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Investigation of Route Maintenance Parameters on the Performance of AODV Routing Protocol in MANET

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Abstract:* Ad-Hoc on Demand Distance Vector (AODV) routing protocol is the most studied routing protocols in MANET that allows mobile nodes in establishing an Ad-Hoc Network. The main feature of AODV is to provide loop free routes even while repairing broken links. The performance of AODV protocol is very much influenced by the choice of values for certain route maintenance parameters, such as Active route Timeout (ART) and Delete Period Constant (DPC). The present article provides vigorous and effective investigation of route maintenance parameters (i.e. ART and DPC) on the performance of AODV routing protocol by mentioning all the significant simulation parameters explicitly and also justify how the performance of AODV gets affected by variation in the above mentioned route maintenance parameters on the basis of node speed and pause time under the influence of Steady state RWP mobility model (SSRWP). NS-3.29 simulator has been used to analyze the performance of AODV routing protocol under the considered performance metrics such as Average End to End Delay, Average Packet Delivery Ratio, and Average Throughput.

***Key Words:*AODV, ART, Delete Period Constant (DPC), NS-3.29, Steady State Random Waypoint Mobility Model (SS-RWP).**

I. INTRODUCTION

Mobile Ad hoc Network (MANET) [1] is a typical type of wireless network which consists of mobile nodes having the ability to communicate directly to each other without any help of centralized administration. Since MANET is an infrastructure-less network therefore every mobile node cooperate in routing by forwarding data from a source node to destination node. This ability makes MANET a dynamic network in which routing is considered to be the most important task since the network topology is changing very frequently.

Thus there are many routing protocols proposed and used by the researchers in the field of Mobile Ad-hoc networkingsuch as DSDV [2], DSR [3], FSR [4], OLSR [5], DYMO [6], AODV [7] and etc. among which AODV has been mostly used. Due to dynamic nature of MANET, it is important to focus on two important features, *firstly;* it is essential that the routing protocol considered in the network should by properly implement with all its considered significant and important attributes. *Secondly;*AMANET is very much dependent upon various important network parameters such as data rate, packet size and the type of wifi- physical standard (IEEE 802.11), therefore it is very important touse the correct values of these parameters. Many researchers have not mentioned the above attributes in their articles properly, due to which there result might not come closer to the real value.

II. MOTIVATION

During the study in the field of MANET and its routing protocols for past few years we came across few important areas such as routing, mobility, quality of service and etc. Among which routing has been widely used and explored by the researchers. It was also found that AODV routing protocol has been mostly used by the researchers to simulate a Mobile Ad Hoc Network, but still key features for simulation and important attribute of AODV were not addressed properly in many articles.Therefore during study over AODV routing protocols, there were many article which motivated us in our research, some of them are mentioned below. Perkins C. et al [8] reported the RFC 3561 (Request for Comment) for Ad Hoc on Demand Distance Vector Routing. The reported RFC gave an elaborative outlook for the implementation of AODV for ad hoc networks. Gupta S. K et al [9] reported the Effect of variation in active route timeout and delete period constant on the performance of AODV protocol. The results, however, are based on a single run and certain significant information viz. MAC and reference loss are not explicitly mentioned. Gupta S. K et al[10] also reported the Effect of ART, DPC and Active Nodes on the Performance of AODV Routing protocol. They reported that ART and DPC have a directeffect on the Quality of Service of a considered network on the basis of considered performance metrics such as throughput, average jitter, average end-to-end delay and droppackets etc.

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The prime concern of their paper was to identify how the number of nodes that are actively participating in communicationat any given time will affect the QoS parameters of the network with variation in ART and DPC, they used QualNet 7.1 Simulator it simulate the network. However still their work was based on single run and no statistical analysis was reported. Gupta S. K et al[11] also reported the Optimal Relation between Active Route Timeout,mobility and transmission range on the performance of AODV routing protocol, they have used QualNet Simulator to identify the results, The main concern of their study was to find out the proper relation between Active route timeout, mobility & nodes transmission range at default QualNet transmission power so that the network performance can be enhanced.

Howevertheir reporting was based on single run and the performance metrics were not explicitly mentioned.

Al-Mandhari et al. [12] evaluated the performance of Active Route Time-Out parameter in Ad-hoc On Demand Distance Vector (AODV) by varying the ART value in which they concluded that at the default value of ART, the PDR values were very low especially at high mobility of station. They further reported that on reducing the ART values the performance of the network gets improved especially for higher mobility values. OPNET simulator was used and the reporting was also based on single run and no statistical analysis was done to achieve the results. Das A. X et al [13] implemented AODV routing protocol using NS 3.29 and analyzed the role of route maintenance parameters (ART, DPC) and explained how these parameters directly affect Average End to End Delay, Packet Delivery Ratio and Throughput, 10 simulation run were considered and proper statistical analysis was done, the performance of route maintenance parameters of AODV was based on 1 – 10 m/sec speed and 1-5 sec pause time was used, but still how variation in speed and variation in pause time affect the performance of route maintenance parameters of AODV was not reported . Kurkowski S. et al [14] reported MANET simulation study in which they specifically focused on common and important Simulation issues which researcher does nowadays. They provided study from their own experienceswith simulations as well as the experience of othersin the field of MANET. They mainly focused on three important issues which many researchers were not mentioning or overlooking in their research, such as results based on single set of data, lack of statistical analysis and confidence interval. The authors encouraged that simulation results should be based on multiple run and the result should be statistically analyzed, with confidence intervals which is a statistical tool that provides a range where we think the population mean (true value) islocated. Once these important issues are seriously mentioned and followed then only the results may be quite authentic.

On the basis of the above mentioned articles the presented paper focuses on various limitations found in the above mentioned articles and followed the major simulation guidelines provided by Kurkowski S. [14] which are as follows;

a) 10 Simulation Run are considered for randomization in the results and proper statistical analysis with confidence interval is done.
b) IEEE 802.11b standard with transmission channel rate as 1 Mbps and proper reference loss (40.0459 dBm) as mentioned in NS-3 documentation is used.
c) Performance matrices as Average End to End Delay, Average Packet Delivery Ratio and Average Throughput are properly reported.
d) The Flow Monitor module of NS-3 is used which provides a flexible system to measure the performance of considered network and Gnuplot is used plot the graphs.

III. AD HOC ON-DEMAND DISTANCE VECTOR

Ad hoc On-Demand Distance Vector (AODV) [7] routing protocol is an on demand reactive routing protocol, where the routes between source node and destination node are established when they are needed.AODV [15] assures dynamic, self-starting, multi-hop routing between mobile nodes, which needs to establish an Ad-Hoc network [9]. In AODV, mobile nodes are quickly able to establish routes for new destinations and at the same time do not require nodes to maintain routes to those destinations, which are not in active communication status. AODV also enables the mobile nodes to respond to link breakages and frequent changes in network topology due to the movement of nodes [7]. In addition, AODV overcomes the problem of formation of loops and count to infinity [16]. AODV also helps the affected set of nodes to be notified so that they are able to invalidate the routes, which use the lost link due to movement of nodes [17]. During the last decades AODV has been tremendously used by the researchers in the field of routing protocols and MANET [18]. Still proper implementation of AODV is not followed. This is all due to lack of correct knowledge on AODV and its important attributes. The proper implementation of AODV [19] depends on its route maintenance parameters such as ART, DPC and etc.

Active Route Timeout (ART):- defines how long a particular route is considered to be active in the routing table of the node, after the last packet transmitted [8]. The default value of ART is mentioned as 3 sec in AODV RFC 3561 [8].Each time a route entry is used to transmit data from a source node to a destination node, the timeout for the entry is reset to the current time plus ART. When a node receives an AODV control packet from its neighbor, it creates or updates the route for a particular destination or subnet. Initially when the forwarding of data packet starts over an active route, Active Route Lifetime field [8] is initialized as the default value of ART, but eventually it gets updated to be no less than current time plus ART.

Delete Period Constant (DPC):-As mentioned in AODV RFC (3561) "Delete Period [8] is intended to provide an upper bound on the time for which an upstream node can have a neighbor as an active next hop for the destination node, while the neighboring node has invalidated the route to the destination node". DP is a function of Hello Interval and ART as described in the formula below, and DPC is a constant as provided in AODV RFC 3561.

DP = DPC * Max (ART, HELLO INTEVAL) **(i)**
Where DPC = 5 as mentioned in AODV RFC)

IV. PROPOSED SIMULATION ANALYSIS

The main purpose of this article is to provide an extensive study on the performance of AODV routing protocol with variation in its route maintenance parameter. The article also provide a brief study on AODV and its performance on different speed and pause time scenarios with proper simulation parameter consideration, which will help the researchers to implement AODV routing protocol with better ideologies in MANET [20], [21].

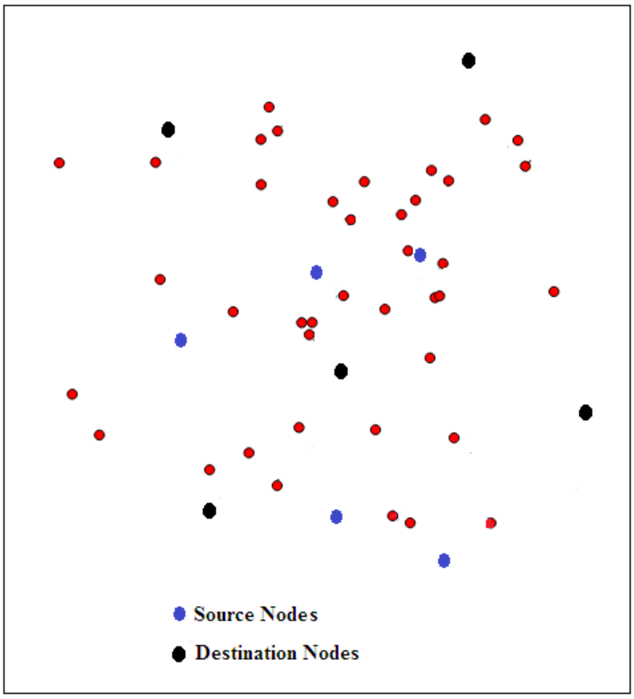

Fig 1: A Mobile Ad Ho Network of 50 Nodes with 5 Source and Destination

Instead of conventional RWP mobility model [22], [23] which warrants a caution to identify the end of the transition phase that is found not to be that much simple task. Any simulation during this transition phase may not be the close representative during the simulation. Therefore Steady State RWP mobility model [24] is used to overcome the transition phase of RWP mobility model [25].
The effective investigation of route maintenance parameter (i.e. ART and DPC) on the performance of AODV routing protocol with Steady State Random Waypoint (SS-RWP) for mobile nodes has been done by using NS-3 Simulator [26] which is a discrete-event network simulator mainly used for research and educational purpose and provides an open, extensible network simulation platform for the researchers. Figure 1 shows the simulation environment of 50 nodes which are randomly deployed in an area of 1200X1200 m^2, among which 5 source and destination pairs are selected.
Different speed scenarios are then tested at different pause time to investigate the effect of ART and DPC on the performance of AODV.MAC Protocol 802.11b is used with reference loss [13] computed and set accordingly; ten iterations for each simulation are used to express the results staticallyby using confidence interval to get better estimation of the population statistics based on more than one sample as per the suggestion by Andel, T. R et al [27].

