehicles trying to broadcast simultaneously. [Eic07] .The IEEE has been extensively studied, the impact of mobility on the performance of VANETs still requires huge attentions and work especially for the V2V mode. The improvements done are a little less related to the mobility of the nodes and rather other factors like DSV,AODV protocol has been done.Various works[AZ12] have been done to simulate VANETs and results show us that using current system and a constant backoff window size is not enough to guarantee the desired delay constraints. Similarly heavy increase in delay is the node density increases has been shown. All this works either use an analytical approach or use simulation. Taking inspiration from these works in this work we try to generate a real life traffic scenario of Guwahati GS Road and simulate it to obtain different performance metrics. We analyse this for standard 802.11p model and then as a new aspect to the work we try to incorporate notion of a p persistent protocol in it.

Chapter 3

Setting up the apparatus for this Work

In this work we will generate a random traffic mobility file with variable number of vehicles. We will attach the generated file with a standard 802.11p model code and then condition on the traffic/packet sending function to obtain a probability factor before transmitting a packet. This later case incorporates the notion of a p persistent carrier sensing mechanism instead of a standard carrier sensing mechanism. We already introduced the notion of carrier sensing in last chapter, here we will like to point out the unique aspect of p persistent protocol which is an additional probability factor conditioned on the packet transmitting function which even after sensing an ideal carrier sends packet with a chance equal to the probability factor. The main aim of this work is to implement this p persistent carrier sensing[WAKP08] for a real time traffic scenario and vary this probability factor to obtain a value for maximum efficiency.

3.1 SUMO and NS3 Technology Introduction

SUMO(Simulation of Urban Mobility) and Network Simulator 3 are two softwares which we will be using in this work. NS3 provides us with basic topology and lets us play with them to achieve results for research studies on desired network scenarios. In our case we need to simulate a vehicular Environment for which either we can choose to go grid basis random walk mobility model or generate real time traffic using SUMO.SUMO lets us choose real world locations and road maps with the help of OSM(open street map) functionality in NS3 to give us more real behaviour of the network.

3.2 Location Map

For this study I have chosen the location of GS Road in Guwahati Down Town, a very busy area with a lot of intersections and variable size sub roads. Here we varied the number of nodes starting from 50 to 300 and took traffic from a practical sparse case to a very peak case traffic scenario.Below is a picture of the area we took and the SUMO file thus generated.

