EVALUATION OF ZONAL CONCEPT FOR VARIOUS MOBILITY MODELS OVER VANETs

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ABSTRACT

Vehicular Ad hoc Networks are recent advancements in wireless network environment for the development of Intelligent Transportation System (ITS). Mostly these networks find their applications built upon the data push communication model, in which information is disseminated to a particular set of vehicles. The applicability of VANET make it diverse and their potential communication systems need protocols that are systematic in nature. Performance of routing protocol is affected by mobility rate as well as mobility model used in the simulation. Mobility Models that are appropriate commonly categorized as either non-realistic or Semi-realistic. In this paper, we have proposed hybrid routing protocols namely Zonal protocol for different Zonal sizes to be compared to evaluate their performance in accordance with the various mobility models namely – Tactical Indoor Mobility Model , Random point Group model, Manhattan, Self-similar Least Action Walk and Gauss-Markov mobility model. CBR has been considered as traffic generator. Zonal size based evaluations are based on the simulation using ns2.

Keyword : - VANETS, ITS, Zonal.

I. INTRODUCTION

Ad hoc network has been developed since the special research done by Defense Advanced Research Projects Agency (DARPA). It was part of a research on a packet radio network in the early 1970s (Jubin & Tornow, 1987), and was aimed at supporting the message switching technology (MST), used for fixed or wired networks. The original aim of the research was to meet the requirements for survival in the battlefield. Communication between each device cannot be established based on the fixed base stations in the battlefield because these base stations may not exist[10]. Also, these base stations might have been destroyed before it could have been used. Thus, a mobile wireless network with a fast self-organizing capability is needed.

The fast self-organizing mobile wireless network is established with a number of mobile nodes without any existing basic network devices. Mobile nodes are dynamically and randomly located in the network and communicate with each other using wireless technology. This mobile wireless network evolved to become the Mobile Ad Hoc Network (MANET or Ad Hoc Network).

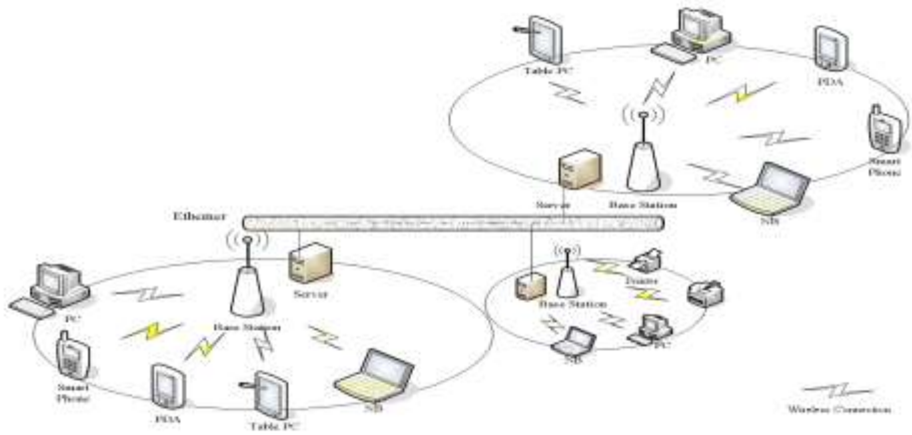

Figure 1 : Infrastructure Network.

With the increase of mobile devices as well as development in wireless communication, adhoc networking is gaining importance with the growing number of well-known applications in the commercial, Military and private sectors. Mobile

Ad-Hoc Networks permit users to access and interchange information regardless of their geographic position or proximity to infrastructure. In comparison to the infrastructure networks, all the nodes in MANETs are moveable and their connections are more dynamic. Unlike other mobile network, MANETs do not require a static infrastructure. This offers a beneficial distributed approach to the network. Decentralization network is more flexible and more robust.

- **Military Sector –** All the military equipment contains some sort of computer equipment. Adhoc networking allows the military to maintain an information network centrally. The basic techniques which are used in ad hoc network came from this field.
- **Commercial Sector –** Ad hoc networks are used in emergency operations for relief after the disaster, e.g. in fire, flood, or earthquake. Rescuers must be able to communicate in order to make the best use of their energy, but also to maintain safety. Job of rescuers made easier by establishing a data network automatically with the equipment, which are already carried by them.
- **Data Networks –** A commercial application for MANETs includes universal computing. By allowing mainframes to forward information for others, data networks may be prolonged far away from the usual reach of installed infrastructure. Networks may be made more widely available and easier to use.
- **Sensor Networks –** A very large number of small sensors are composed in the network. These sensors can be used to detect any number of properties of an area. E.g. temperature, pressure, toxins, pollutions, etc. The abilities of each sensor are limited, and each must trust on others in order to forward data to a central computer.

The real world components of MANET and one should know them before choosing to model them in a simulator and the components of these networks can be broadly divided as follows:

- **Nodes –** A component which has the capabilities of transmitting, processing and receiving of information is called as node or host. In real world, these are powered by on-board batteries. They also contain sensors and navigation devices which perform different varieties of functions start like storing the data to intelligent aggregation of data.
- **Architecture of the node –** Nodes/hosts are the main communication devices (i.e., radio devices) and their internal architecture is defined in terms of the OSI protocol stack and the protocol layers are physical, data link, medium access control (MAC), network, transport, session, presentation and application layer. Even the implementation of the networks with the simulators is similar to the real time counterparts.
- **Communication Architecture –** As the term, "mobile ad hoc" means the nodes which are mobile and those don't have a central entity to maintain/organize them. From this we know that the nodes are independent and they use wireless communication in order to communicate with other nodes in the network, but the nodes will be able to communicate only when the other nodes lie within the radio transmission range. The physical properties of a node are transmission and reception.
- **Network –** This is the place where the nodes/hosts are present and obviously only a group of them is called as a network. Always there will be physical boundaries for every network. For example, all the cell phone service providers will have their network coverage only limited to the country that they exist. Even if they offer service outside the physical territory of their country, they borrow of the service where the mobile user is actually present. The count of the nodes will not be constant as they keep moving so nodes will be leaving and entering the network at any time.
- **Traffic –** The process of moving data from one node to another node or transfer of information from one layer to another layer (according to OSI protocol layers) is termed as traffic.
- **Mobility –** As the term MANET, has mobile in it which means the nodes are mobile and are free to move in any given direction. But the simulators follow certain types of mobility models such as linear mobility, restricted linear speed mobility and so on. In real world they don't have any specific model for their mobility but for simulators we have to use certain mobility models which are almost similar to different mobility patterns of the real world.