The sample size could not be taken sufficiently large due to computational constraint of the lab. Once the statistical data have been achieved, the graphs are then plotted using Gnuplot 3.07 [28].

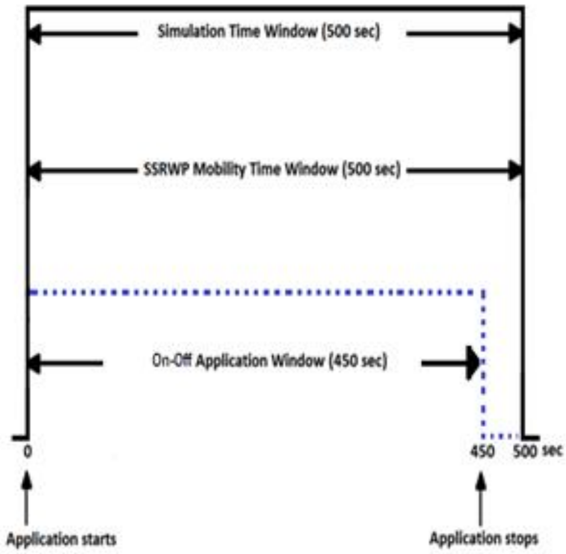

Fig 2: Simulation, Mobility and Application Time Windows

Figure 2 describes the Time Windows of Simulation, SSRWP mobility and On-Off Application. The simulation starts at t = 0 sec and it stops at t = 500 sec. SSRWP Mobility Time Window is analogous to that of Simulation Time Window.
On-Off Application starts at t = 0 sec and stops 50 sec earlier than the cessation of simulation to let the packets in transit to have fair opportunity to reach to the destination nodes.

V. SIMULATION PARAMETER

The simulation parameter mentioned below describes the overall implementation of the considered investigation

Parameter	**Value**
Simulator	NS-3.29
Seed	1
No. of Nodes	50
No. of Source and Destination Pair	5
Simulation Area	1200 x 1200 m^2
Simulation Time	500 sec
Mobility Model	Steady State RWP
Speed (Min – Max)	**a.** (0.01-1, 1-10, 10-20, 50-70, 75-100) m/sec **b.** (0.03, 3, 13, 55, 75) m/sec
Pause Time (Min-Max)	**a.** 0 sec **b.** 1-5 sec
Application	On-Off Application
Traffic Type	CBR
Packet Size	512 Bytes

Data Rate	8 kbps
Transport Layer Protocol	UDP
Routing Protocol	AODV
Active Route Timeout (ART)	1,2,3, 4, 5 sec
Delete Period Constant (K)	1, 2, 3, 4, 5,…., 10
MAC Mode	Ad-hoc
Physical Standard	IEEE 802.11b
Bandwidth	1 Mbps
Propagation Delay Model	Constant Speed Propagation Delay Model
Propagation Loss Model	LogDistancePropagationLossModel
Reference Loss	40.0459 dBm
Node Transmission Range	250 m
Confidence Interval	95%

Table 1: Simulation Parameters

The above mentioned investigation is done under the consideration of 10 simulations run, with proper statistical analysis and confidence interval so that the results achieve should be closer to the true representative of the population statistics (statistical results). The three considered performance metrics under which the performance of ART and DPC has been investigated are as follows:

(a) Average End-to-End Delay:

End to End Delay is defined as sum of all delay for all received packet at a flow (source and destination pair); [flow monitor], [29]

(For an individual flow)

$$\textbf{End to End Delay} = \frac{\text{SumofallDelayoccouringateverypacket}}{\text{Total Recieved Packet}} \quad \textbf{(ii)}$$

(b) Average Packet Delivery Ratio:

Packet Delivery Ratio (PDR) is defined as the ratio of the number to data packets delivered to the destination to that of data packets generated by the source [30].

$$(\textbf{PDR}) = \frac{\text{Number of Data Packets Received by Destination}}{\text{Number of Data Packets Transmitted by Source}} * 100$$

(iii)

(c) Average Throughput: Throughput is defined as the number of bytes delivered per unit time to the destination, the formula below describes throughput for an individual flow of a network. [31]

$$\textbf{Throughput} = \frac{\text{Total Bytes Recieved} * 8}{\text{Last Rx Packet time} - \text{First Tx Packet time}} \Big/ 1024 \quad \textbf{(iv)}$$

A. Average End to End Delay Vs Delete Period Constant (DPC) for Different values of ART at Different Speed Scenarios and Pause time

VI. SIMULATION SETUP

The considered investigation has been done on the basis of mobile nodes Speed and pause time. During the Study over AODV routing protocol, it was observed that very few researchers have focused on the correct implement of the protocol. Most of the researchers have implemented AODV in their work without its proper study; which may lead to wrong description of the considered work.

The performance of AODV mainly depend on its route maintenance parameters and there variation at different nodes speed and pause time, for studying the effect of variation in route maintenance parameters (ART and DPC) Four important speed and pause time scenarios are considered.Table 2 described below mentions how Speed and Pause Time can affect the performance of AODV routing protocol, it further describes how route maintenance parameters of AODV i.e. ART and DPC behaves in different Speed and Pause time scenarios. The four scenarios mentioned below determine the true behavior of route maintenance parameters (ART and DPC).

In scenario 1 and 2 the nodes speed are fixed where as the pause time is varied, in scenario 1 pause time is 0 sec, and in scenario 2 pause time is varying between 1 – 5 sec.

In scenario 3 and 4 the nodes speed are varied, where as the pause time is 1 - 5 sec in scenario 3 and inscenario 4 pause time is 0 sec.

These four scenarios mentioned below justify the true behavior of AODV routing protocol with different speed and pause time.

SCENARIO	SPEED	Pause time
SCENARIO1	**0.03 m/sec**	**0 sec**
	3 m/sec	
	13 m/sec	
	55 m/sec	
	75 m/sec	
SCENARIO 2	**0.03 m/sec**	**1 - 5 sec**
	3 m/sec	
	13 m/sec	
	55 m/sec	
	75 m/sec	
SCENARIO 3	**0.01-1 m/sec**	**1 – 5 sec**
	1-10 m/sec	
	10-20 m/sec	
	50-70 m/sec	
	70-100 m/sec	
SCENARIO 4	**0.01-1 m/sec**	**0 sec**
	1-10 m/sec	
	10-20 m/sec	
	50-70 m/sec	
	70-100 m/sec	

Table 2: Speed Vs Pause time Scenario

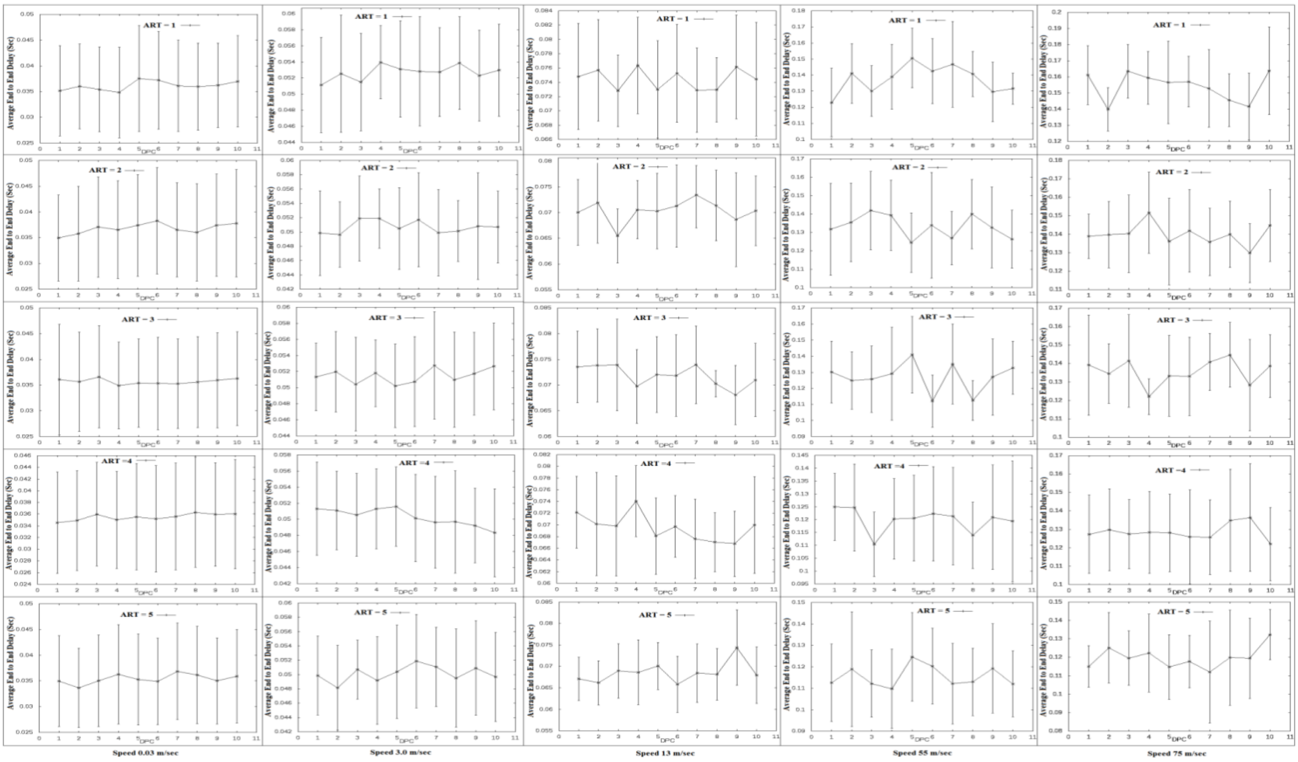

Fig 3 (a): Average End to End Delay Vs Delete Period Constant (DPC) for Different values of ART at Constant Speed Scenariosand at Pause 0 Sec