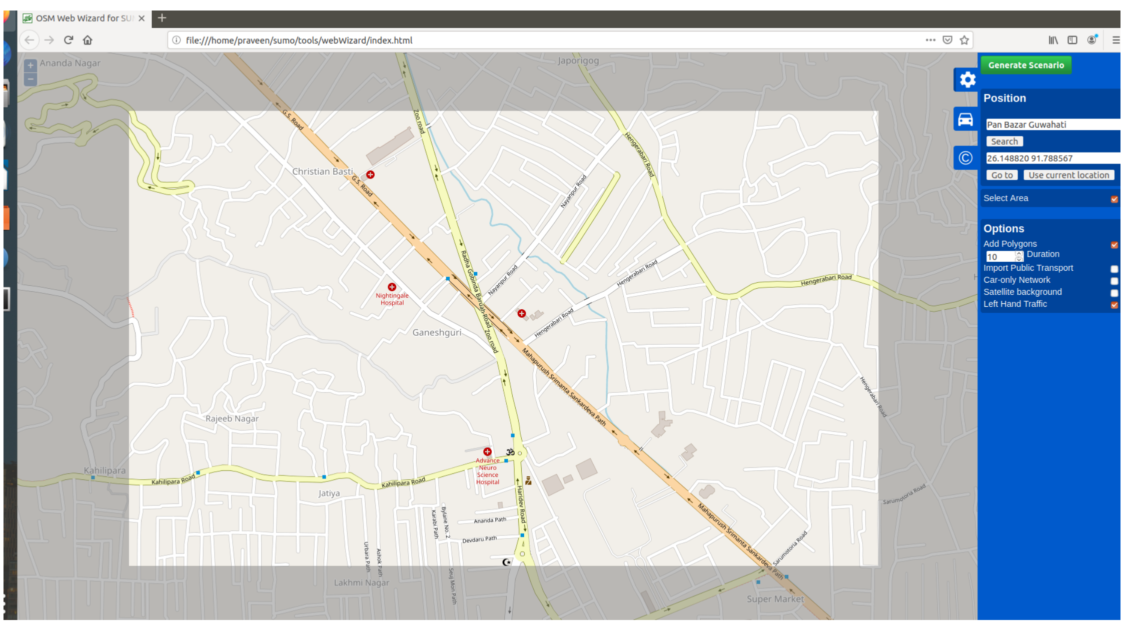

Fig. 3.1 MAP of GS Road Area

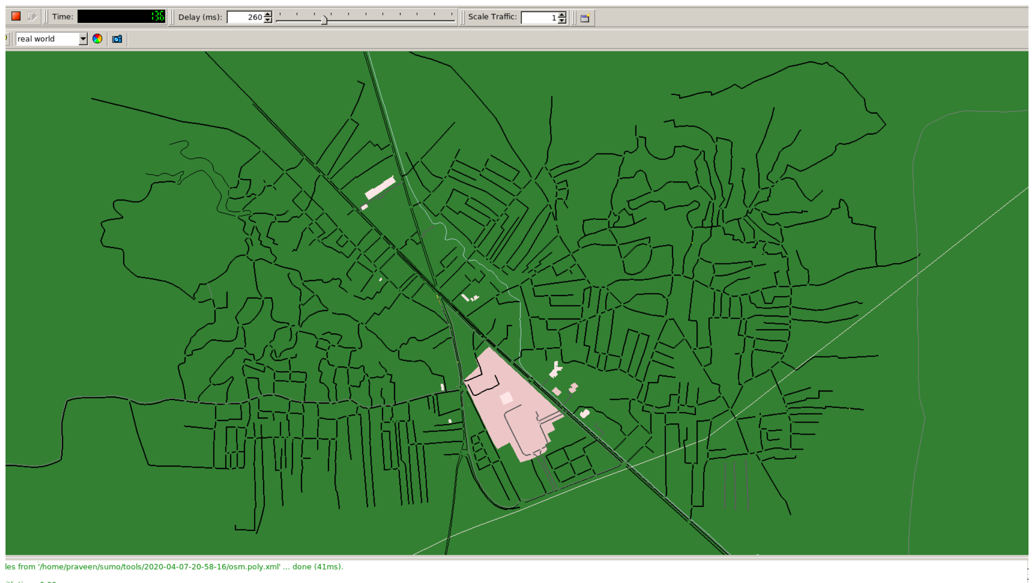

Fig. 3.2 SUMO generated Map of Scenario

3.3 P persistent Logic Implementation

Our code lets us add any randomly generated traffic scenario and inject that for analysis but the file need to be in .tcl format. We converted initially generated traffic file to this by using the command " python traceExporter.py -i 2020-03-26-06-49-54/trace.xml –ns2mobility-output=/home/praveen/mobility.tcl". This with the help of sumo gives us a text file which can be attached to the code for our work and analysis. Then this mobility.tcl file was attached to our code and run simulation.

3.4 Process of Simulation

For every given value of number of nodes which are 56,83,127,161,197,243,288 we did ten iterations each on the same traffic scenario for ten seconds of traffic movement(more was consuming extra time) and obtained throughput, delay and packet dropped for each case.

Chapter 4

Results

The iterations done for each number of nodes were used to take average to estimate values and three standard performance metric graphs were plotted to obtain a better comparison and study of the work.

4.1 Factors Affecting Performance

In general the performance of such a scenario depends on a lot of variables and the most common and affecting once are listed below:

1) No. of packets generated and contending.

2) No. of nodes in the range.

3) Probability factor.

4) Vehicles Mobility(speed) pattern/scenario.

5) Size of contention window slot. (constant here)

4.2 Graphs

Below are the three graphs for three performance metrics namely packets received/total packets, packets dropped/packets generated and delay against number of nodes.

