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Precipitate Data Dissemination (PDD) Protocol for Infostations Based Content Delivery Systems in VANET

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Abstract -- Vehicular Ad-Hoc Network (VANET) communication has become an increasingly popular topic recently in the area of Wireless Communication networking for efficient and epidemic data dissemination with required scalability. WiFi Infostations or WiFi Information systems are one of the most popular content delivery systems in VANET. Increasing the data dissemination throughput is one of the challenging tasks in Infostations. The number of protocols for data dissemination from Infostations to vehicles which were introduced so far achieved little better results in reducing the data loss. In this paper, Precipitate Data Dissemination (PDD) protocol is proposed for improving the performance of Infostations by reducing redundancy of data using Multihop neighbor Information and group forming functionalities. The experimental results are analyzed to evaluate the performance of PDD protocol and are also compared to starfish data scavenging protocol.
Keywords --- Vehicular Ad hoc Network (VANET); Wireless Ad hoc Networks; Communication Networks; Information Stations (Infostations); Multihop; Bit-Torrent Like Protocols; Congestion Control; AODV Protocol; PDD Protocol; Geometrical based dissemination Method; Routing; Broadcasting; Starfish Data Scavenging (SDS) Protocol; Data dissemination; Dedicated Short Range Communication (DSRC); Online Resource Allocation (ORA) Protocol; WINMAC protocol; Intelligent Transport System (ITS).

I. INTRODUCTION

Communication networks have been assumed to be connected almost all the time because there exists at least one end to end path between every pair of nodes. After the occurrence of partitions, they are considered as transitory failures. The core network functions such as Routing and Broadcasting react to these failures by attempting to find alternate paths. Wireless Multihop Ad hoc Networks (e.g., MANETs) have also short-lived partitions. However, some of the emerging network applications like special operations, emergency response, smart environments, and VANETs, may be disconnected at most of the time [1].
Among advanced wireless communication technologies, VANET (Vehicular Ad Hoc Network) is one of the new technologies which have taken enormous attention in the recent years [2]. Vehicular Ad hoc Networks (VANETs) communication has recently become hot topic in the area of wireless networking [3].
In Ad-hoc Network, the VANET not only maintain the information but also update the routing information among all nodes of a given network at all times [4]. The Vehicles equipped with some applications are able to communicate over the 5.9 GHZ frequency band via a Dedicated Short-Range Communication (DSRC) based device. DSRC allows high speed communications up to the range of 1000m between vehicles for Intelligent Transport system (ITS) related applications [5]. However, the inherent VANET characteristic makes data dissemination quite challenging [6].
Data dissemination services in wireless Vehicle Ad hoc Networks are becoming more and more important, as telecommunication applications require the distribution of a certain amount of information in the network. Data dissemination employs wide applicability in different types of Wireless networks, ranging from traffic information and warnings to parking availability, food prices, road conditions, and advertisements. Data dissemination services can be supported by the traditional cellular networks such as General Packet Radio Service (GPRS) and 3G. But they provide only limited bandwidth for accessing data at high costs and also have limitations in granularity and coverage [7].
In contrast, VANET technology can also be used to provide various Vehicular services such as transport connection to Internet and intranet, telecommunication services, intra car communication, especially Infostations [8] which are the ideal alternative for deploying Location-Aware-Information Services to Vehicles. With the ubiquity and high bandwidth of WiFi devices, Content Providers such as restaurants and tourism offices can easily deploy a small number of WiFi Infostations (Information stations) for quick delivery of the content to passing users [9]. Infostations and Vehicles act as sender and receiver respectively in

Infrastructure to Vehicles communication.

Numerous protocols have been proposed to improve data dissemination by using application level encoding techniques such as network coding [10] [11] and Bit Torrent–like Protocols [12]. No one considers techniques to improve the performance of senders or receivers individually.

In this paper, one of the main and important entity of I2V communication called receivers (Vehicles or Destinations) are considered and Precipitate Data Dissemination (PDD) Protocol has been proposed for receivers to increase the data dissemination throughput by improving the functionality of the Broadcast Infostations and avoiding the unwanted broadcast processes within their transmission range. Section 1.1 presents an Overview about proposed PDD protocol.

A. *Overview of the proposed protocol:*

An overview of the proposed system is given in Fig 1. The data dissemination process of location aware information for both the existing starfish data scavenging protocol and proposed Precipitate Data Dissemination (PDD) Protocol are tested in the Broadcast Infostations and their performance are analyzed using statistical parameters such as Throughput, packet delivery ratio and packet lost rate.