			DPC (Delete Period Constant)									
	Speed		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pause Time = 0 Sec	**0.03 m/sec**	ART 1	0.0351522	0.0359968	0.0354188	0.0348147	0.0375298	0.0371913	0.0361145	0.0359874	0.0361946	0.0369937
		ART 2	0.0349316	0.0357585	0.0370624	0.0365422	0.0373752	0.0382936	0.0365254	0.0360188	0.0374364	0.0378120
		ART 3	0.0360885	0.0356379	0.0366108	0.0349215	0.0354236	0.0353173	0.0352684	0.0355754	0.0359345	0.0362620
		ART 4	0.0345318	0.0348967	0.0359920	0.0350142	0.0355412	0.0352147	0.0356004	0.0363153	0.0359381	0.0360029
		ART 5	0.0349764	0.0336461	0.0350092	0.0362794	0.0352744	0.0348955	0.0368548	0.0361405	0.0350226	0.0359076
	3 m/sec	ART 1	0.0511399	0.0525287	0.0515026	0.0539585	0.0531136	0.0528369	0.0527432	0.0538781	0.0522969	0.0529824
		ART 2	0.0498309	0.0496373	0.0518804	0.0518748	0.0504882	0.0516905	0.0498926	0.0501377	0.0508116	0.0506899
		ART 3	0.0513275	0.051984	0.0504335	0.0518058	0.0502346	0.0507512	0.0527581	0.0509966	0.0517459	0.0526497
		ART 4	0.0513132	0.0510996	0.0505582	0.0513049	0.0515900	0.05016	0.0496254	0.0496798	0.0492325	0.0483253
		ART 5	0.0498695	0.048152	0.0506864	0.0491852	0.0503856	0.0518957	0.0510671	0.0495074	0.050894	0.049677
	13 m/sec	ART 1	0.0748104	0.0756825	0.0727990	0.0763713	0.0729950	0.0752388	0.0729032	0.0729408	0.0761547	0.0744279
		ART 2	0.0700527	0.0719056	0.0654846	0.0705685	0.0702922	0.0712627	0.0733994	0.0713794	0.0686357	0.0703518
		ART 3	0.0735523	0.0738186	0.0739264	0.0697719	0.0720429	0.0718615	0.0739522	0.0702850	0.0680791	0.0709929
		ART 4	0.0721378	0.0701372	0.0698115	0.0740638	0.0680827	0.0697242	0.0676084	0.0670362	0.0667572	0.0699802
		ART 5	0.0671094	0.0661719	0.0689624	0.0686360	0.0701140	0.0658049	0.0684212	0.0681247	0.0744131	0.0679418
	55 m/sec	ART 1	0.122954	0.14103	0.130146	0.138946	0.150593	0.142514	0.146791	0.140759	0.129583	0.131602
		ART 2	0.131676	0.13546	0.141845	0.139298	0.124419	0.133850	0.126839	0.139943	0.132686	0.126384
		ART 3	0.130169	0.124916	0.125682	0.129073	0.140842	0.111987	0.135095	0.112497	0.127024	0.132792
		ART 4	0.124984	0.124673	0.110411	0.120353	0.120560	0.122307	0.121335	0.113881	0.120921	0.119374
		ART 5	0.112491	0.118879	0.112179	0.109765	0.124616	0.122415	0.112054	0.112968	0.119228	0.111993
	75 m/sec	ART 1	0.161171	0.139864	0.163522	0.159376	0.156604	0.157067	0.152871	0.145594	0.141662	0.163759
		ART 2	0.138879	0.139727	0.140204	0.151640	0.136007	0.141815	0.135781	0.139879	0.129694	0.144790
		ART 3	0.139172	0.134526	0.141402	0.121990	0.133299	0.133021	0.140859	0.144668	0.128207	0.138635
		ART 4	0.127360	0.129687	0.127400	0.128342	0.128119	0.125881	0.125756	0.134907	0.136436	0.121999
		ART 5	0.115082	0.125231	0.119619	0.122415	0.114753	0.11772	0.111972	0.119829	0.119478	0.132362

Table 3 (a) Average End to End Delay Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 0 Sec

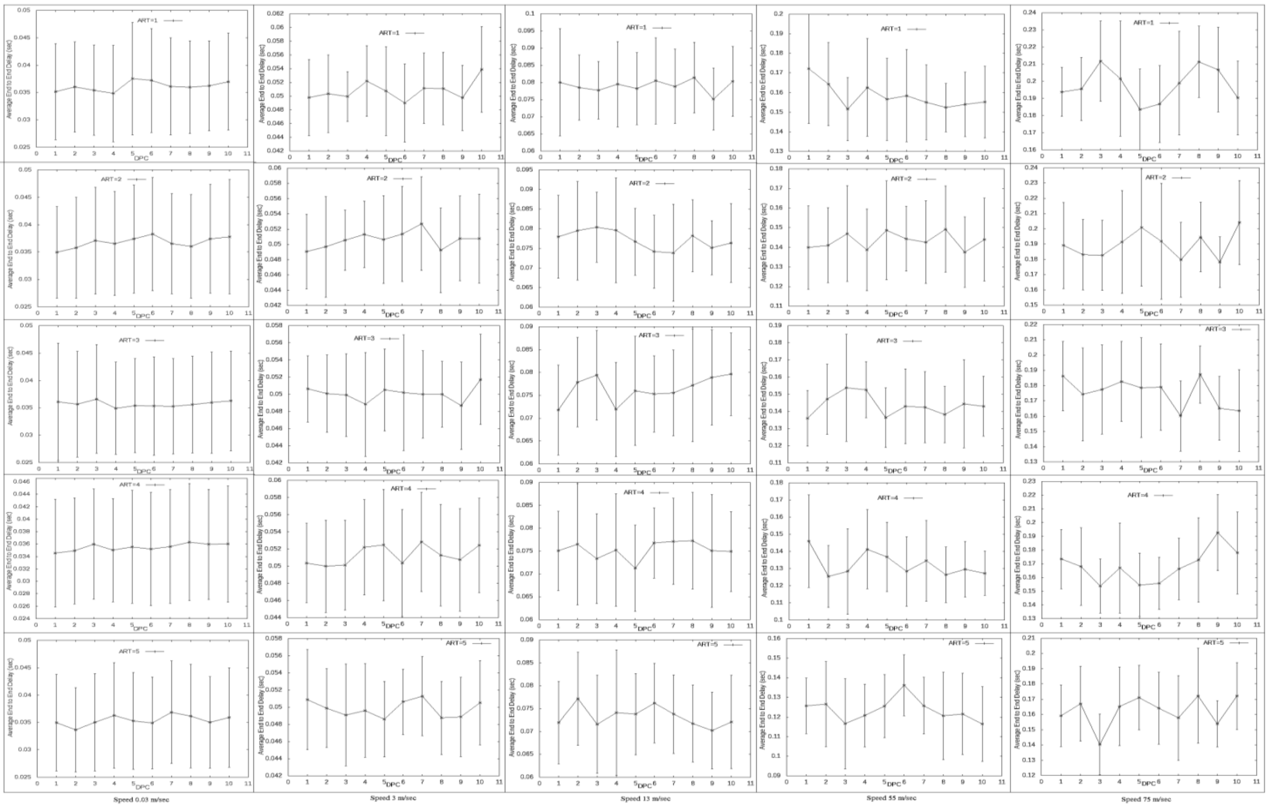

Fig 3 (b): Average End to End Delay Vs Delete Period Constant (DPC) for Different values of ART at Constant Speed Scenariosat Pause 1-5 sec

Pause Time	Speed	DPC (Delete Period Constant)										
			1	2	3	4	5	6	7	8	9	10
Pause Time = 1 – 5 Sec	0.03 m/sec	ART 1	0.0351444	0.0360282	0.0353276	0.0348218	0.0375342	0.0371818	0.036098	0.035986	0.0361985	0.0364189
		ART 2	0.0349268	0.0357484	0.0369447	0.0365753	0.0373743	0.0383015	0.0365314	0.0360188	0.037067	0.0377592
		ART 3	0.0360885	0.0358356	0.0366137	0.0349244	0.0355782	0.0354093	0.0354097	0.0355424	0.0359337	0.0361929
		ART 4	0.0345288	0.0348927	0.035988	0.0350102	0.0351670	0.0352164	0.0354597	0.0361117	0.035934	0.0359981
		ART 5	0.034977	0.0336511	0.0350181	0.0362261	0.0352753	0.0348707	0.0369603	0.0361401	0.0351042	0.0359061
	3 m/sec	ART 1	0.0498001	0.0503436	0.0499310	0.0521983	0.0507328	0.0490077	0.0511372	0.0511179	0.0497655	0.0539140
		ART 2	0.0490751	0.0496873	0.0505298	0.0513035	0.0506454	0.0513687	0.0527303	0.0492293	0.0507932	0.0507555
		ART 3	0.0506325	0.0500792	0.0499163	0.0488242	0.0505019	0.0501800	0.0499828	0.0500021	0.0486623	0.0517296
		ART 4	0.0503608	0.0499960	0.0501335	0.0522146	0.0524613	0.0503443	0.0528330	0.0512799	0.0507473	0.0524294
		ART 5	0.0508744	0.0498953	0.049089	0.0496100	0.0486084	0.0506251	0.0512959	0.0487426	0.0488623	0.0505181
	13 m/sec	ART 1	0.0800213	0.0785145	0.0777285	0.079494	0.0782236	0.080465	0.0788361	0.0813756	0.0751373	0.0803201
		ART 2	0.0779075	0.0794749	0.0803791	0.0795879	0.0766894	0.0741361	0.0738504	0.0781903	0.0751247	0.0763837
		ART 3	0.0717709	0.0778554	0.0793897	0.0718952	0.0759764	0.0753117	0.0754921	0.0772046	0.0788874	0.0796186
		ART 4	0.0750423	0.0764758	0.0733545	0.0752405	0.0712525	0.076764	0.0771334	0.077278	0.0750474	0.0749061
		ART 5	0.0719224	0.0771405	0.0715286	0.0740828	0.0737823	0.0761915	0.0737666	0.0717053	0.0702174	0.0720780
	55 m/sec	ART 1	0.172091	0.164257	0.151458	0.162627	0.156552	0.158383	0.155039	0.152316	0.153999	0.155153
		ART 2	0.139838	0.141049	0.146988	0.138660	0.148614	0.144344	0.142610	0.149280	0.137562	0.143968
		ART 3	0.136070	0.147100	0.153743	0.152680	0.136369	0.142998	0.142496	0.138199	0.144422	0.143059
		ART 4	0.146005	0.125462	0.128365	0.141291	0.136854	0.128316	0.134501	0.126368	0.129623	0.127270
		ART 5	0.125701	0.126575	0.116557	0.120724	0.125512	0.136208	0.125734	0.120545	0.121587	0.116395
	75 m/sec	ART 1	0.193887	0.195547	0.211765	0.20154	0.183658	0.186792	0.198952	0.211418	0.206841	0.190304
		ART 2	0.189076	0.183112	0.182599	0.191377	0.20082	0.191891	0.179705	0.194646	0.178051	0.204172
		ART 3	0.186174	0.174296	0.177499	0.182701	0.1787	0.179038	0.160101	0.18734	0.165116	0.163595
		ART 4	0.173475	0.167963	0.153763	0.166901	0.154615	0.155825	0.166163	0.172753	0.192737	0.177953
		ART 5	0.159131	0.167008	0.140336	0.165288	0.171023	0.164052	0.157691	0.172312	0.153818	0.172097

Table 3 (b) Average End to End Delay Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 1 - 5 Sec