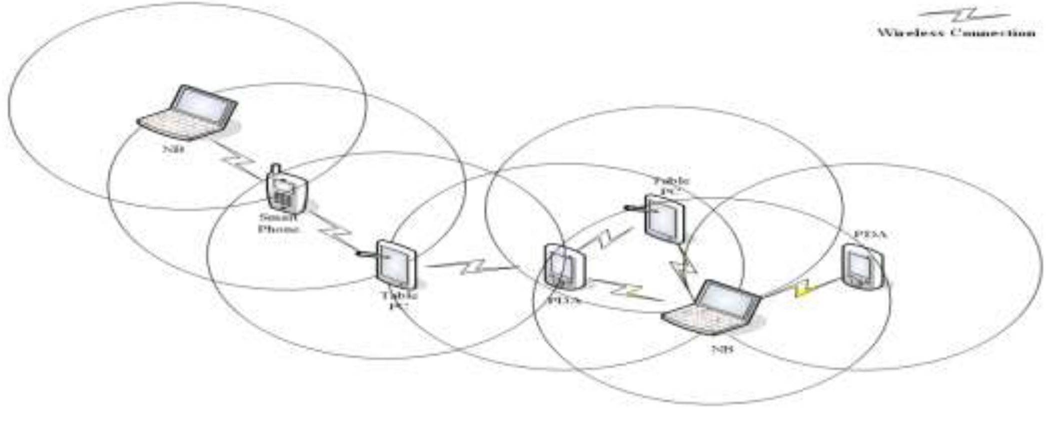

Figure 2: Mobile Ad Hoc Network Architecture

A. Vehicular Ad-hoc Networks (VANETs)

Vehicular Ad-hoc networks, a new form of MANET, provides the communication platform for the vehicles, among nearby vehicles, between vehicles, and between vehicle and nearby fixed equipments known as Road Side Units(RSUs). Every node (vehicle capable of forming network) communicates in single hop or multi hop. VANETs are designed for goal of enhancing safety of vehicles and providing comfort for the passenger. The various types of communication involved in VANET are[1] :

- Vehicle – to- Vehicle (V-V) (Inter- Vehicle Communication)
- Vehicle-to-Infrastructure (V-I) or Vehicle to RSU
- Between RSU

Most of the research is carried out with focus on military applications with few of them commercial applications that seems viable. The area has significantly changed in the last 5 years or so with the advancement of the automobile industry. The growth in the area of VANET is devoted towards safety applications. It is one of the biggest new commercial level application of ad hoc networks having real and concrete applications which is driving the march of the underlying technology.

Currently , this area is growing at a fast pace with great interest in it, from academic point of view as well as automobile industry. These contemporary cars are the example of best mobile computing applications that on could dream of. These are equipped with high power and tremendous amount of embedded computing power. Car and automible industry , for the safety of vehicle and pessengers and other safety applications , has embraced this type of new technical area and its technology, due to which the present number of potential application are expanding quickly beyond safety and further includes other types of applications as well.

VANETs , a subset or special case of MANET, have been studied extensively . This research area is relatively new and spans only the last decade. While research resulted in several achievement and significant progress, but it has to remember that their remains many key research and development issues which are still open.[5] In terms of V2V , the frequencies used have a wide variety in it i.e. very high frequency, micro, and millimeter waves and also include the infrared waves . While some of these only support line-of-sight communications (for infrared and millimeter waves) others like VHF and microwaves can support broadcast applications as well. For long links and low speed VHF can serve the purpose. Microwaves constitute the use for the mainstream mode.Drivers will be well informed of vital information about traffic (such as treacherous road conditions, accident sites) by using vehicular communication application which communicate with other entities to provide such information. By having large amount of information about road conditions, traffic conditions with the driver this results in alleviating the problem of road accidents. Traffic monitoring and management is one of advantage provided by Vehicular communications to raise the flow capacity and imrove vehicle fuel economy. Due to the distinct features of VANETs, different problems have been tackled by the researchers. A main part of research works has focused on designing routing algorithms. Since the wireless nodes in a VANET, i.e., vehicles are faster than nodes in a usual MANET, and the mobility patterns of vehicles are confined to road maps and thus more predictable, routing algorithms proposed for MANETs are not necessarily suitable for VANETs.

Applications developed for vehicular ad hoc networks (VANETs) have very specific and clear goals such as providing intelligent and safe transport systems. Emergency warning for public safety is one application that is highly time-critical and requires an intelligent broadcast mechanism to distribute warning messages. In order to design a broadcast protocol for VANETs, one must consider two major problems:

- ✓ The broadcast storm problem, which occurs when multiple nodes attempt to transmit at the same time, thereby causing several packet collisions and extra delay at the medium access control (MAC) layer.
- ✓ The disconnected network problem, which occurs when the number of nodes in the area to help disseminate the broadcast message is not sufficient.

II. ZONAL ROUTING SCHEME

ZRP is an example of a hybrid reactive/proactive routing protocol based on parameter called routing Zonal [52]. ZRP is proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols [53]. ZRP was introduced by Haas in 1997. In ZRP a node proactively maintains routes to destinations within a local neighborhood which is referred to as routing Zonal.

A routing Zonal is defined for each node separately [3]. A node routing Zonal is defined as a collection of nodes whose minimum distance in hops from the node in question is no longer greater than a parameter called Zonal radius. Each node maintains Zonal radius and routing Zonals of neighboring nodes overlap. The construction of a routing Zonal requires a node first to know who its neighbors are. A neighbor is a node that can communicate directly with a node in question. Neighbor discovery is implemented through a Mac level neighbor discovery protocol (NDP).

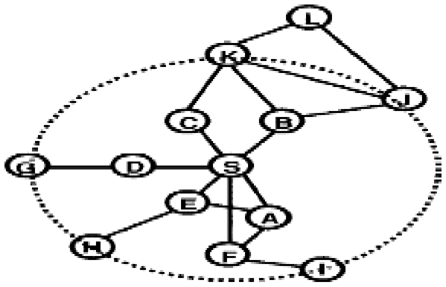

Figure 3: Routing Zonal of radius 2.

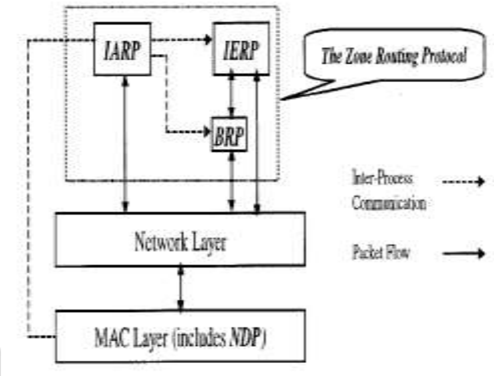

Figure 4: ZRP Architecture.