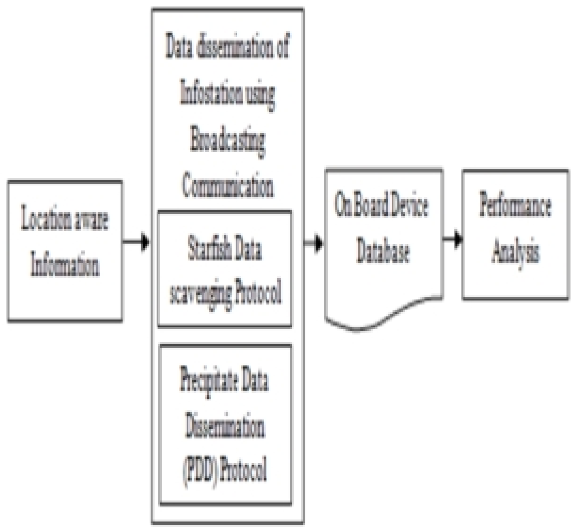

Fig 1: Block diagram of the proposed model

In the rest of the paper, Section 2 exposes a short review of related works regarding data dissemination protocols for Infostation based VANET. In Section 3, proposed system is explained in detail. The performance of the proposed protocol is analyzed and results are projected in Section 4. The work is concluded in Section 5 with future possible enhancements.

II. RELATED WORKS

Effective data dissemination process transmits the content from source vehicle node to destination vehicle node and most of the problems are resolved by using different type of protocols. During the data dissemination, many parameters such as network size, vehicle's speed, patchy and intermittent connectivity between vehicle nodes and also latency requirements are considered to evaluate the Infostations Network.

The data dissemination process has been classified into different approaches such as opportunistic data dissemination, vehicle-assisted data dissemination and cooperative data dissemination [13]. The review of data dissemination protocol for WiFi Infostation is presented in section 2.1.

A. *Data dissemination protocols for Wi-Fi Infostations*

In 1999, an intelligent transmission protocol called WINMAC was proposed by Gang Wu et al, for Infostations to handle channel allocation and access, adjustment of adaptive transmission rate and retransmissions of packets. It utilizes TDMA/TDD channel structure and Rate Switching Algorithm (RSA) for data dissemination. The parameters such as time slots and three transmission rates (250 kbps, 1mbps and 2mbps) were used to evaluate the model. The results revealed that it provided better data dissemination when compared to others [14]. In 2007, Ilias Leontiadis et al proposed an opportunistic event dissemination protocol for Vehicular Networks. The Opportunistic cache and replay mechanisms are used to deliver the notifications to new subscribers. It was simulated using realistic Vehicular Traces and results are compared to standard epidemic protocol in terms of message delivery and overhead in various scenarios [15].

In 2008, Laura Galluccio et al, proposed Energy efficient protocols to design efficient infostation systems for rural areas to improve the data dissemination process. These protocols have the functionalities to decrease the cost of the devices and also increase the energy of the Infostation. The main goal of them is to reduce the cost of the devices as well as increase the energy of the rural infostation systems. The parameters Maximum probability of neighbor communication success P (max), Power consumption constraint c* and Time variations TCycle are used to evaluate the method. The results clearly showed that the energy efficient rural infostations are better when compared to generic wireless mobile networks [16].

In 2011, Yifan Li et al proposed a Distributed Hierarchical cooperation formation algorithm for recovering the improper cooperation between Access Points (APs) and Mobile Users (MUs) in Mobile Infostation Networks. The merge and split mechanisms are used in the model to achieve the stable hierarchical cooperation among APs and MUs. The method is investigated using different system parameters such as Mobile Users (MU), Access Points (AP), and Expected Payoff to prove the effectiveness of the proposed algorithm [17]. In 2012, Hao Liang et al proposed an Online Resource Allocation (ORA) protocol to solve an optimal resource allocation problem for on-demand data delivery in high speed trains of cellular/infostation integrated networks. It was demonstrated that the proposed resource allocation protocol improved the total reward of delivered services over the existing approaches such as FIFO, EDF and RAPID. The performance of the proposed protocol is evaluated based on a real high-speed train schedule. Compared to other approaches, the proposed algorithm can significantly improve the quality of on-demand data service provisioning over the trip of a train [18].

Vehicles arrive within coverage area, Infostation can disseminate content even when the vehicles do not require the content of particular Infostation. This process may cause some issues such as energy loss, wastage of time. Due to these issues, Infostation is not able to achieve maximum data dissemination throughput. Vehicles which need to access that Infostations are also affected by these issues. To avoid the data loss and increase the efficiency of data receiving from an Infostation, Starfish data scavenging protocol was introduced by Vinod Kone et al in 2013 [9]. The data loss in Infostation network is reduced to some extent simply by adding the bandwidth of both faraway vehicles and nearby vehicles for communicating between themselves. When faraway vehicles do not find any neighboring vehicles within their communication bandwidth to scavenge the data, the concept of starfish data scavenging protocol totally fails. This protocol is not concentrated on controlling the data loss of Infostation during data dissemination effectively because it provides only temporary solution for data loss. To address these issues, the protocol Precipitate Data Dissemination (PDD) is proposed and its detailed description is given in section 3.