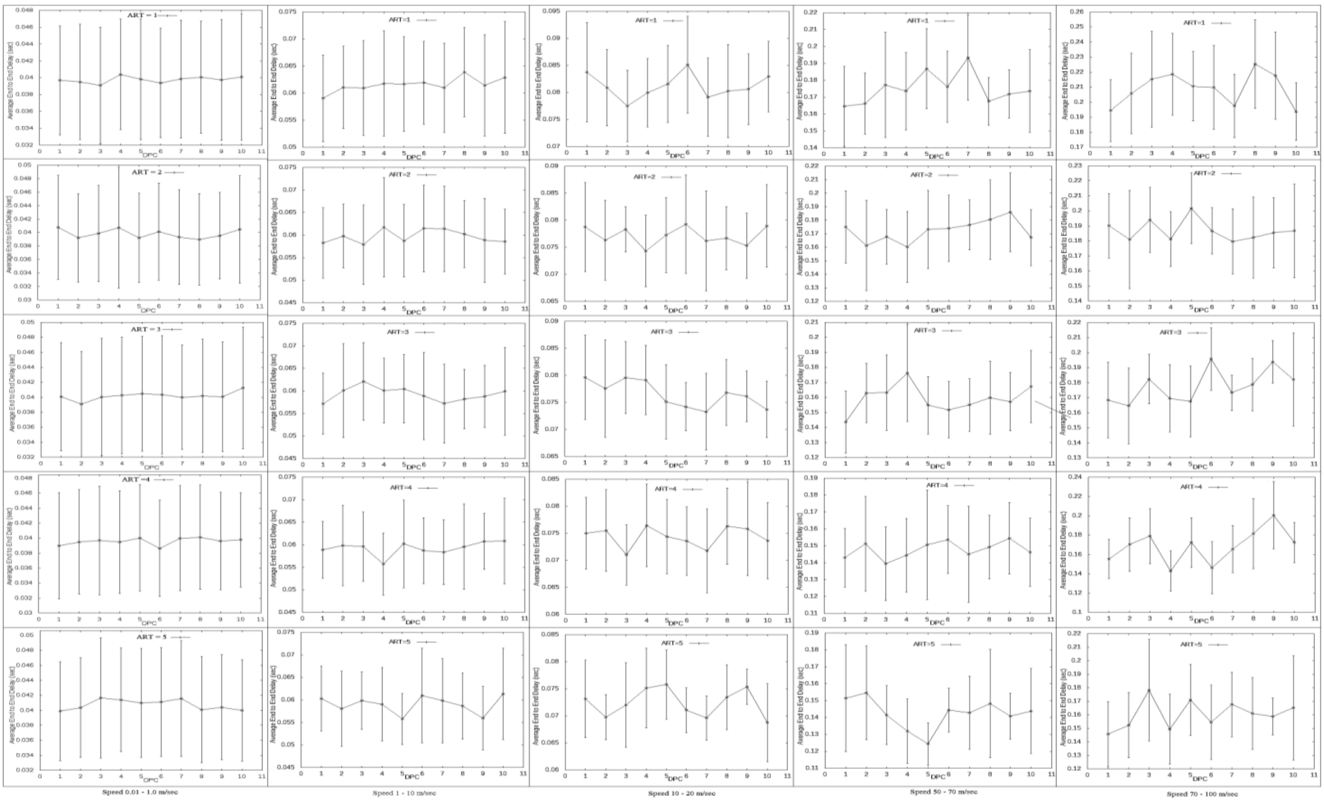

Fig 3 (c): Average End to End Delay Vs Delete Period Constant (DPC) for Different values of ART at Different Speed Scenarios and at Pause 1 -5 sec

Pause Time	Speed		DPC (Delete Period Constant)									
			1	2	3	4	5	6	7	8	9	10
Pause Time = 1 – 5 Sec	0.01–1.0 m/sec	ART 1	0.0396836	0.0395063	0.0390995	0.0403970	0.0398224	0.0393791	0.0398416	0.040076	0.0397433	0.0401188
		ART 2	0.0407627	0.0392004	0.0398554	0.0407113	0.0392388	0.0401295	0.0393057	0.0389939	0.0395187	0.0404817
		ART 3	0.0400756	0.039063	0.0400508	0.0402351	0.0404766	0.0403602	0.0399954	0.0401809	0.0400576	0.0412525
		ART 4	0.0389854	0.0394875	0.0396837	0.0394865	0.0400236	0.0386360	0.0399859	0.0401202	0.0396071	0.0397709
		ART 5	0.0398780	0.0403593	0.0416635	0.0413994	0.0409573	0.0411157	0.0415577	0.0400818	0.0404123	0.0399923
	1 – 10 m/sec	ART 1	0.0590566	0.0610572	0.0609383	0.0617794	0.0616808	0.0619063	0.0609882	0.0638635	0.0614576	0.0628966
		ART 2	0.0582782	0.0598115	0.0578662	0.0617379	0.0587612	0.0614811	0.0613954	0.0601967	0.0588611	0.0585760
		ART 3	0.0571831	0.0600650	0.0621017	0.0600522	0.0604842	0.0588989	0.0571914	0.0582259	0.0587982	0.0599469
		ART 4	0.0588618	0.0598611	0.0596026	0.0557316	0.0602113	0.0587045	0.0583485	0.0595818	0.0607769	0.0608489
		ART 5	0.0602920	0.0580737	0.0598231	0.0590559	0.0557954	0.0609707	0.0598226	0.0586623	0.0559334	0.0613263
	10 –20 m/sec	ART 1	0.0837389	0.0808805	0.0774903	0.0799458	0.0815663	0.0851056	0.0791146	0.0802356	0.0805984	0.0829561
		ART 2	0.0787325	0.0763014	0.0783286	0.0743169	0.0772572	0.0792732	0.0761835	0.0766707	0.0752854	0.0789142
		ART 3	0.0796549	0.0775588	0.0795788	0.0791534	0.0751275	0.0742152	0.0732594	0.0768415	0.0761451	0.0737084
		ART 4	0.0749833	0.0755240	0.0709995	0.0764586	0.0743718	0.0735379	0.0717513	0.0763208	0.0758406	0.0736075
		ART 5	0.0731492	0.0697650	0.0720180	0.0751257	0.0757840	0.0710482	0.0696110	0.0734201	0.0753677	0.0687426
	50-70 m/sec	ART 1	0.1646360	0.166236	0.1772580	0.1735370	0.186859	0.176172	0.193465	0.1675000	0.1718890	0.1736550
		ART 2	0.1750250	0.161310	0.1677380	0.1602720	0.173174	0.174080	0.176536	0.1804700	0.1858810	0.1672080
		ART 3	0.1436970	0.162967	0.1631830	0.1763180	0.154859	0.151796	0.155018	0.1598300	0.1572050	0.1672730
		ART 4	0.1429110	0.151253	0.1394480	0.1444720	0.150617	0.153621	0.145000	0.1492270	0.1544840	0.1461280
		ART 5	0.1514930	0.154575	0.1413700	0.1319110	0.124321	0.144465	0.142750	0.1482720	0.1408710	0.1438980
	70-100 m/sec	ART 1	0.194465	0.205822	0.215253	0.218522	0.210551	0.209902	0.197422	0.225359	0.217629	0.193688
		ART 2	0.190080	0.180928	0.194015	0.181192	0.201729	0.186599	0.179671	0.182217	0.185465	0.186694
		ART 3	0.168514	0.164668	0.182486	0.169708	0.167567	0.195820	0.173343	0.178791	0.193948	0.182225
		ART 4	0.155281	0.170177	0.178932	0.142854	0.172293	0.146073	0.165552	0.181674	0.200493	0.172373
		ART 5	0.145678	0.152284	0.178337	0.149342	0.170976	0.154497	0.167694	0.161076	0.158731	0.165137

Table 3 (c) Average End to End Delay Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 1 - 5 Sec

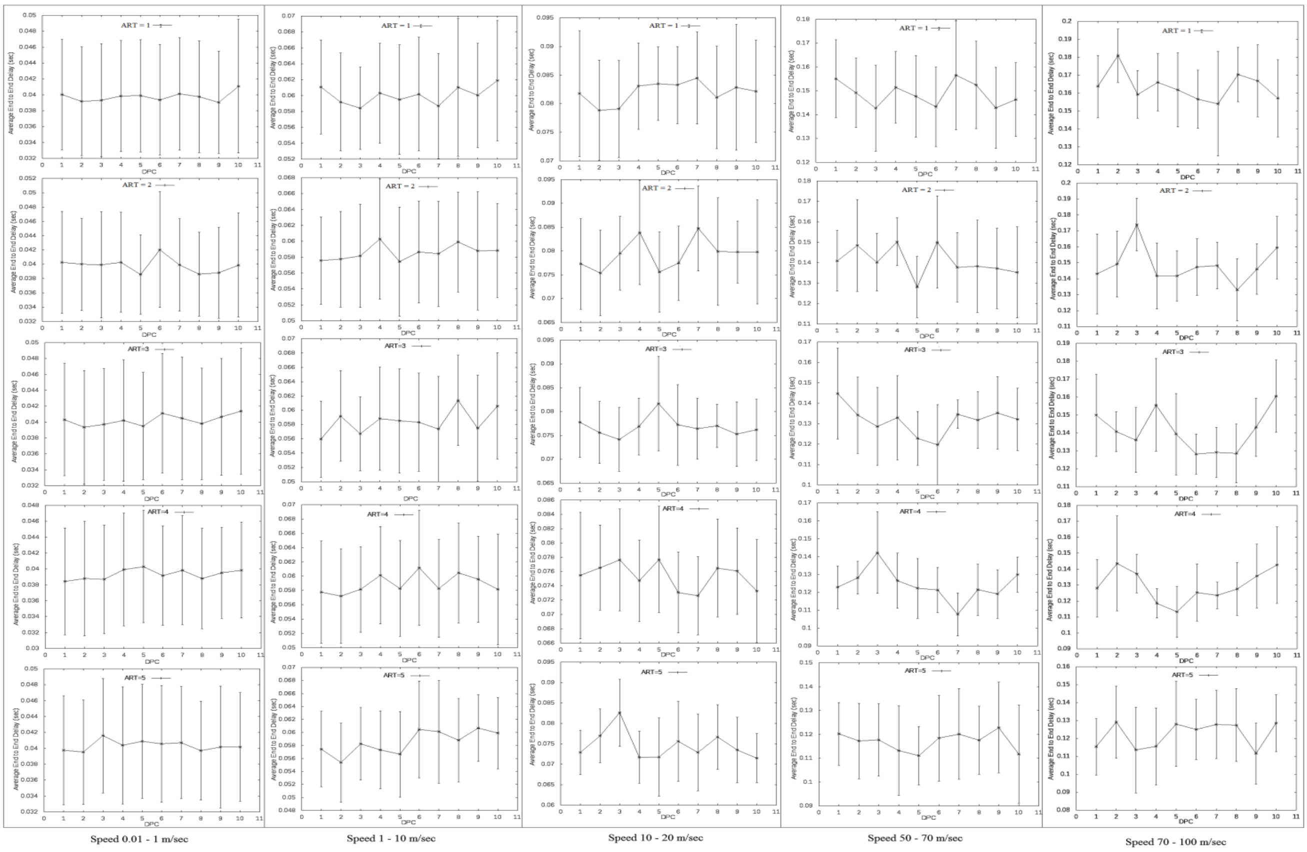

Fig 3 (d): Average End to End Delay Vs Delete Period Constant (DPC) for Different values of ART at Different Speed Scenariosat Pause 0 sec