An example of routing Zonal of radius 2 is shown in figure 3.1 Nodes A through K are members of nodes S's routing Zonal whereas node L lies outside. Peripheral nodes are the nodes whose minimum distance to the node in question is equal to Zonal radius. Nodes G through K are peripheral whereas nodes A through F are interior. Each node maintains its own routing Zonal [51].

The number of nodes in the routing Zonal can be regulated by adjusting the transmission power of the nodes. Lowering the power reduces the number of the nodes within direct reach and vice versa. The number of neighboring nodes should be sufficient to provide adequate reliability and redundancy. The relationship between components is illustrated in figure 3.3. The proactive maintenance of routing Zonal topology is performed by IARP through exchange of route packets. Route updates are triggered by the MAC level (NDP) which notifies IARP when a link to a neighbor is established or broken

IERP reactively requires routes to nodes beyond the routing Zonal using query reply mechanism. It forwards query to peripheral nodes from through the bordercast delivery service keeping track of peripheral nodes through update routing Zonal topology information provided by IARP [23]. IERP makes use of IARP routing Zonal information to determine whether a query for destination belongs to its routing Zonal.

The Zonal routing protocol consists of several components which only together provide the full routing benefit to ZRP.

III. RELATED WORK

Niroj Kumar Pani proposed a secure hybrid ad hoc routing protocol, called Secure Zonal Routing Protocol (SZRP), which aims at addressing the above limitations by combining the best properties of both proactive and reactive approaches. The proposed protocol is based on the concept Zonal routing protocol (ZRP). It employs an integrated approach of digital signature and both the symmetric and asymmetric key encryption techniques to achieve the security goals like message integrity, data confidentiality and end to end authentication at IP layer. This paper detailed the design of the proposed protocol and analyzed its robustness in the presence of multiple possible security attacks that involves impersonation, modification, fabrication and replay of packets caused either by an external advisory or an internal compromised node within the network [1].

Hongyan Du proposed a Zonal-Based routings protocol, where the network area was divided into fixed none-overlapping square Zonals. As we know that Zonal routing protocol is a hybrid protocol. It combines the advantages of both proactive and reactive routing protocols. This paper used a source routing, which reduces the routing overhead. Mobility factor is defined and can be collected by each node itself according to the statistic data and is considered in Zonal head selection and route determination. A more stable path has been discovered which leads to lower probability of link breakage, and reach higher throughput for the network [2].

M.N. SreeRangaRaju et al. proposed an algorithm to provide improved quality of service via hybrid routing protocol-Zonal Routing Protocol (ZRP). In this paper considered two reactive routing protocols Dynamic Source Routing (DSR) and Ad hoc On Demand Distance Vector (AODV) as reference for analyzing ZRP by considering route acquisition delay and quick route reconfiguration during link failure. These parameters viz., route acquisition delay and quick route reconfiguration have their impact on increase in end to end delay, this automatically decreases the number of packets received thus the throughput. In this paper used well known network simulator QualNet version 5.0 to compare QoS parameters viz., throughput, number of bytes received, number of packets received, average end-to-end delay and the time at which first packet is been received for DSR, AODV and ZRP [3].

K. Prabu et al analyzed the performance of various on-demand/reactive routing protocols (DSR, AODV, and TORA). They first analyzed the performance with low mobility and low traffic. Then with high mobility and high traffic. They also analyzed the performance of these protocols with other important parameters to study robustness and steadiness particularly with overhead. In some cases DSR and AODV outperform TORA [4].

Vikas Singla et al conducted the study to evaluate the performance of three MANET protocols i.e. DSR, AODV and DSDV based on CBR traffic. These routing protocols were compared in terms of Packet delivery ratio, Average routing overhead and Average end-to-end delay when subjected to change in pause time and varying no. of nodes. Simulation results show that AODV performs better in terms of packet delivery ratio. DSR has the second highest packet delivery ratio among the three protocols. DSDV performs the poorest in terms of packet delivery ratio. In terms of average routing overhead DSDV performs better than AODV and DSR. AODV follows DSDV closely for average routing overhead. For average end-to-end delay metric, the performance of DSDV and AODV is quite similar to each other. DSR performs poorly for this metric. From the comparison and analysis, it can be concluded that the overall performance of AODV protocol is better among all three. DSR performs averagely for change in pause time and no. of nodes. DSDV performs worst for the variation of all test scenarios [5]. After the literature surveyed, let us discuss routing protocols of our interest.

Bhavyesh Divecha et al. observed the Impact of Node Mobility on MANET Routing Protocols Models. The performance of a routing protocol varies widely across different mobility models and hence the study results from one model cannot be applied to other model. Hence it has considered the mobility of an application while selecting a routing protocol. DSR gives better performance for highly mobile networks than DSDV. DSR is faster in discovering new route to the destination when the old route is broken as it invokes route repair mechanism locally whereas in DSDV there is no route repair mechanism. In DSDV, if no route is found to the destination, the packets are dropped [6].

G. Santhosh Kumar et al. observed that mobility of sensor node can be considered as an extra dimension of complexity, which poses interesting and challenging problems. Node mobility is a very important aspect in the design of effective routing algorithm for mobile wireless networks. In this work, this paper intended to present the impact of different mobility models on the performance of the wireless sensor networks. Routing characteristics of various routing protocols for ad-hoc network were studied considering different mobility models. Performance metrics such as end-to-end delay, throughput and routing load were considered and their variations in the case of mobility models [7].

Brent Ishibashi et al. studied a number of characteristics concerning the links and routes that make up an ad hoc network. Several network parameters are examined, including number of nodes, network dimensions, and radio transmission range, as well as mobility parameters for maximum speed and wait times. In addition to suggesting guidelines for the evaluation of ad hoc networks, the results reveal several properties that should be considered in the design and optimization of MANET protocols. Overall, the results are cause for concern. Not only do many links break after a relatively short time period, but their short-lifespan is also propagated and exacerbated in the life spans of the routes. The shortness of the route life spans is a problem. With route building already an expensive proposition in MANETs, these rapid routing changes are a severe challenge to the network. For today's protocols, the challenge is insurmountable. Current MANETs simply cannot effectively handle that level of change [8].

Joy Ghosh et al. described that most routing protocols in MANET adopt the popular Random Waypoint model for its simplicity and suitability for theoretical study and analysis. Recently, several entity, group and scenario based mobility models and frameworks have been proposed to model much more realistic and practical movements of mobile nodes in real scenarios. This paper developed a practical mobility model that recognizes an orbital pattern in the sociological movement of mobile users, and then proposed a novel Orbit Based Routing (OBR) protocol, that leverages the underlying orbital mobility to accurately determine a set of likely regions containing any node in the MANET [9].