III. PRECIPITATE DATA DISSEMINATION (PDD) PROTOCOL

Among different types of vehicular communication networks, the Precipitate Data Dissemination (PDD) Protocol is proposed for the Infostation to Vehicle communication (I2V communication) for mainly concentrating in vehicle side or receiver side with advanced functionalities. The main goal of the proposed protocol is to reduce the data loss in Infostation, and unwanted broadcasts are avoided for reducing the redundancy.

By implementing this protocol, Infostation frequently updates its neighbors (vehicles which are in direct transmission range). If Infostation finds a vehicle with in its transmission range, it will check the node Id to identify the group of the nodes. After identifying the particular group, Infostation transmits the message to the respective group of vehicle nodes that are distributed in a uniform manner. By using the PDD protocol, number of vehicle nodes accessing the same content of Infostation is decreased exponentially in some complex scenarios of Infostations such as low distance between two neighbor vehicle nodes and more vehicle node density. This functionality of PDD protocol significantly reduces redundant broadcasts within the Infostation coverage area.

The PDD protocol in vehicle nodes decides whether or not to accept the content from the Infostation in broadcast communication. The advantage of Precipitate Data Dissemination Protocol is the size of the data packet which is not increased while adding the list of forwarding neighbors. The main challenge in the design of Precipitate Data Dissemination (PDD) protocol for vehicles is to find out whether the received message from Infostation is to be broadcast or not. The step by step process of PDD protocol is shown in Fig 2.

Precipitate Data Dissemination (PDD) Protocol

Input : Number of sent packets from Infostations
Output: Number of successful delivery of data packets at destination vehicles

Step 1: Build an Infostation to vehicles Network by creating source to other node distance within the range of 250 meters using

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Distance = sqrt ((x1- x2)^2- (y1-y2)^2) in which x_1 and y_1 mentions x axis and y axis positions of source node and x_2 and y_2 point out x axis and y axis positions of each node.

Step 2: Vehicle nodes are partitioned into different group names such as Taxi, Bus, Bike and Trunk.

Step 3: Store the details such as Time, source, Neighbor node and Neighbor count in a separate file similar to the neighbor details.

Step 4: store neighborhood forwarding nodes in a file separately which contains Group name, the node ID, neighbor node ID, X position of node, Y position of node, distance between node and Neighbor node using "proc" command.

Step 5: Node to node relationship is carried out to find the shortest path for disseminating content using the source to node distance calculation file.

Step 6: Neighbor information are updated for each time for effective data dissemination.

Step 7: Infostations take the individual group as a input for which the message is transmitted and repeated through steps 1 to 3.

Step 8: Broadcast transmission occurs if Infostation finds vehicles within the coverage area at particular time interval.

Step 9: A particular vehicle node can avoid broadcasting of data if its neighbor vehicle has already received same content from Infostation or it finds another stranger vehicle closer to its neighbor vehicle nodes that has the same content.

Step 10: After certain time duration (approximately 0.2 seconds), stop the transmission and read the next neighbor information from the file.

Fig 2: Precipitate Data Dissemination (PDD) Protocol

A vehicle can broadcast content to its neighboring vehicles (at least one vehicle node) which have not received the content with in a particular defer time interval. The PDD protocol clearly determines that whether the broadcast process is redundant or not. If a defer time of a particular vehicle node (X) is low compared to the maximum defer time of another vehicle node (Y) in same group, then X will communicate with Y for accessing the data.

However, this broadcast gets redundant if all such neighbor vehicle nodes receive the message from other vehicle nodes even when their particular time interval expired. The proposed protocol reduces the redundant broadcasts without changing the defer time design of MAC-layer. It reduces the computational complexity by selecting maximum number of forwarding neighborhood nodes for the vehicles to improve the overall network performance.

The PDD protocol helps the vehicles to utilize the resources effectively within the Infostation coverage area. So it leads to build an efficient Infostation network in VANET. Experimental results and their extensive analysis are given in section 4.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The performance of the starfish data scavenging protocol and Precipitate Data Dissemination (PDD) Protocol described in previous sections are analyzed using NS2 simulator in the context of data dissemination of location aware information.

The execution of NS2 is carried out by means of cluster surroundings of wireless vehicle nodes. It came as an extension of Tool Command Language (TCL). The simulation area of NS2 execution is 1200 meters and information of each data packet has a size of 1024 bytes. Source to destination connections are indicated by the simulation path. NS2 is used to build non real time vehicular Ad-hoc environment at low cost. The parameters and their values used for simulation configuration settings are tabulated in Table 1.