Pause Time	Speed		DPC (Delete Period Constant) 1	2	3	4	5	6	7	8	9	10
Pause Time = 0 Sec	0.01–1.0 m/sec	ART 1	0.0400408	0.039175	0.0393237	0.039854	0.0398802	0.0393749	0.0401081	0.0397502	0.0390487	0.0410843
		ART 2	0.0402651	0.040008	0.0399342	0.0402819	0.0385542	0.0420392	0.0399067	0.038626	0.0388301	0.0398778
		ART 3	0.0403046	0.0393509	0.039711	0.040188	0.0395073	0.0411222	0.0404743	0.0397956	0.0406588	0.0413646
		ART 4	0.0384366	0.0387791	0.0386976	0.0399404	0.0402894	0.039172	0.0398427	0.038777	0.0395346	0.0398543
		ART 5	0.0397486	0.0395131	0.041600	0.0403814	0.0408837	0.0405658	0.0407248	0.0397262	0.0401644	0.040179
	1 – 10 m/sec	ART 1	0.0610613	0.059195	0.0584175	0.0602851	0.0594868	0.0601756	0.0586846	0.0610219	0.0600252	0.0618778
		ART 2	0.057594	0.0577516	0.0581518	0.0602768	0.0574423	0.0586541	0.0584172	0.0599198	0.0588048	0.0588394
		ART 3	0.0559529	0.0591776	0.0567094	0.058823	0.0584997	0.0582972	0.0573814	0.0613893	0.0574791	0.0605994
		ART 4	0.0577728	0.0572103	0.0581472	0.060131	0.0582937	0.0611738	0.0582828	0.0604578	0.0595723	0.0581463
		ART 5	0.0574533	0.0553782	0.0582484	0.0573388	0.056635	0.0604632	0.0601082	0.0588073	0.0606727	0.0598851
	10 –20 m/sec	ART 1	0.0817548	0.0788274	0.0790719	0.0830677	0.0834892	0.08327	0.0845033	0.0810711	0.0828688	0.0821435
		ART 2	0.0773055	0.0753894	0.0795256	0.0838987	0.075609	0.077477	0.084748	0.0798789	0.0797774	0.0798259
		ART 3	0.0777453	0.0756108	0.0741984	0.0768987	0.0816913	0.0772187	0.0764214	0.0770268	0.0753179	0.0761891
		ART 4	0.0754503	0.0765485	0.077626	0.0747006	0.0776972	0.0730806	0.0726294	0.0764931	0.0760587	0.0732563
		ART 5	0.0728768	0.0769251	0.0826033	0.0716796	0.0717359	0.0756245	0.0729087	0.0766932	0.0735083	0.0715059
	50-70 m/sec	ART 1	0.155073	0.149127	0.142737	0.151426	0.147627	0.143315	0.156548	0.152468	0.142801	0.146328
		ART 2	0.140960	0.148408	0.140207	0.150252	0.128122	0.150071	0.137697	0.138281	0.137202	0.135251
		ART 3	0.144701	0.134132	0.128613	0.132919	0.122829	0.119693	0.134601	0.131771	0.13522	0.132147
		ART 4	0.122804	0.128114	0.142225	0.12648	0.122192	0.121252	0.107606	0.121434	0.119026	0.129976
		ART 5	0.120203	0.117177	0.117720	0.113151	0.110995	0.118351	0.120105	0.117554	0.122835	0.111645
	70-100 m/sec	ART 1	0.157134	0.180959	0.159277	0.165993	0.161871	0.156614	0.154082	0.170341	0.166891	0.163708
		ART 2	0.143023	0.149174	0.173929	0.141689	0.141764	0.147350	0.148224	0.133015	0.146087	0.159417
		ART 3	0.149952	0.140713	0.136051	0.15569	0.139338	0.128182	0.129223	0.12862	0.143183	0.160596
		ART 4	0.12798	0.143628	0.137095	0.118527	0.113151	0.125398	0.123503	0.127618	0.135705	0.142585
		ART 5	0.11532	0.129121	0.113551	0.115504	0.128083	0.124999	0.127797	0.127473	0.111647	0.128534

Table 3 (d) Average End to End Delay Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 0 Sec

Since the considered scenario consists of five flows (5 Source and Destination Pairs) therefore the End to End delay for the network will be as follows,

Network End to End delay =

$$\frac{\text{SumofallEndtoEndDelayoccouringatindividualflow}}{\text{TotalNo.ofFlows}} \quad \text{(v)}$$

i.e.

(For Single run)

Network End to End Delay =

$$\frac{\text{EndtoEndDelayat (Flow1+Flow2+Flow3+Flow4+Flow5)}}{5} \quad \text{(vi)}$$

Since the results of our simulation are based on 10 simulation runs, therefore the Average End to End Delay will be as follows:

Average End to End Delay

$$= \frac{NetworkEndtoEndDelayfor\ (run\ 1+run\ 2+run\ 3\ ....+\ ..+run\ 10}{10} \quad \text{vii)}$$

Fig 3(a), 3(b), 3(c) and 3(d) show the variation in Average End to End Delay Vs Delete Period constant (DPC), for ART = 1, 2, 3, 4 and 5 sec. for various Speed and Pause Time Scenarios.

Fig.3 (a) consists of five cases of constant nodes speed (i.e. 0.03 m/sec, 3 m/sec, 13 m/sec, 55 m/sec and 75 m/sec)with Pause time 0 sec,from the figure it an be observed that when nodes speed is 0.03 m/sec the average End to End Delay is ~ 0.035 sec for all the values of ART (i.e. 1,2,3,4 and 5 sec) for overall range of DPC, since the nodes speed is quite low therefore there is no abrupt change in Average End to End delay with variation in ART and DPC.whereas when nodes speedare considered as 3.0 m/sec and 13 m/sec, Average End to End Delay increases and is observed for most of the considered ART values, a minimum Average End to End Delay of 0.048152 sec is recorded for ART = 5 sec with DPC = 2 when nodes speed is 3.0 m/sec.When the node speed is 13m/sec, it is observed that minimum average End to End Delay is 0.06544846 sec for ART = 2 with DPC = 3. Since the nodes are provided with sufficient amount of speed therefore the possibility of frequent change in route must have occurred due to which end to end delay has increased. When the nodes speed is increased up to 55 m/sec and 75 m/sec,minimumAverage End to End Delay of 0.10965 sec is recorded for ART = 5 sec with DPC = 4 (for nodes speed 55 m/sec.), and Average End to End Delay of 0.11192 sec for ART 5 sec with DPC = 7 (when nodes speed is 75 m/sec) is recorded. From fig 3(a) it is observed that Average end to end delay is mostly depends on the nodes speed, when the nodes speed was 0.03 m/sec the average end to end delay was quite low but as soon as the nodes speed was gradually increased the end to end delay was also increased due to frequent change in the network topology due to the movement of nodes

Fig 3(b), is similar to fig 3(a), the only difference is the pause time. In fig 3(b) the pause time is considered to be 1 – 5 sec.It is observed that Average End to End Delay depends not only on speed of nodes, but also on its Pause time. As the speeds of nodes are increased in the considered scenario Average End to End Delay also increases. When the speed of the nodes were considered 0.03 m/sec with pause time 1 – 5 sec,it observed that Average End to End Delay is minimum for most of the values of ART for overall range of DPC, and it recorded to be 0.03365 sec when ART = 5 sec with DPC = 2, but when the node speed is increased to 3.0 m/sec and 13 m/sec with pause time 1 – 5 sec, it is observed that Average End to End Delay is also increased, for node speed 3.0 m/sec is considered Average End to End Delay is 0.0486084 sec for ART = 5 sec and DPC = 5, and for nodes speed 13m/sec Average End to End Delay is 0.012525 sec. for ART = 4 sec and DPC = 5, however, when nodes speed are considered to be 55 m/sec and 75 m/sec it is observed that Average End to End Delayis minimum when ART=5 sec and DPC = 3 which is recorded as 0.116557 sec (for speed 55 m/sec) and 0.140336 sec (for speed 75 m/sec).

Fig 3 (c) consists of five cases of different constant nodes speed (i.e. 0.01-1 m/sec, 1-10 m/sec, 10-20 m/sec, 50-70 m/sec and 70-100 m/sec)with Pause time 1-5 sec,From the considered figure it is observed that Average End to End Delay depends not only on variation in speed of nodes, but also on its Pause time.it is observed that the Average End to End Delay increases with increase in the nodes speed and pause time for ART =1, 2, 3, 4 and 5 sec. When the speed of the nodes were considered to be 0.01-1m/sec,the average end to end delay was varying between 0.03 to 0.04sec, since in this speed range the node are moving quite slow due to which very minimum possibility of route break and new route discovery is needed which results in less Average End to End Delay. When nodes speed is 1 -10 m/sec the average End to End delay was nearly below ~ 0.05 sec, but as the speed of the nodes were increased above 10 -20 m/sec and 50 – 70 m/sec the Average End to End delay was quite high, which can be observed from the fig 3 (c) and table 3 (c). Therefore it can be concluded that, to have lesser Average End to End Delay the value of ART should be considered 3or 4 sec in low nodes speed scenarios whereas for high nodes speed scenarios ART=1 sec should be considered.

Fig 3 (d) is similar to fig 3(c) the only difference is the pause time. In fig 3(d) the pause time is considered to be 0 sec. It is observed that the average End to end delay depends on three major factors, firstly, on the nodes speed, secondly on the specific value of ART and thirdly on the pause time. From the figure it is observed that Average End to End delay is better when nodes speeds are low i.e. 0.01-1, 1-10 and 10-20 m/sec. for these speed scenarios, nodes are able to get sufficient time to be in active range with other nodes since they are provided with low speed. Whereas when the nodes speed is increased upto 50-70 and 70-100 m/sec, average end to end delay also increases due to high speed and considered pause time i.e. 1-5 sec, this increases the possibility of route break which may contribute in high average end to end delay for higher nodes speed scenarios.