Mona Ghassemian et al. evaluated different proposed routing schemes for mobile ad hoc networks with respect to different mobility metrics. Mobility metrics applied for ad hoc protocol performance evaluations have been studied in this paper. Within an ad hoc network with unreliable links and connections, applying a precise mobility metric that captures the impact of mobility can lead to reliable results. In this paper a new mobility metric called link stability metric that can capture the random mobility of mobile nodes in an ad hoc network has been analyzed in an environment with a random waypoint mobility model [10].

Byung-jae Kwar et al. described that the performance of a mobile ad hoc network is related to the efficiency of the routing protocol in adapting to changes in the network topology and the link status. However, the use of many different mobility models without a unified quantitative “measure” of the mobility has made it very difficult to compare the results of independent performance of routing protocols. In this paper, a mobility measure for MANET’s is proposed that is flexible and consistent. It is flexible because one can customize the definition of mobility using a remoteness function. It is consistent because it has a linear relationship with the rate at which links are established or broken for a wide range of network scenario [11].

R. Manoharan et al. analyzed the impact of mobility pattern on multicast routing performance of mobile ad hoc networks. They observe that in addition to the strengths and weaknesses of the individual multicast routing protocols, the mobility patterns does also have influence on the performance of the routing protocols. The connectivity of the mobile nodes, route setup and repair time are the major factors that affect protocol performance. This conclusion is consistent with the observation of the previous such studies on unicast routing protocols. There is no clear winner among the protocols in our case, since different mobility patterns seem to give different performance rankings of the protocols [12].

Sabina Baraković et al. concluded that in low mobility and low load scenarios, all three protocols react in a similar way, while with mobility or load increasing DSR outperforms AODV and DSDV routing protocols. Poor performances of DSR routing protocol, when mobility or load are increased, are the consequence of aggressive use of caching and lack of any mechanism to expire stale routes or determine the freshness of routes when multiple choices are available [37].

IV. SIMULATION RESULTS

We have used TIMM, Random Point Group Mobility (RPGM), Manhattan mobility (MHM) and Gauss Markov mobility (GMM), and SLAW as these are widely used in VANET simulations. In TIMM, nodes move at a speed uniformly distributed in [MIN SPEED, MAX SPEED]. In our simulation, we have considered different zonal size with offered load for data transfer and ZONAL size considered are 60 nodes. Each node begins the simulation by moving towards a randomly chosen destination. Whenever a node chooses a destination, it rests for a pause time. Our pause time is zero. It then chooses a new destination and moves towards the same. This process is repeated until the end of the simulation time.

Table 1: The simulation parameters

S.no.	Parameters	Values
1	Mobility Models	TIMM, GMM, SLAW, MHM and RPGM
2	Radio Propagation Model	Two Ray Ground Model
3	MANET Routing Protocols	ZONAL Protocol
4	Nominal Traffic Type	FTP
5	No. of Nodes	60
6	Simulation Time	200 seconds
7	Data Rate	2 Mbps
8	Terrain Area	2500x2500 m^2
9	Packet Size	512 bytes
10	MAC type	802.11
11	Zonal size	1, 2, 3 and 4
13	Antenna	Omni-Antenna
14	ZONAL RADIUS	1, 2, 3, and 4.

There are many parameters which can be used to evaluate the performance of routing protocols. Performance metrics are considered as follows**:**

- **Throughput**

There is two representations of throughput; One is the amount of data transferred over the period of time expressed in Kilobits per second (Kbps). The other is the packet delivery percentage obtained from a ratio of the number of data packets sent and the number of data packets received.

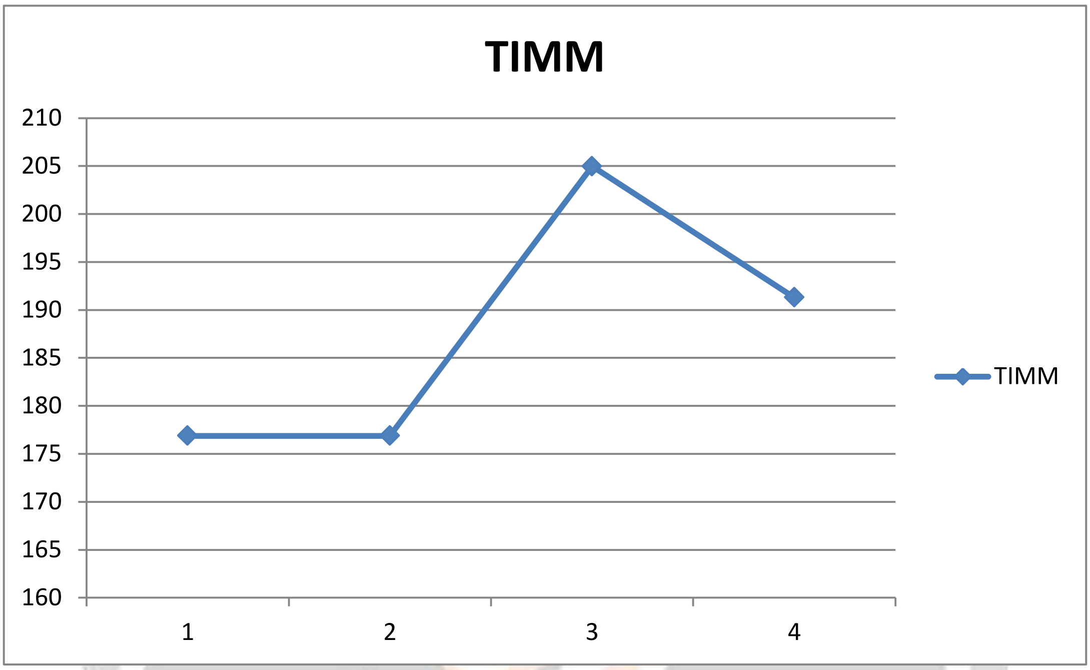

Figure 5: Throughput with respect to Zonal size in TIMM Mobility Model.

From the Figure 5, it is observed that Zonal radius 3 has highest throughput as compared with other considered Zonal radius. As we can see in figure 4.1 when ZONAL size is maximum that is 3 and 4; for maximum Zonal radius the no of packets received per unit simulation time are highest which means throughput is maximum in this case.