Table 1: NS-2 Simulation Configuration Settings

PARAMETERS	VALUES
Version	NS-allinone 2.28
Protocols	PDD
Simulation Area	1200 m x 1200 m
Broadcast Area	400 m
Data packet Size	1024 bytes
Simulation time	300 seconds
No of vehicles	4,10,50,75,113
MAC protocol	IEEE 802.11

From the first node itself, the data dissemination process from Infostation to vehicle nodes is started. In the existing starfish data scavenging protocol, faraway vehicles (vehicles that are located at long distance from Infostation) scavenge data from nearby vehicles (vehicles that are very near to the Infostation) within the Infostation coverage area by combining their communication bandwidth.

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Precipitate Data dissemination (PDD) Protocol categorizes the vehicle nodes into different groups such as cars; vans etc for disseminating the data in more efficient manner. Vehicles decide whether they need data or not in broadcast communication from Infostations to reduce the data loss of Infostation Network. To analyze the performance of the proposed protocol, the mobility of all vehicle nodes is traced through simulations and it is noted for 300 seconds. The parameters such as Throughput, packet delivery ratio and packet lost rate are used to evaluate the performance of the proposed PDD protocol for data dissemination in Infostation based VANET and are compared to starfish data scavenging protocol. The parameters and their formulae are shown in Table 2.

Table 2: Parameters with its Formulae

parameters	Formulae
Throughput	$\dfrac{\text{No of received packets x packet size}}{\text{Transmission Time}}$
Packet delivery ratio	$\dfrac{\sum \text{No of packets received}}{\sum \text{No of packets sent}} \text{x100}$
Packet lost rate	(No. of packet sent – No. of packet received)

The throughput is the amount of work which is successfully delivered by an Infostation within a particular amount of time and it is used to measure the effectiveness of data dissemination approaches. The proposed Precipitate Data Dissemination (PDD) protocol achieves high throughput when compared to starfish data scavenging protocol. The throughput earned by these approaches for various vehicle nodes 4, 10, 50, 75 and 113 in different transmission time 60s, 120s, 180s, 240s and 300s are tabulated in Table 3 and the graphical representation of the same is given in Fig 3, Fig 4, Fig 5, Fig 6 and Fig 7 respectively.

Table 3: Average Throughput (bits per second)
of data dissemination protocols

Transmission time (seconds)	Data dissemination protocols									
	Starfish data scavenging protocol					Precipitate Data Dissemination Protocol				
	4N	10N	50N	75N	113N	4N	10N	50N	75N	113N
60	8055	7236	5734	4915	4096	9830	9011	8192	7918	7509
120	4505	4232	3686	3345	2594	5324	5051	4642	4232	4300
180	3367	3231	2821	2548	2139	4050	3868	3458	3276	3094
240	2867	2730	2457	2218	2048	3208	3037	2901	2594	2525
300	2457	2348	2129	1911	1747	2676	2594	2484	2239	2184

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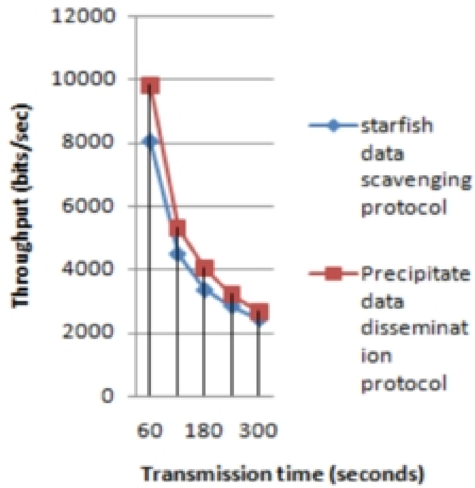