B. Average Packet Delivery Ratio (PDR) Vs Delete Period (DPC) for Different values of ART at DifferentSpeed Scenarios and Pause Time

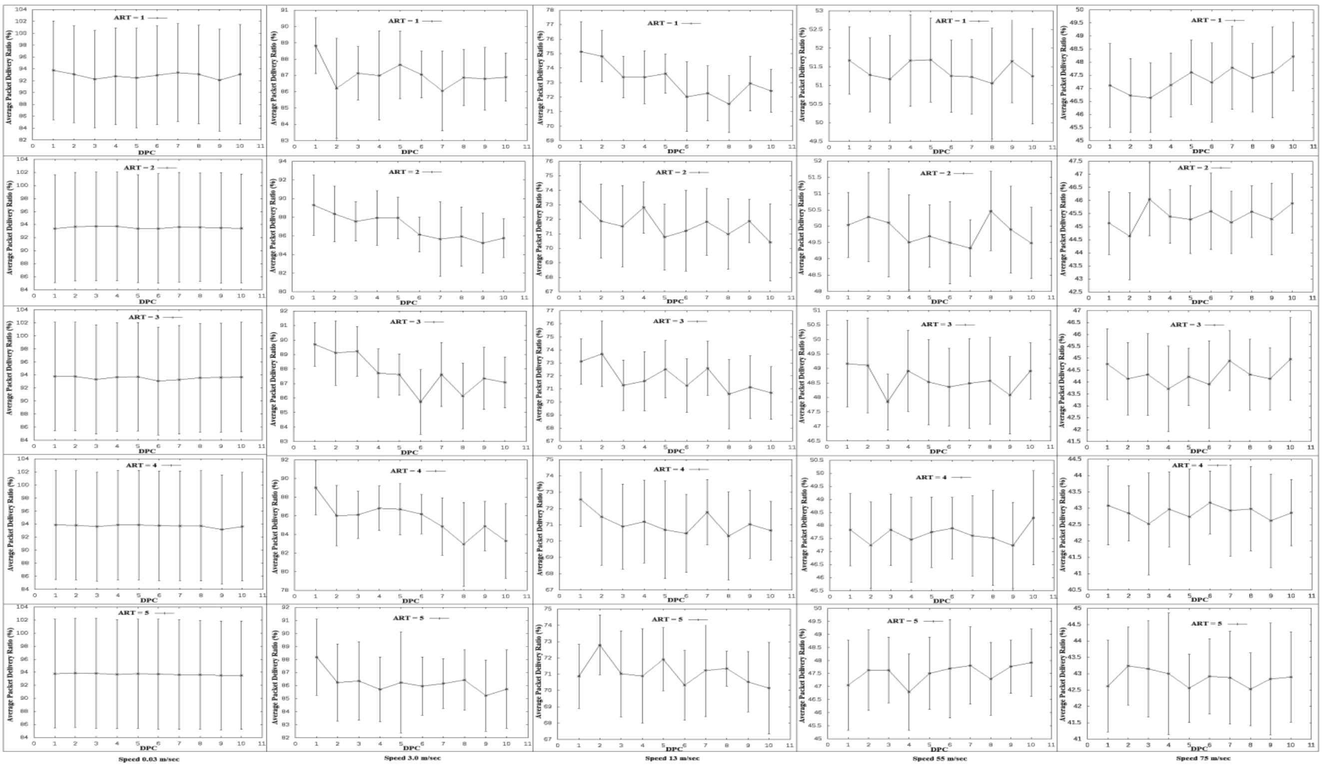

Fig 4 (a) Average Packet Delivery Ratio (PDR) Vs Delete Period Constant (DPC) for Different values of ART at Constant Speed Scenarios with Pause Time = 0 Sec.

Pause Time	Speed		DPC (Delete Period Constant) 1	2	3	4	5	6	7	8	9	10
Pause Time = 0 Sec	0.03 m/sec	ART 1	93.7267	93.0797	92.2483	92.7722	92.4601	92.9134	93.344	93.0569	92.0911	93.0843
		ART 2	93.3895	93.6811	93.7061	93.7016	93.3713	93.3872	93.6105	93.5945	93.467	93.4123
		ART 3	93.7699	93.7517	93.3166	93.6743	93.7243	93.0866	93.2779	93.5763	93.6037	93.6947
		ART 4	93.877	93.8314	93.6128	93.8565	93.8633	93.7608	93.7381	93.7381	93.1822	93.6196
		ART 5	93.7859	93.8907	93.8018	93.6925	93.7745	93.7152	93.631	93.6036	93.4988	93.5307
	3 m/sec	ART 1	88.8178	86.205	87.1367	86.9977	87.6424	87.0547	86.0501	86.8656	86.7859	86.8952
		ART 2	89.2847	88.3599	87.5444	87.918	87.918	86.148	85.6469	85.9225	85.2187	85.754
		ART 3	89.6925	89.1048	89.221	87.7084	87.6242	85.7335	87.6264	86.1458	87.3508	87.0774
		ART 4	89.0000	86.0136	86.1048	86.8155	86.6993	86.1777	84.8383	82.9362	84.8838	83.303
		ART 5	88.1799	86.2415	86.3576	85.7107	86.2415	85.9613	86.164	86.426	85.2392	85.7426
	13 m/sec	ART 1	75.1321	74.8292	73.3781	73.3667	73.6219	72.0296	72.2597	71.5194	72.9453	72.4396
		ART 2	73.2324	71.8793	71.5216	72.8109	70.7699	71.2027	71.8223	70.9772	71.8793	70.4032
		ART 3	73.1048	73.7016	71.2824	71.5991	72.5216	71.2665	72.5991	70.6128	71.1458	70.6993
		ART 4	72.5535	71.4829	70.8884	71.2005	70.6948	70.4738	71.7813	70.3098	71.0342	70.6446
		ART 5	70.8702	72.7973	71.0205	70.8952	71.9157	70.3235	71.2392	71.3417	70.5353	70.1526
	55 m/sec	ART 1	51.6651	51.2825	51.1663	51.6652	51.6811	51.2506	51.2278	51.0501	51.6492	51.2437
		ART 2	50.0387	50.2824	50.1048	49.508	49.6948	49.4943	49.328	50.4693	49.893	49.4875
		ART 3	49.164	49.1002	47.8406	48.9157	48.5262	48.3599	48.4852	48.5718	48.0752	48.9157
		ART 4	47.8337	47.2415	47.8292	47.4487	47.7403	47.8929	47.5991	47.5217	47.2323	48.2984
		ART 5	47.0547	47.6264	47.6378	46.7904	47.5102	47.6902	47.8132	47.2984	47.7677	47.9225
	75 m/sec	ART 1	47.1162	46.7244	46.6424	47.1253	47.6173	47.221	47.7836	47.4055	47.6082	48.2187
		ART 2	45.139	44.6378	46.0501	45.3918	45.2688	45.5831	45.1617	45.574	45.2893	45.8884
		ART 3	44.754	44.1412	44.3212	43.7153	44.2187	43.9043	44.8998	44.3189	44.1367	44.9704
		ART 4	43.0843	42.8451	42.5216	42.9659	42.7358	43.1731	42.9294	42.9818	42.6173	42.8633
		ART 5	42.6242	43.2392	43.1503	43.0000	42.5558	42.918	42.8838	42.5285	42.8383	42.8998

Table 4 (a) Average Packet Delivery Ratio Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 0 Sec

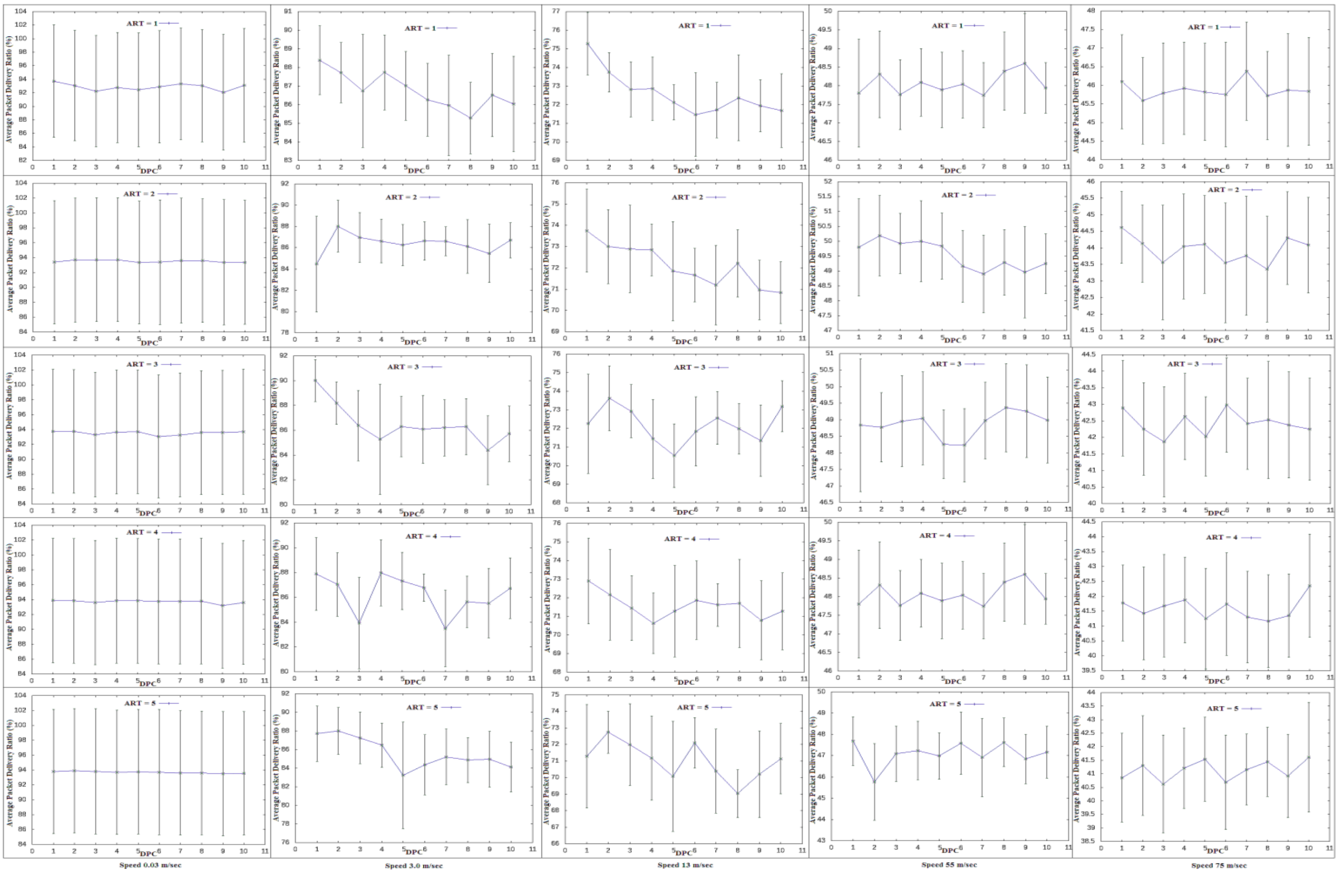

Fig 4 (b) Average Packet Delivery Ratio (PDR) Vs Delete Period Constant (DPC) for Different values of ART at Constant Speed Scenarios with Pause Time = 1 – 5 Sec.