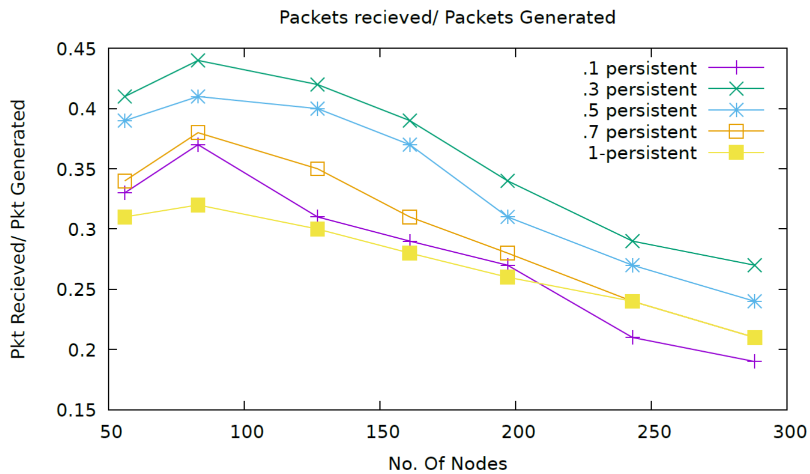

Fig. 4.1 Packets Received/Total Packets Generated vs Number of Nodes

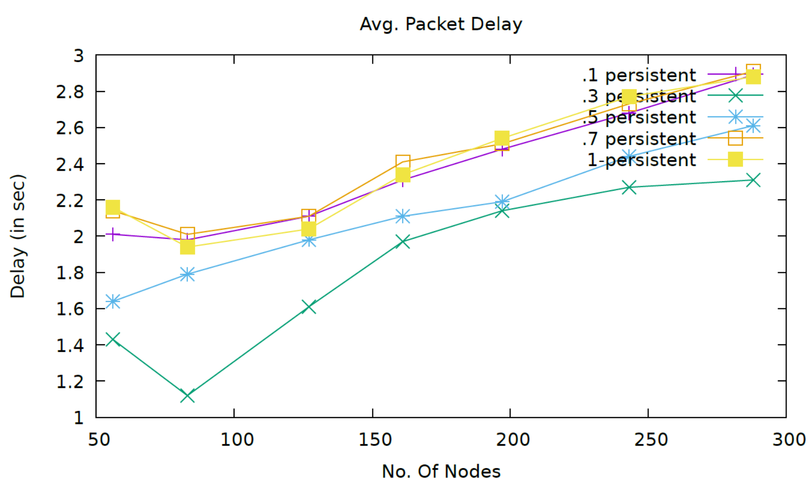

Fig. 4.2 SUMO generated Map of Scenario

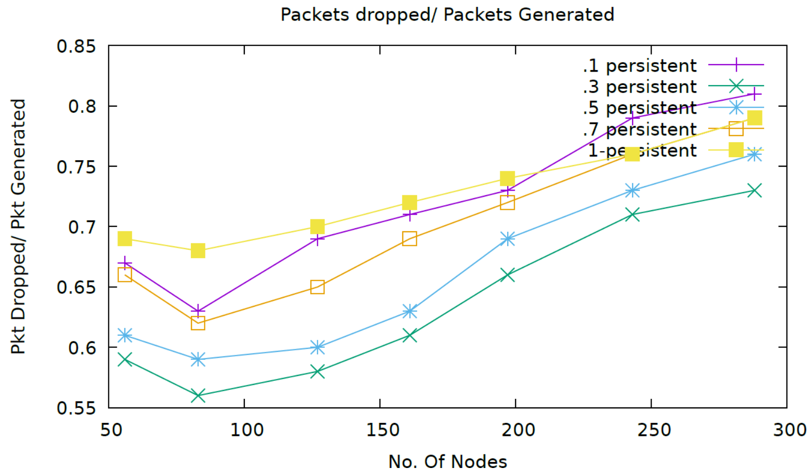

Fig. 4.3 Packets Received/Total Packets Generated vs Number of Nodes

4.3 Explanation for the result (Probability = .3)

In the experiment, We chose a traffic scenario of GS road and generated artificial traffic in it. Our number of nodes were varied from 50 to 300. The factors affecting the performance(delay and throughput) are listed above. Here, as the number of nodes increases the number of packets generated also increases, and thus contention also increases. The scenario has a lot of small roads and the main highway where the nodes are less congested comparatively. When 50 nodes were used the traffic was a little sparse and nodes had fewer neighbours for hops/communication. This resulted in little low packets delivered and higher delay as compared to 80 vehicles where traffic was dense optimally. As the nodes kept increasing after this the contention kept increasing and the dropped packet and delay increased. This is a general trend.This general trend can be explained as increase in the number of packets generated and thus increasing the number of packets that are contending for the channel in every time slot.This is a general property which we also saw in our related works section. But as in this work we tried to condition the transmission function with a probability factor to make the channel contention similar to P persistent CSMA. Now given that we were trying to use a probability factor while deciding to transmit a packet. when .1 probability factor was used even if there was less contention the probability factor caused some hindrance in packets transfer but helped to ease collision as nodes kept increasing. At .5 probability factor, the collisions increased relatively, but also enabled more consumption/use of the transmission window. As we kept increasing the probability factor more collisions occurred and the delay and dropped packets increased further.The dip or a local optimum around 80 vehicles can be explained with the argument that at 50 vehicles the network is very sparse and so the nodes in the vicinity are very less. From 80 nodes on wards the network start to show a gradual trend. The best results were obtained at .3 probability which is understandable from the factors which we discussed. At .3 the collisions and channel consumption turned out optimum for the traffic scenario we took.

Chapter 5

Conclusion and Future Work

In this work we tried to simulate a real life traffic scenario with variable number of nodes and studied the variations of different performance metrics with variation of probability factor. Our work has shown a general trend for the results with a local dip/peak due to network being excessively sparse at 50 nodes. We have compared probability factors .1, .3(best case), .5 , .7 and 1 to cover the overall essence of the conditioning of probability factor on the standard implementation. As seen in the last chapter we found out that our study gives .3 as an optimum value of probability to work with p persistent carrier sensing mechanism. To summarize the reason behind one can say as we increase the probability factor the chances of collision increases and hence the efficiency decreases. And as the nodes kept increasing after this the contention kept increasing and the dropped packet and delay increased. Both of this facts are visible in our work.

5.1 Future Work

In this work we just conditioned the transmit function with a probability factor but it was observed after the work that after introduction of the probability factor performance can further be challenged and should be studied with variations in inter frame space and contention window size keeping rest of things the same. This can be amended in the code and can be worked upon in future. Also as very obvious the early implementation of this type of a work are more suitable in a planned city/area where we can program the general map/mobility ways of the nodes better, work can also be extended to cover such scenarios and trying gird based mobility as modern cities with the help of engineers are being planned better and better.

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