Fig 3: Average Throughput for 4 nodes

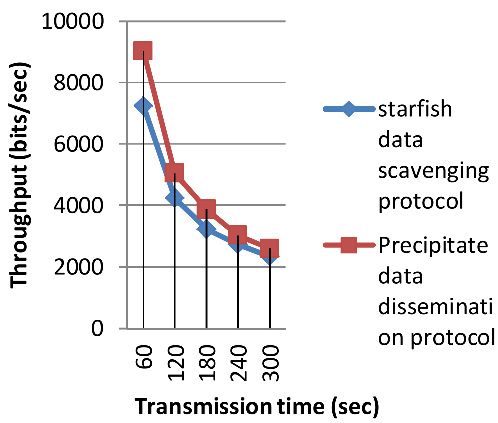

Fig 4: Average Throughput for 10 nodes

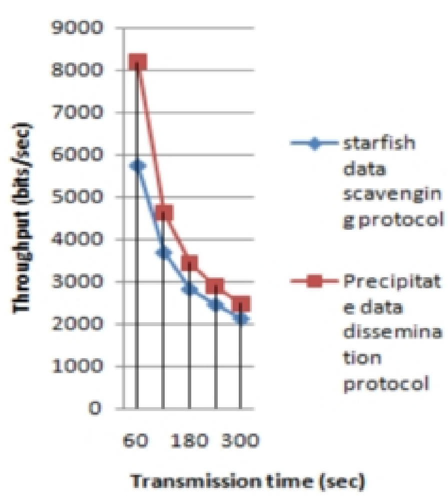

Fig 5: Average Throughput for 50 nodes

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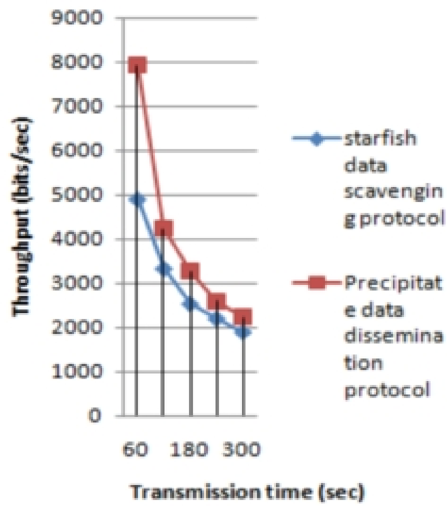

Fig 6: Average Throughput for 75 nodes

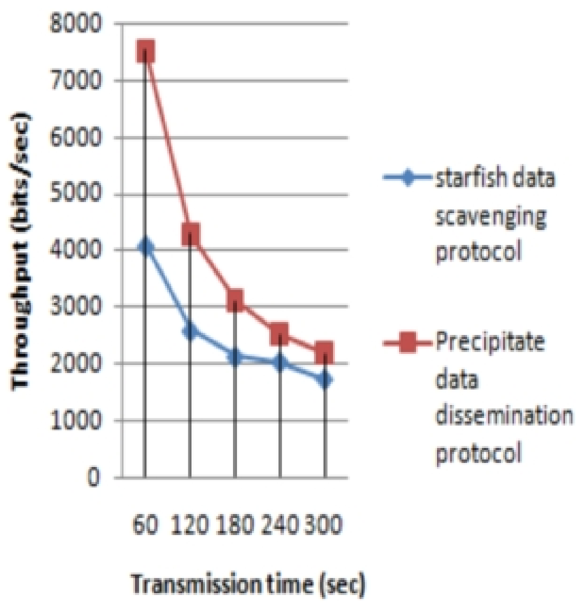

Fig 7: Average Throughput for 113 nodes

From the simulation results, it is analyzed that the high throughput value is achieved by starfish data scavenging protocol for 4 vehicle nodes in 60 seconds and it reduces gradually when the time increases. The same fashion is reflected when number of vehicle nodes increased like 10, 50, 75 and 113. Proposed Precipitate Data Dissemination (PDD) Protocol achieves high throughput value compared to starfish data scavenging protocol. The protocol which earns the maximum throughput values is considered as efficient data dissemination protocol. Hence, the proposed PDD protocol performs better than starfish data scavenging protocol with respect to throughput.

The ratio between sum of total number of packets received by vehicles and sum of total number of packets sent by Infostation is called as packet delivery ratio.

It determines efficiency, completeness and correctness of the model and also measures the data loss rate of dissemination protocols used in Infostation. The packet delivery ratio of each data dissemination protocols for various vehicle nodes in varying time are projected in Table 4 and the diagrammatic representation of the same are also given in Fig 8, Fig 9, Fig 10, Fig 11and Fig 12 respectively.

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Table 4: Average packet delivery ratio (%) of data dissemination protocols

Transmission time (seconds)	Data dissemination protocols									
	Starfish data scavenging protocol					Precipitate Data Dissemination (PDD) protocol				
	4N	10N	50N	75N	113N	4N	10N	50N	75N	113N
60	59	53	42	36	30	72	66	60	58	55
120	66	62	54	49	38	78	74	68	62	63
180	74	71	62	56	47	89	85	76	72	68
240	84	80	72	65	60	94	89	85	76	74
300	90	86	78	70	64	98	95	91	82	80