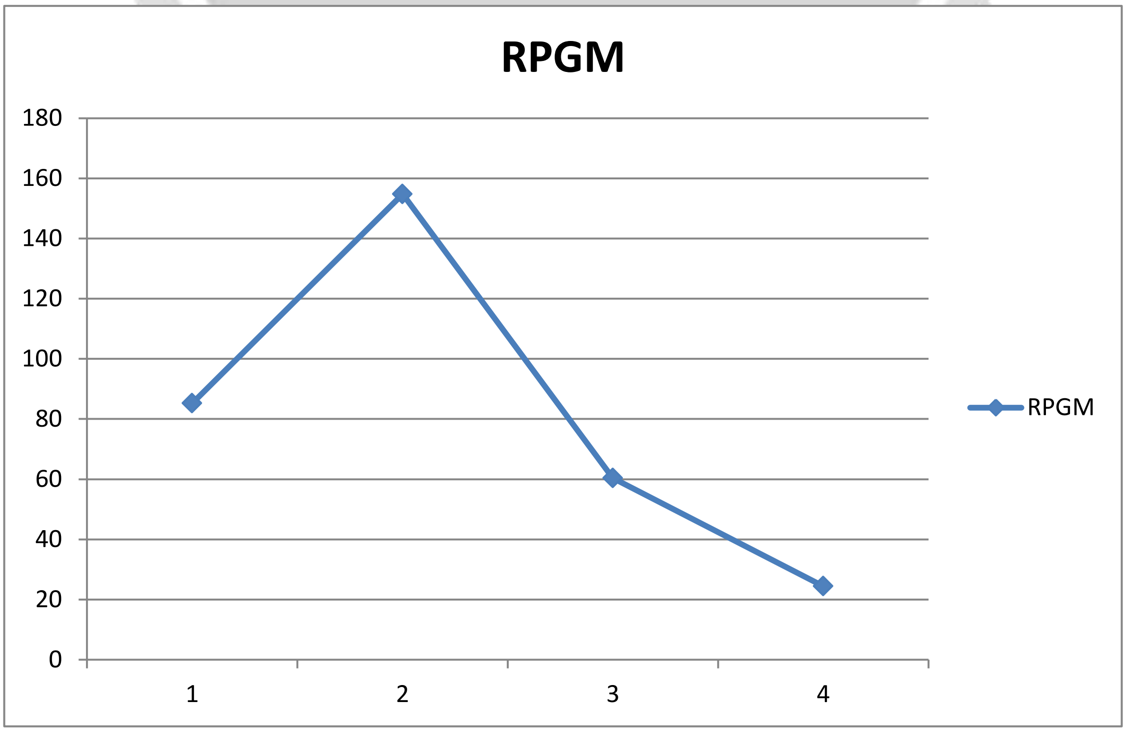

Figure 6: Throughput with respect to Zonal size in RPGM Mobility Model.

Simulation Graph shows the effect of ZONAL size on the throughput in Group Mobility model. lower Zonal radius i.e Zonal size 2 is good in throughput when we increase the network density.

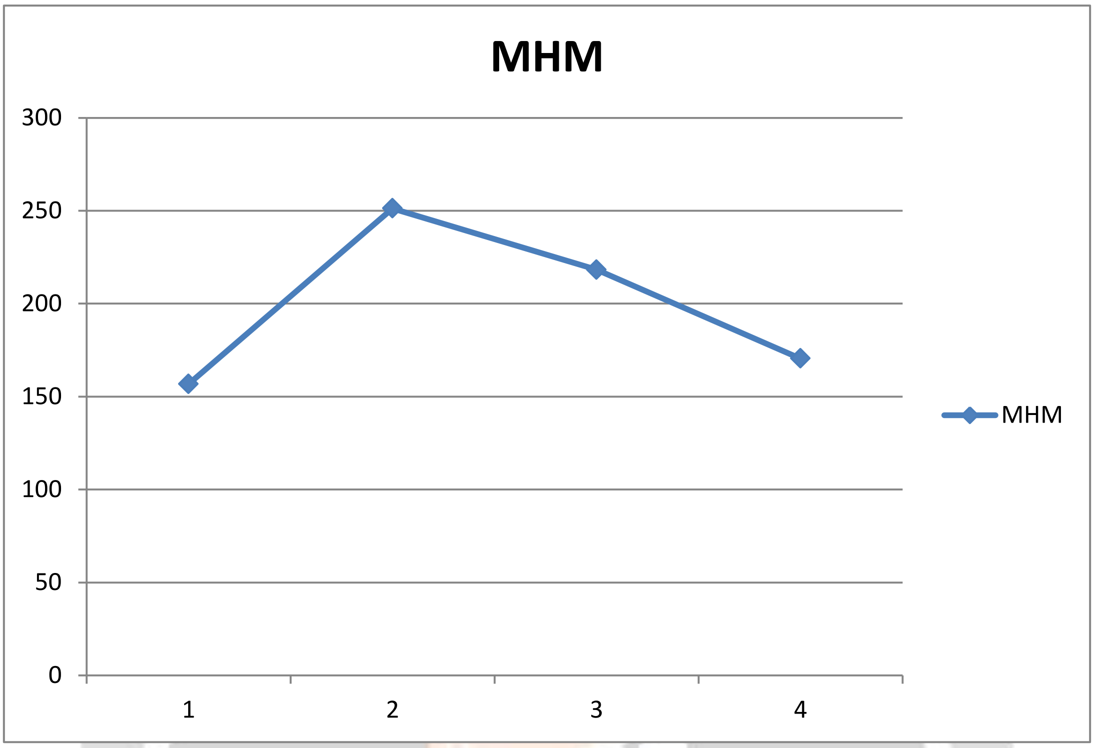

Figure 7: Throughput with respect to Zonal size in MHM Mobility Model.

Graph shows the effect of ZONAL size on the throughput in Manhattan mobility model. Zonal radius 2 and 3 are good in throughput when we increase the ZONAL size.