	Speed		DPC (Delete Period Constant)									
			1	2	3	4	5	6	7	8	9	10
Pause time = 1 – 5 Sec	0.03 m/sec	ART 1	93.7267	93.0797	92.2506	92.7677	92.4556	92.8975	93.3212	93.0569	92.0911	93.1093
		ART 2	93.3895	93.6765	93.7221	93.7175	93.3713	93.3827	93.6059	93.5945	93.3736	93.3599
		ART 3	93.7699	93.7494	93.3166	93.6743	93.7175	93.0729	93.262	93.5763	93.6037	93.6925
		ART 4	93.8770	93.8314	93.6128	93.8565	93.8337	93.7608	93.7517	93.7791	93.1822	93.6196
		ART 5	93.7859	93.8907	93.8018	93.6925	93.7745	93.7198	93.6242	93.6036	93.5057	93.5444
	3 m/sec	ART 1	88.3873	87.7198	86.738	87.7312	87.0137	86.2528	85.9567	85.2756	86.5216	86.0478
		ART 2	84.4670	88.0251	86.9658	86.6264	86.2483	86.6287	86.5968	86.1139	85.467	86.6993
		ART 3	90.0114	88.1982	86.3781	85.2733	86.3007	86.0774	86.2073	86.287	84.3827	85.7153
		ART 4	87.8998	87.041	83.9339	87.9795	87.3235	86.7859	83.492	85.6333	85.5285	86.7312
		ART 5	87.7130	88.0159	87.2528	86.4647	83.2301	84.3554	85.2118	84.8633	84.9727	84.1162
	13 m/sec	ART 1	75.2779	73.7381	72.8201	72.861	72.123	71.4693	71.7107	72.369	71.9339	71.6765
		ART 2	73.7471	73.0000	72.8907	72.8451	71.8474	71.6606	71.1845	72.2118	70.9567	70.8383
		ART 3	72.2506	73.615	72.9294	71.4305	70.5353	71.8405	72.5558	71.9749	71.3417	73.1845
		ART 4	72.9089	72.1595	71.4487	70.6219	71.2802	71.8633	71.615	71.6902	70.7882	71.2711
		ART 5	71.2825	72.7449	71.9818	71.1754	70.0774	72.0957	70.3895	69.0273	70.2027	71.1344
	55 m/sec	ART 1	51.1708	51.724	51.293	51.059	51.296	51.321	51.191	50.881	51.075	51.430
		ART 2	49.7996	50.189	49.927	49.997	49.836	49.157	48.897	49.287	48.965	49.246
		ART 3	48.836000	48.7745	48.9567	49.041	48.2574	48.2301	48.9749	49.3645	49.2597	48.9909
		ART 4	47.799500	48.3052	47.7585	48.0888	47.8861	48.0387	47.7426	48.3895	48.5968	47.9431
		ART 5	47.685700	45.7631	47.0888	47.2437	46.9841	47.5831	46.9134	47.6287	46.8428	47.1663
	75 m/sec	ART 1	46.09800	45.5877	45.7904	45.9203	45.8246	45.754	46.3781	45.7244	45.8724	45.8405
		ART 2	44.61960	44.1276	43.5581	44.0433	44.1071	43.549	43.7563	43.3576	44.2961	44.082
		ART 3	42.88840	42.2551	41.8679	42.631	42.0296	42.9772	42.4169	42.5285	42.3781	42.2551
		ART 4	41.77670	41.426	41.6811	41.8724	41.2506	41.7358	41.3007	41.1617	41.3485	42.3554
		ART 5	40.85650	41.3007	40.6241	41.2141	41.5376	40.6811	41.1595	41.4419	40.918	41.6128

Table 4 (b) Average Packet Delivery Ratio Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 1 - 5 Sec

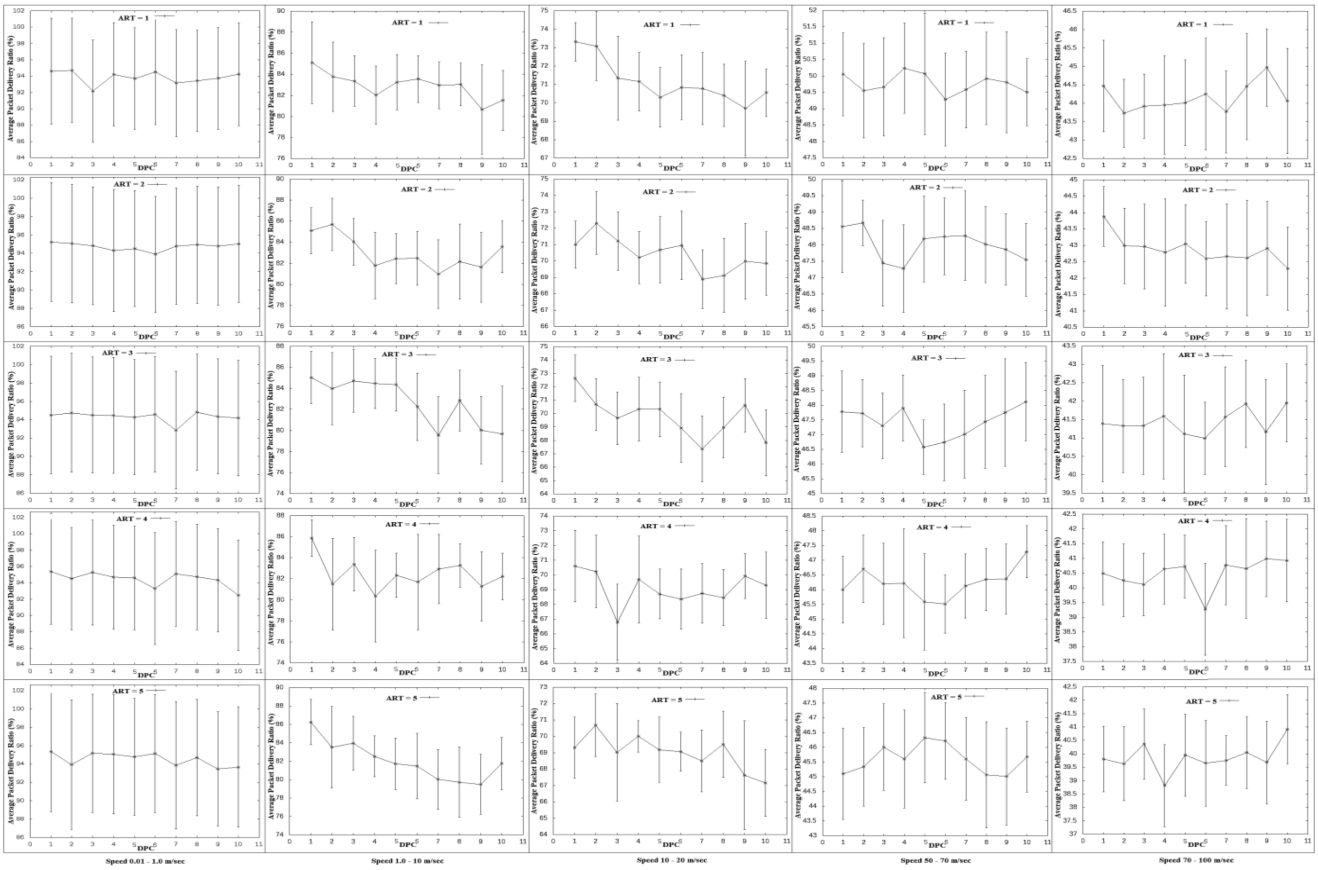

Fig 4 (c) Average Packet Delivery Ratio (PDR) Vs Delete Period Constant (DPC) for Different values of ART at Variable Speed Scenarios with Pause Time = 1 – 5 Sec.

			DPC (Delete Period Constant)									
	Speed		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pause Time = 1 – 5 Sec	**0.01– 1.0 m/sec**	**ART 1**	94.6059	94.6925	92.1777	94.2141	93.6902	94.533	93.1412	93.4077	93.7335	94.2232
		ART 2	95.2323	95.0797	94.8155	94.3052	94.5171	93.8861	94.7836	94.9294	94.7677	95.0182
		ART 3	94.5080	94.7563	94.5103	94.4806	94.2734	94.5763	92.8405	94.8246	94.3576	94.1686
		ART 4	95.3599	94.5034	95.262	94.6834	94.5991	93.2984	95.082	94.7176	94.3121	92.4783
		ART 5	95.3371	93.9521	95.1686	95.0683	94.779	95.1435	93.8588	94.6948	93.4784	93.6743
	1.0- 10 m/sec	**ART 1**	85.1093	83.7677	83.3645	82.0137	83.246	83.5581	82.9567	83.0387	80.656	81.5194
		ART 2	85.0934	85.6948	84.0433	81.7722	82.4396	82.4738	80.9795	82.164	81.6196	83.5558
		ART 3	85.0205	83.9635	84.7107	84.4715	84.3645	82.2483	79.5421	82.8497	80.0251	79.6674
		ART 4	85.8633	81.4806	83.3713	80.3485	82.3212	81.6879	82.9294	83.2825	81.2916	82.2164
		ART 5	86.2551	83.5148	83.9704	82.5376	81.7153	81.4784	80.0319	79.7312	79.492	81.7768
	10-20 m/sec	**ART 1**	73.3166	73.0888	71.3349	71.1572	70.2939	70.8497	70.7882	70.41	69.7084	70.5581
		ART 2	70.9977	72.3098	71.2118	70.2027	70.6765	70.9522	68.8747	69.1116	69.9863	69.8428
		ART 3	72.6355	70.6788	69.6606	70.3371	70.3189	68.9111	67.3645	68.9613	70.6196	67.8291
		ART 4	70.5991	70.2369	66.7836	69.6902	68.7084	68.3622	68.754	68.4579	69.9294	69.2984
		ART 5	69.3098	70.6856	69.0251	69.9977	69.1845	69.0706	68.5103	69.5125	67.6242	67.1503
	50-70 m/sec	**ART 1**	50.0524	49.5467	49.6629	50.2369	50.0638	49.2779	49.5763	49.9203	49.8041	49.5011
		ART 2	48.5581	48.6697	47.4419	47.2779	48.1868	48.2597	48.2825	48.0182	47.861	47.5467
		ART 3	47.7768	47.7289	47.3007	47.9043	46.5786	46.738	47.0159	47.4396	47.7517	48.1185
		ART 4	46.0000	46.7062	46.2028	46.2164	45.5877	45.5102	46.1253	46.344	46.3576	47.287
		ART 5	45.0980	45.3371	46.0046	45.5991	46.328	46.2141	45.6036	45.0615	45.0068	45.6811
	70-100 m/sec	**ART 1**	44.4715	43.7289	43.9203	43.9545	44.0137	44.2529	43.7677	44.4556	44.9727	44.0592
		ART 2	43.8770	42.9818	42.9659	42.7790	43.0387	42.5968	42.6606	42.6105	42.9043	42.2847
		ART 3	41.3872	41.3280	41.3280	41.5900	41.1139	40.9909	41.5740	41.9294	41.1640	41.9499
		ART 4	40.4897	40.2551	40.1116	40.6333	40.7289	39.2779	40.7699	40.6538	40.9841	40.9225
		ART 5	39.8080	39.6280	40.3640	38.8100	39.9490	39.6460	39.7560	40.0470	39.6760	40.9200