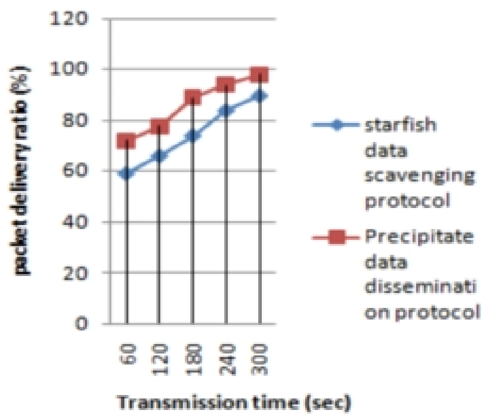

Fig 8: Average packet delivery ratio for 4 nodes

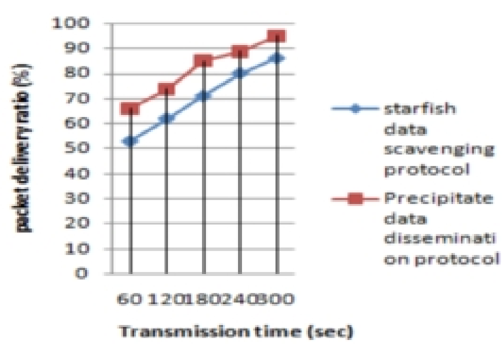

Fig 9: Average packet delivery ratio for 10 nodes

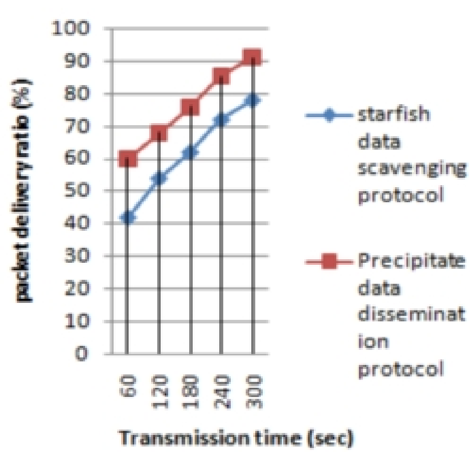

Fig 10: Average packet delivery ratio for 50 nodes

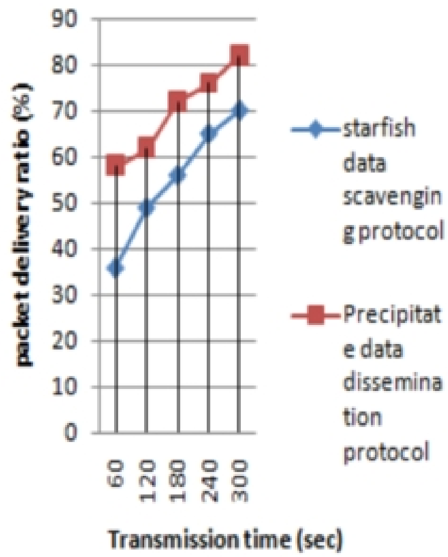

Fig 11: Average packet delivery ratio for 75 nodes

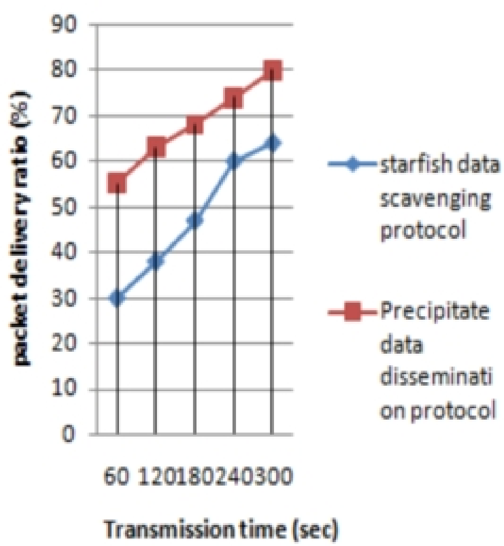

Fig 12: Average packet delivery ratio for 113 nodes

The simulation results clearly showed that packet delivery ratio value will be low in transmission time by 60 seconds. Packet delivery ratio values are increased while the transmission time increases from 60 seconds to 300 seconds for both starfish data scavenging protocol and PDD protocol. But the same is decreased when the vehicle nodes are increased from 10 to 113. The approach which yields high packet delivery ratio is considered as better data dissemination protocol.

While comparing starfish data scavenging protocol with Precipitate Data Dissemination (PDD) protocol, PDD yields highest packet delivery ratio. From this study, reliability of PDD protocol is greater than starfish data scavenging protocol for different number of nodes. It is noted that PDD protocol is the efficient data dissemination protocol and also reduces data loss. The difference between number of sent packets and received packets by the infostation and vehicles respectively is called as packet lost rate. It is used to know how many packets are lost during the transmission, and it also helps to analyze the data dissemination protocols. The average packet lost rate of starfish data scavenging protocol and PDD protocol for 4, 10, 50, 75, and 113 vehicle nodes in different transmission times 60s, 120s, 180s, 240s and 300s are shown in Table 5 and the same are flashed in Fig 13, Fig 14, Fig 15, Fig 16, and Fig 17 respectively.