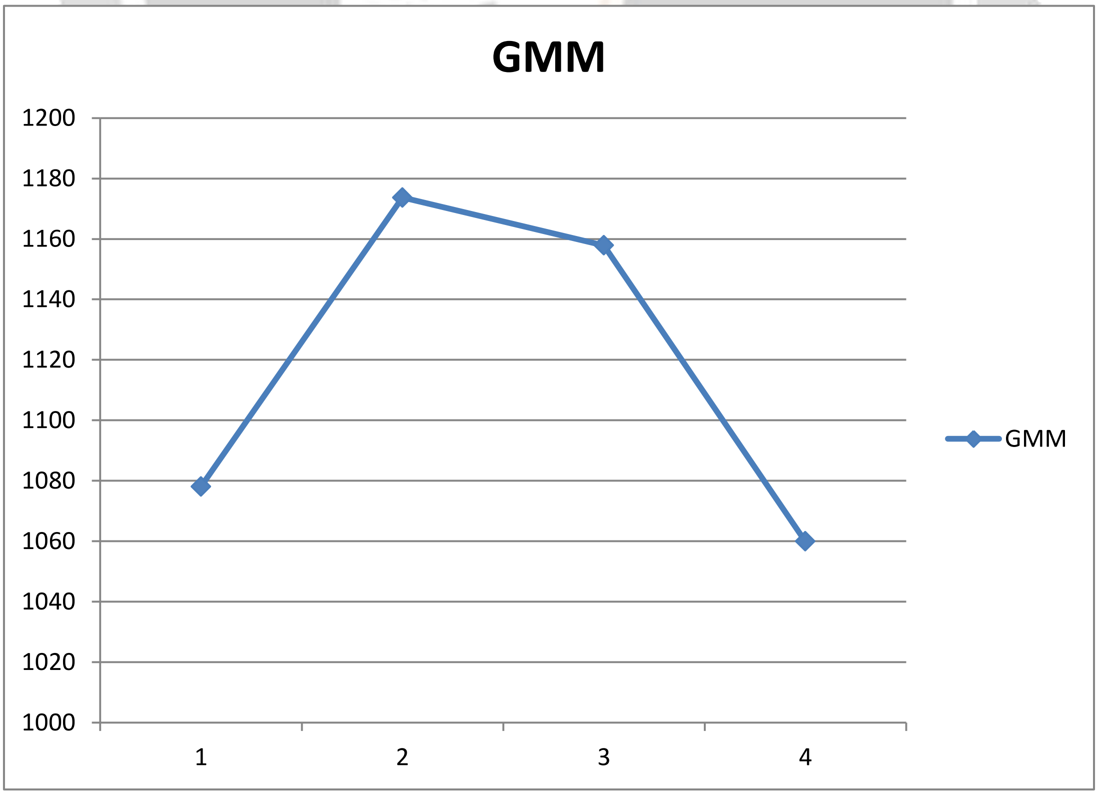

Figure 8: Throughput with respect to Zonal size in GMMM Mobility Model.

Graph shows the effect of ZONAL size on the throughput in Gauss-Markov model. Higher Zonal radius gives better throughput when ZONAL size is 2, and 3 .

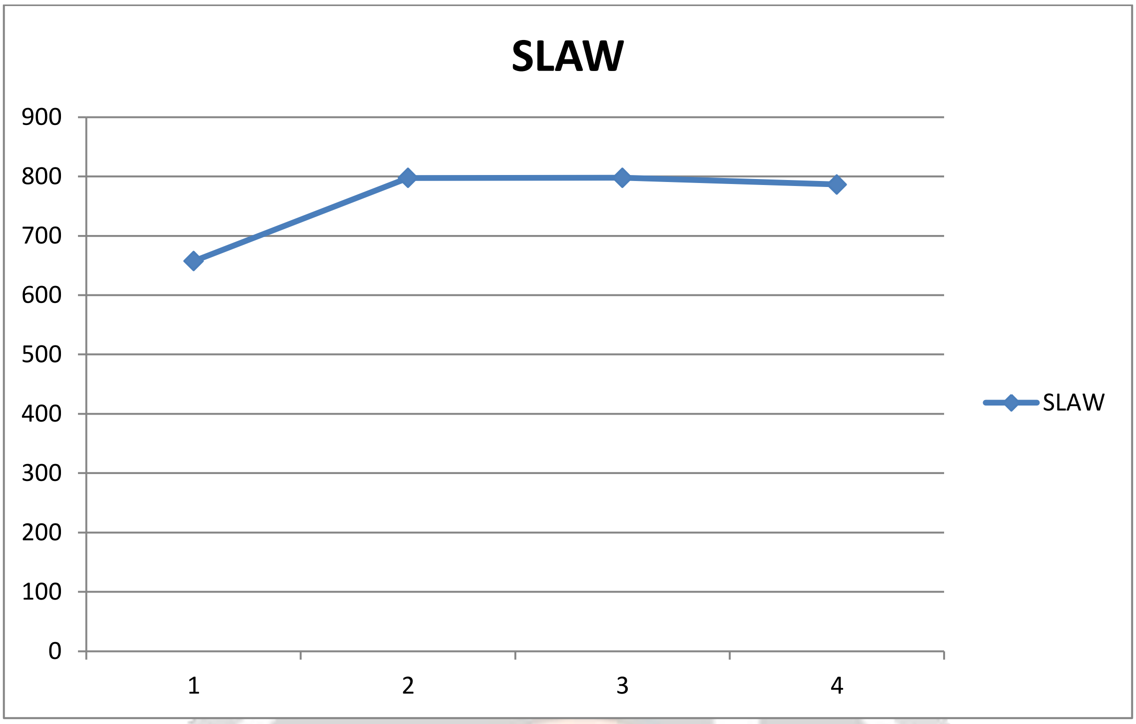

Figure 9: Throughput with respect to Zonal size in SLAW Mobility Model.

Graph shows the effect of ZONAL size on the throughput in SLAW model. Higher Zonal radius gives better throughput when ZONAL size is higher.

- **Packet Delivery Ratio**

Packet delivery ratio is calculated by dividing the total number of data packets received at all the nodes, by the total number of data packets sent out by the FTP sources. Packet delivery ratio forms an important Metric for performance evaluation of an ad hoc routing protocol because, given similar scenarios, the number of data packets successfully delivered at the destination depends mainly on path availability, which in turn depends on how effective the underlying routing algorithm is in a mobile scenario [2].