Table 5: Average packet lost rate (%) of data dissemination protocols

Transmission time (seconds)	Data dissemination protocols									
	Starfish data scavenging protocol					Precipitate Data Dissemination (PDD) Protocol				
	4N	10N	50N	75N	113N	4N	10N	50N	75N	113N
60	41	47	58	64	70	28	34	40	42	45
120	34	38	46	57	62	22	26	32	38	37
180	26	29	38	44	53	11	15	24	28	32
240	16	20	28	35	40	6	11	15	24	24
300	10	14	22	30	36	2	5	9	18	20

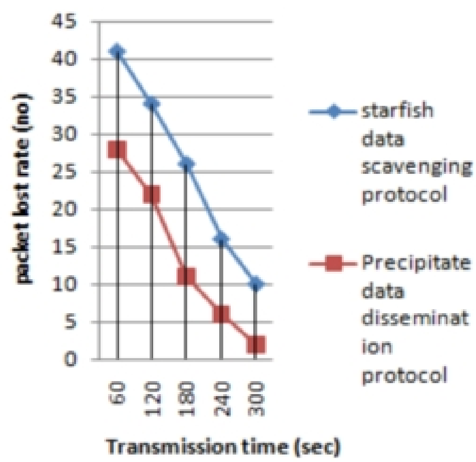

Fig 13: Average packet lost rate for 4 nodes

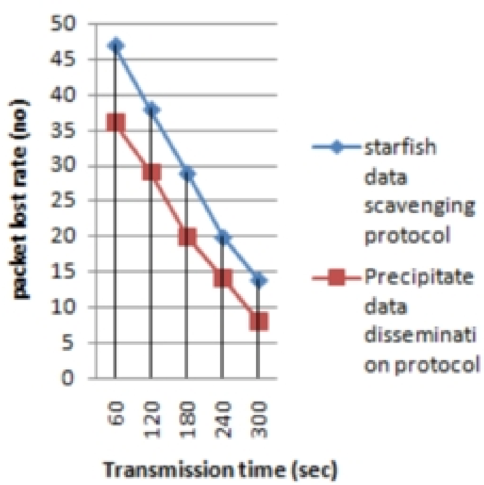

Fig 14: Average packet lost rate for 10 nodes

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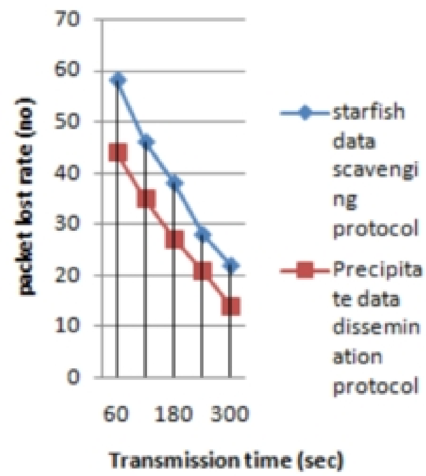

Fig 15: Average packet lost rate for 50 nodes

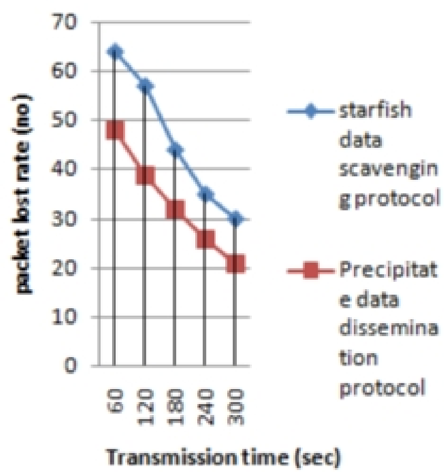

Fig 16: Average packet lost rate for 75 nodes

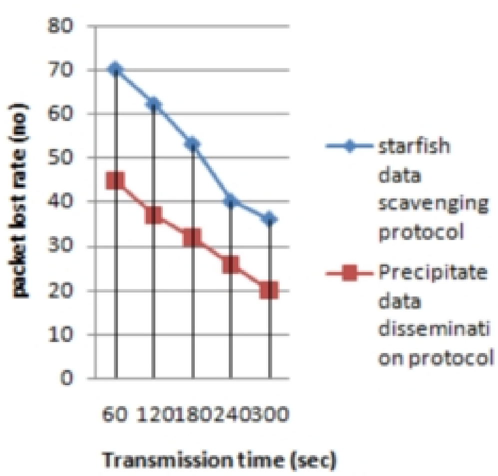

Fig 17: Average packet lost rate for 113 nodes

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According to the simulation results, initially the packet lost rate of starfish data scavenging protocol in 4 vehicle nodes is high at 60 seconds and get reduced when transmission time increases from 60 seconds to 120 seconds, 180 seconds, 240 seconds and 300 seconds respectively. The same is also reflected in the result for different vehicle nodes like 10, 50, 75, and 113. The packet lost rate of PDD Protocol is low compared to starfish data scavenging protocol. The protocol which has the low packet lost rate values in high time interval is considered as efficient data dissemination protocol. Hence, PDD Protocol shows better performance than starfish data scavenging protocol with respect to packet lost rate. From the experimental results and discussion, results revealed that the proposed Precipitate Data Dissemination (PDD) protocol is the better data dissemination protocol when compared to starfish data scavenging protocol since it provides high throughput, high Packet Delivery Ratio, and low Packet Lost Rate.

V. CONCLUSION AND FUTURE CONSIDERATIONS

The performance of data dissemination protocols such as starfish data scavenging protocol and Precipitate Data Dissemination (PDD) protocol are analyzed using NS2 Simulator, in context of broadcast Infostations. The results revealed that the proposed Precipitate Data Dissemination (PDD) protocol is more efficient for data dissemination from Infostations to vehicles in VANET. The protocol mainly helps Infostations for delivering location aware information without any data loss. It works well in limited coverage area accessibility of Infostations and differentiates the vehicles into various groups. PDD protocol also provides the authority to the vehicles for deciding whether to broadcast the data within Infostation coverage area or not. In future, researchers may develop data dissemination protocols to maximize the data dissemination throughput without data loss. These protocols should adopt the complex scenarios of Infostation Networks such as increased transmission time, more vehicle density and high Infostation coverage area.

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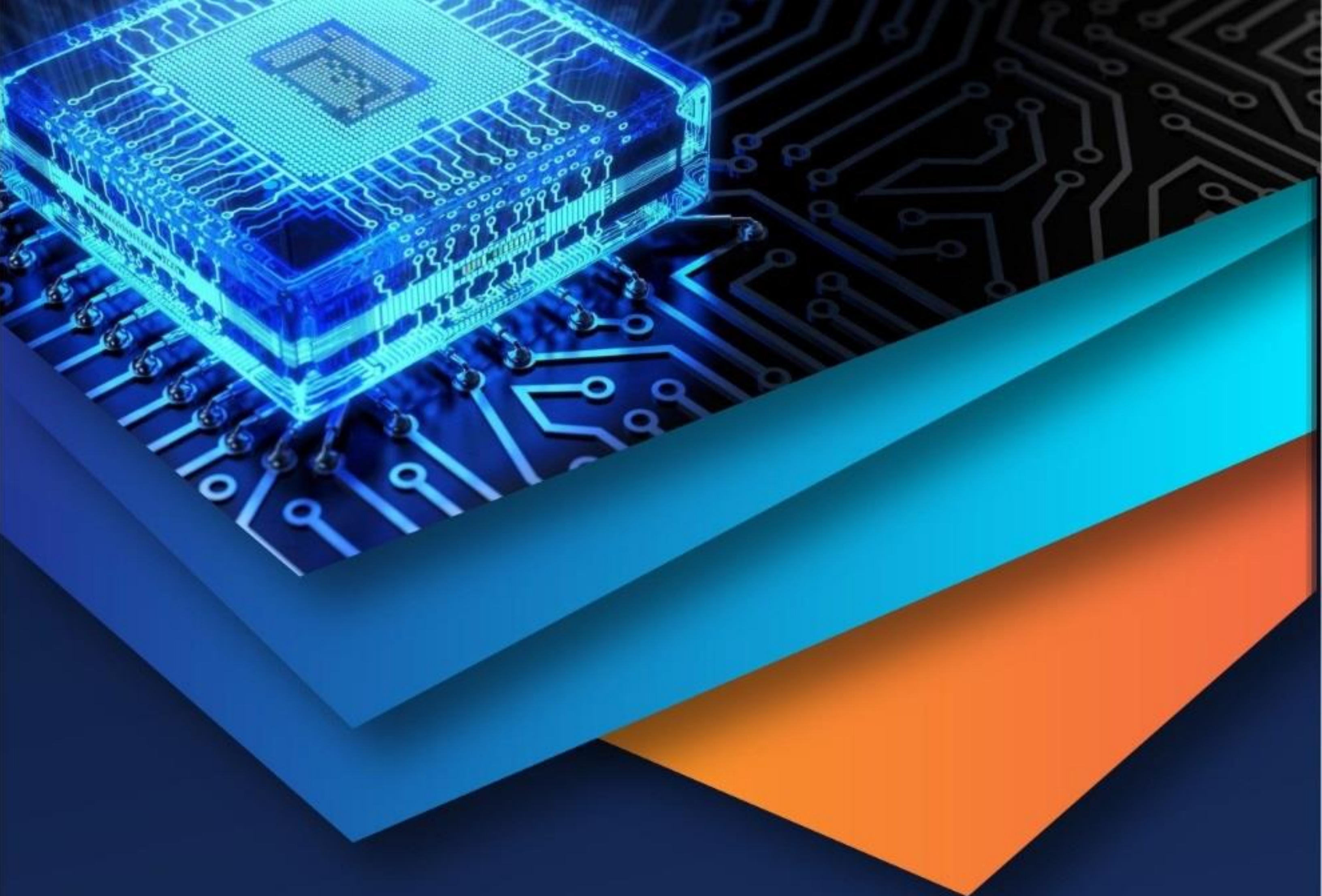

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