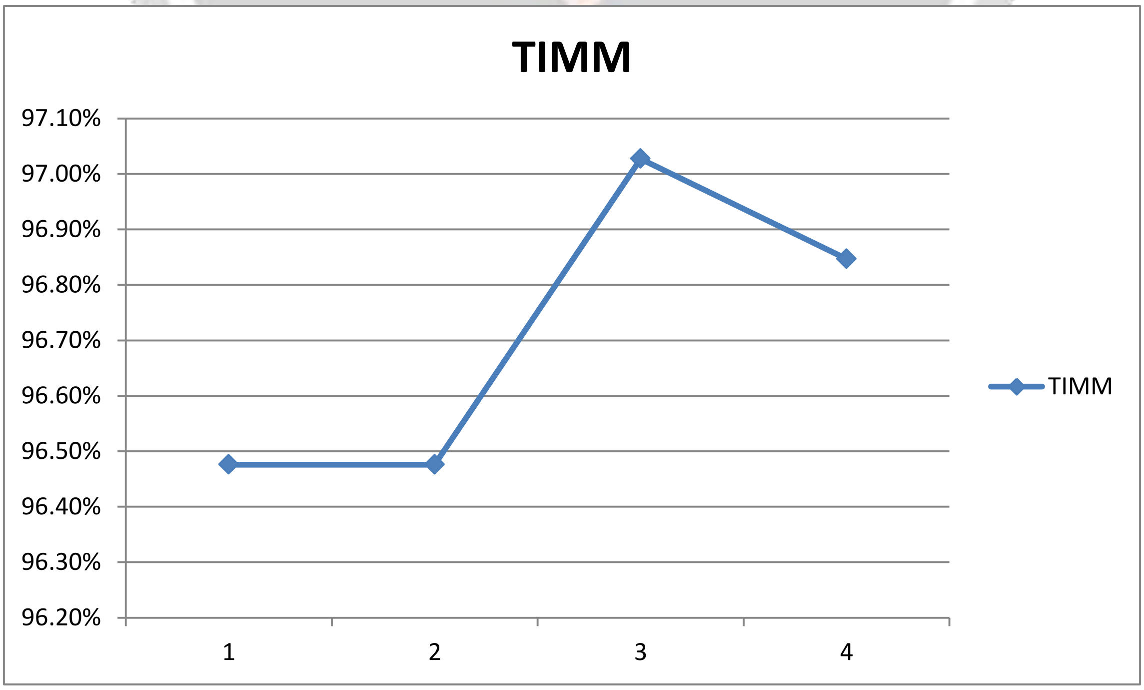

Figure 10: PDR with respect to Zonal size in TIMM Mobility Model.

Simulation Graph shows the effect of mobility on PDR in TIMM model. Higher Zonal size is good in terms of PDR in this mobility model.

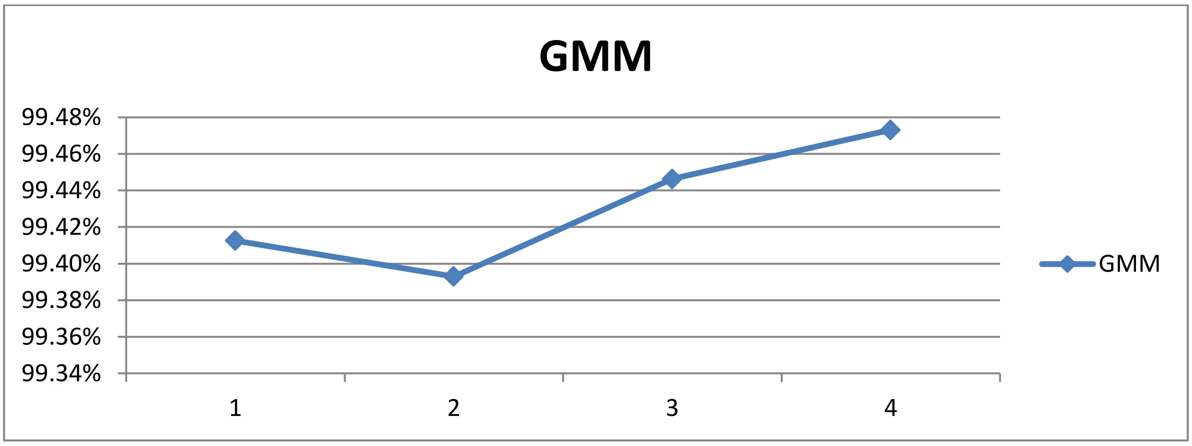

Figure 11: PDR with respect to Zonal size in GMM Mobility Model.

Graph shows the effect of mobility on PDR in GMM model. Higher considered Zonal radius is bad in terms of PDR for lower ZONAL size in this mobility model. Zonal radius 4 is better than Zonal radius 1 for network size of 60 nodes.

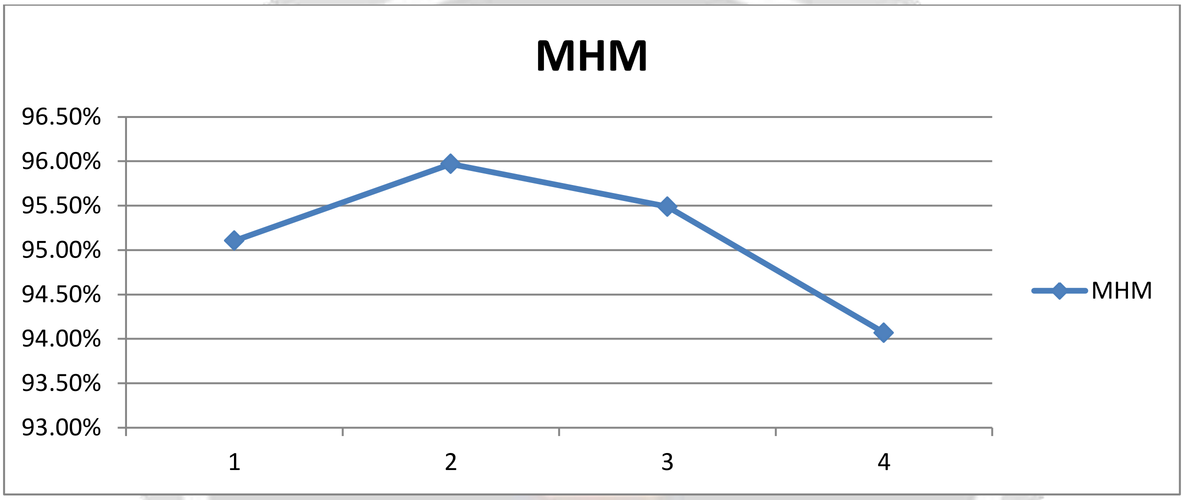

Figure 12: PDR with respect to Zonal size in MHMM Mobility Model.

Graph shows the effect of mobility on PDR in MHM model. Higher Zonal radius is bad in terms of PDR in this mobility model. Zonal radius 2 has better PDR than Zonal radius 3, and 4 .

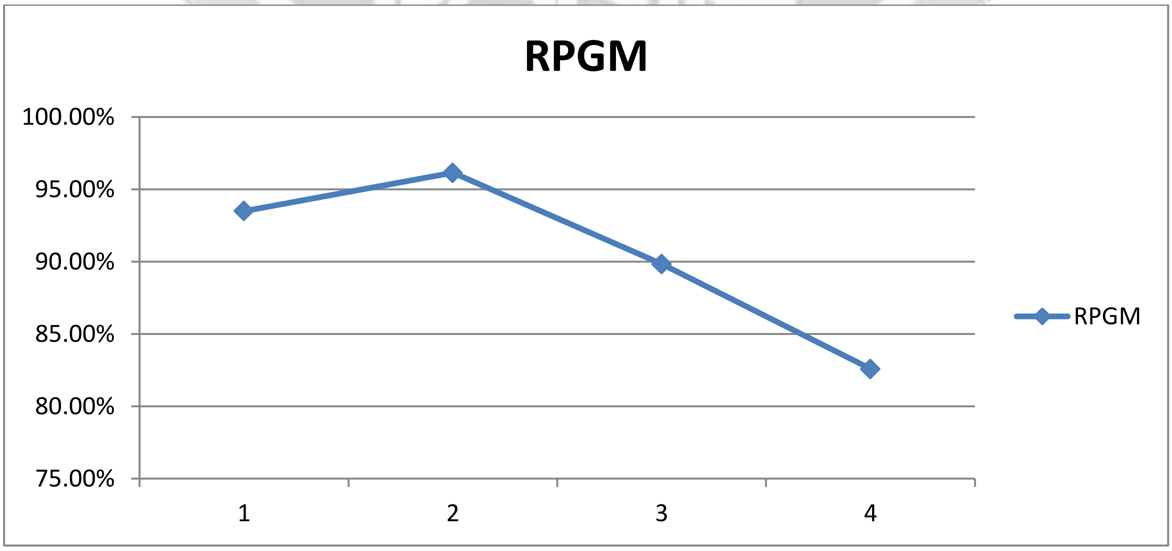

Figure 13: PDR with respect to Zonal size in RPGM Mobility Model.

The results analyzed from Figure 4.9 indicates that the throughput is highest when the mobility rate and Zonal radius is minimum. on PDR in RPGM model. The results analyzed from figure 4.9 indicates that the PDR is highest when the Zonal radius is minimum.

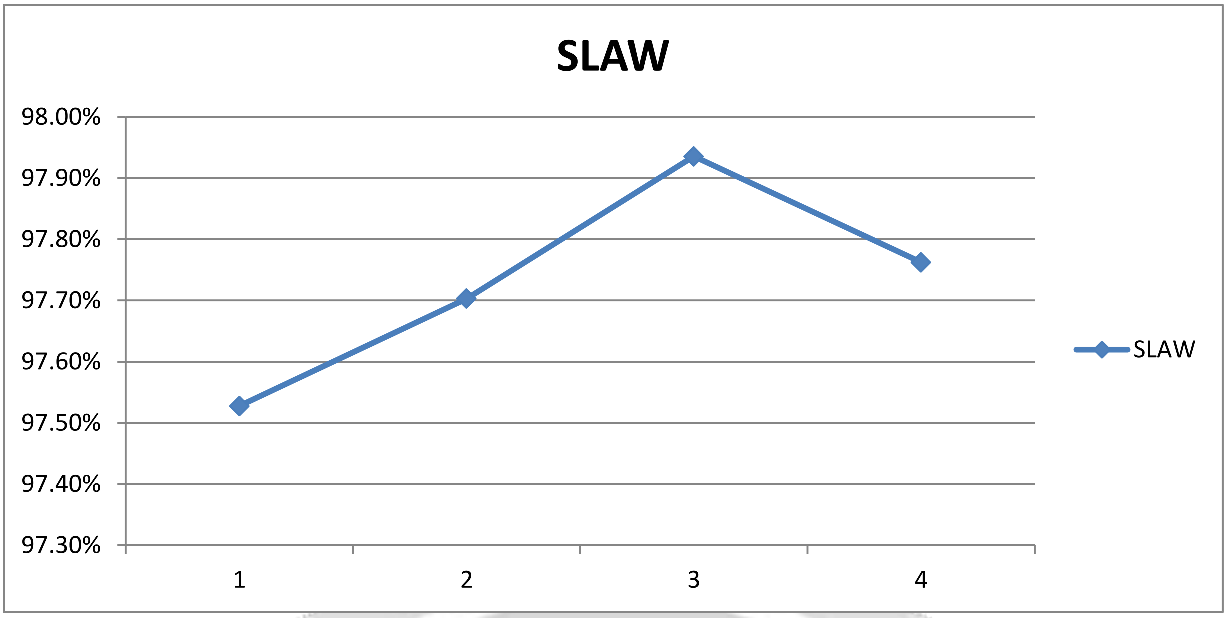

Figure 14: PDR with respect to Zonal size in SLAW Mobility Model.

V.CONCLUSION

In this paper, the effect of proposed hybrid routing protocol namely ZONAL Protocol is examined to compare the performance of different mobility models such as TIMM, SLAW, RPGM, MHM and GMM mobility models under FTP traffic.

Table II: Results showing the impact of varying Zonal Size in TIMM

METRICS USED	**CONCLUSION-TIMM**	
	BEST PERFORMANCE	WORST PERFORMANCE
Throughput	**Zonal size 3**	**Zonal size 1**
Packet Delivery Ratio	**Zonal size 3**	**Zonal size 1**

Table III: Results showing the impact of varying Zonal Size in RPGM

METRICS USED	**CONCLUSION-RPGM**	
	BEST PERFORMANCE	WORST PERFORMANCE
Throughput	**Zonal size 2**	**Zonal size 4**
Packet Delivery Ratio	**Zonal size 2**	**Zonal size 4**

Table IV: Results showing the impact of varying Zonal Size in MHM

METRICS USED	**CONCLUSION-MHM**	
	BEST PERFORMANCE	WORST PERFORMANCE
Throughput	**Zonal size 2**	**Zonal size 4**
Packet Delivery Ratio	**Zonal size 2**	**Zonal size 4**

Table V: Results showing the impact of varying Zonal Size in GMM

METRICS USED	CONCLUSION-GMM	
	BEST PERFORMANCE	WORST PERFORMANCE
Throughput	**Zonal size 2**	**Zonal size 4**
Packet Delivery Ratio	**Zonal size 2**	**Zonal size 4**

As Shown in Table V, Gauss MarkovMobility Model scenario when we compared different Zonal radius, Zonal size 2 shows good in throughput, PDR ratio and Average end to end delay than higher Zonal radius. Similarly Zonal radius 2 show better results for considered scenarios under Manhattan mobility whereas overall result shows that lower Zonal radius is good in MHM model and Gauss-Markov mobility model scenario.

Table VI: Results showing the impact of varying Zonal Size in SLAW

METRICS USED	CONCLUSION-SLAW	
	BEST PERFORMANCE	WORST PERFORMANCE
Throughput	**Zonal size 3**	**Zonal size 1**
Packet Delivery Ratio	**Zonal size 3**	**Zonal size 1**

In SLAW Mobility Model scenario when we compared different Zonal radius, higher Zonal size is good in throughput, PDR ratio and Average end to end delay than higher Zonal radius.

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