Table 4 (c) Average Packet Delivery Ratio Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 1 - 5 Sec

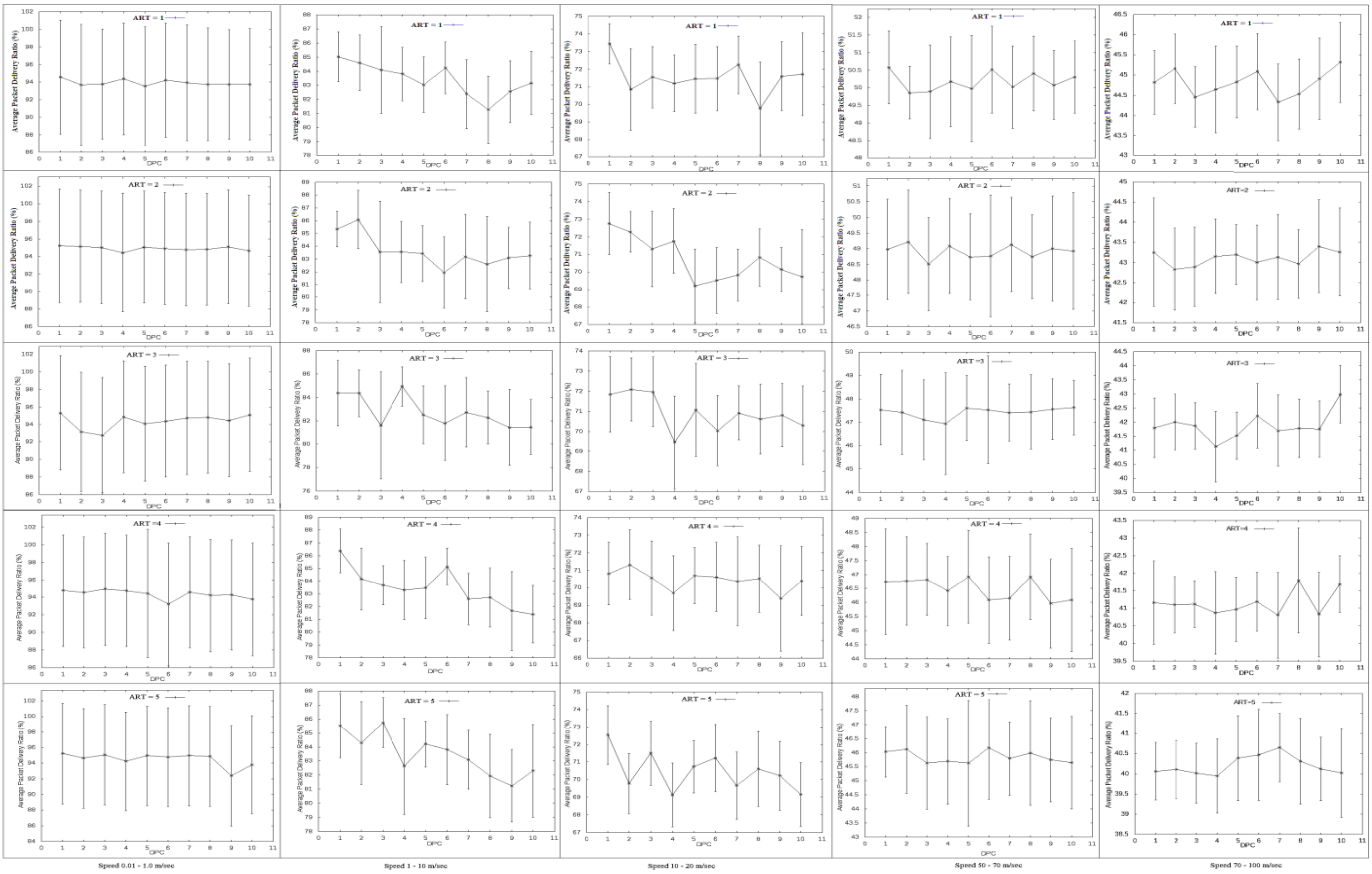

Fig 4 (d) Average Packet Delivery Ratio (PDR) Vs Delete Period Constant (DPC) for Different values of ART at Variable Speed Scenarios with Pause Time = 0 Sec.

Pause Time	Speed		DPC (Delete Period Constant) 1	2	3	4	5	6	7	8	9	10
Pause Time = 0 Sec	0.01– 1.0 m/sec	ART 1	94.5672	93.6856	93.7927	94.3667	93.533	94.2255	93.943	93.7449	93.7289	93.7403
		ART 2	95.205	95.1549	95.0228	94.4351	95.0683	94.8975	94.7699	94.8178	95.0934	94.672
		ART 3	95.3189	93.1708	92.7676	94.8565	94.0911	94.3736	94.7267	94.8132	94.4761	95.1002
		ART 4	94.7722	94.5422	94.9248	94.7494	94.4373	93.2005	94.5786	94.205	94.2779	93.7836
		ART 5	95.2323	94.6241	95.0729	94.2415	94.9431	94.7859	94.943	94.8906	92.3713	93.8064
	1.0- 10 m/sec	ART 1	85.0228	84.6037	84.0888	83.8087	83.041	84.2415	82.3804	81.2734	82.549	83.1731
		ART 2	85.3417	86.082	83.5399	83.5558	83.4328	81.9294	83.1936	82.5945	83.0934	83.2734
		ART 3	84.3849	84.3827	81.6219	84.9476	82.5239	81.8086	82.7449	82.2802	81.4465	81.4875
		ART 4	86.3827	84.1686	83.6765	83.2961	83.4601	85.1435	82.6105	82.7244	81.6697	81.4032
		ART 5	85.5125	84.2893	85.738	82.6264	84.2096	83.82	83.1002	81.9408	81.2437	82.3189
	10-20 m/sec	ART 1	73.4374	70.8405	71.5467	71.1913	71.4556	71.4693	72.2460	69.7585	71.5968	71.7084
		ART 2	72.7540	72.2734	71.3121	71.7540	69.2073	69.5216	69.8246	70.8292	70.1390	69.7175
		ART 3	71.8405	72.0866	71.9727	69.4465	71.0660	70.0410	70.9180	70.6105	70.8109	70.2961
		ART 4	70.8200	71.3212	70.5672	69.6993	70.6925	70.6196	70.3690	70.5239	69.3941	70.3918
		ART 5	72.5467	69.7813	71.5125	69.1321	70.7426	71.2323	69.6606	70.6150	70.2232	69.1572
	50-70 m/sec	ART 1	50.5786	49.8565	49.8907	50.1708	49.9772	50.5171	50.0205	50.4077	50.0797	50.303
		ART 2	48.9772	49.2187	48.5034	49.0820	48.7358	48.7677	49.1253	48.7403	49.0023	48.9248
		ART 3	47.5376	47.4260	47.1093	46.9408	47.6105	47.5353	47.4192	47.4465	47.5604	47.6355
		ART 4	46.7449	46.7677	46.8246	46.4123	46.918	46.0957	46.1526	46.9203	45.9635	46.0957
		ART 5	46.0319	46.1184	45.631	45.6902	45.6264	46.1686	45.7904	45.9886	45.7449	45.6469
	70-100 m/sec	ART 1	44.8223	45.1572	44.4556	44.6469	44.8292	45.0888	44.328	44.5307	44.9111	45.3144
		ART 2	43.2528	42.8314	42.8929	43.1526	43.2004	43.0023	43.1344	42.9681	43.4009	43.2597
		ART 3	41.7996	42.0091	41.8702	41.1276	41.5217	42.2301	41.7061	41.7859	41.7631	42.9932
		ART 4	41.1640	41.1048	41.1230	40.8747	40.9727	41.1936	40.8132	41.7950	40.8269	41.6948
		ART 5	40.0592	40.1071	40.0114	39.9453	40.3873	40.4715	40.6515	40.3075	40.1185	40.0205

Table 4 (d) Average Packet Delivery Ratio Vs DPC for Different Values of ART at various Speed Scenarios and Pause Time = 0 Sec

Since the considered scenario consist of fiveflows therefore the network PDR will be,

$$\textbf{Network PDR} = \frac{\text{Sum of all the Data Packets Received at five flows}}{\text{Sum of all the data Packets Transmited at five Flows}} * 100 \quad \textbf{(viii)}$$

Hence Average PDR based of 10 simulation runs will

$$(\textbf{Average PDR}) = \frac{\textbf{Network PDR for } (\textbf{run 1+run 2+run 3 ....+ ..+run 10})}{\textbf{10}} \quad \textbf{(ix)}$$

Fig 4 (a), 4 (b), 4 (c) and 4 (d) show the variation in Average Packet Delivery Ratio (PDR) Vs Delete Period constant (DPC), for ART = 1, 2, 3, 4 and 5 sec. for various Speed and Pause Time Scenarios.

Fig.4 (a) consists of five cases of different constant nodes speed (i.e. 0.03 m/sec, 3 m/sec, 13 m/sec, 55 m/sec and 75 m/sec)with Pause time 0 sec,

Fig 4(a), shows that Average PDR is high when speed is 0.03 m/sec and 3.0 m/sec. the maximum measured average PDR is 93.8907% for ART = 5 sec and DPC =2 when nodes speed are range upto 0.03m/sec, but when speed of the nodes is considered to 3.0 m/sec the maximum average PDR is recorded for ART = 3 sec and DPC = 1, which is 89.6295%.

In these two speed scenarios it is quite clear that when the node speed is less the Average PDR is high for all the values of ART and overall range of DPC, since the nodes are moving quite slow therefore there is less possibilities of route break and new route discovery, this results in high PDR values. Once the nodes speed is increase to 13 m/sec the average PDR drops for overall ART values upto ~75%. The maximum value of PDR is 75.1321% when ART =1 sec and DPC = 1, in this scenario the less amount of average PDR occurs due to nodes speed, since now the nodes are moving with adequate amount of speed which might have created a situation in the network when route break and new route discovery might have occur, due to which many packet in the network may not have been received in the required simulation time.

The same situation happens when the node speed is increase upto 55 m/sec and 75 m/sec the average PDR abruptly drops, when the nodes speed is 55 m/sec the maximum average PDR is 51.6651% for ART = 1 sec and DPC = 1, and when the node speed is 75 m/sec the average PDR = 47.7836% for ART = 1 sec and DPC = 7.

Fig 4(b), is similar to fig 4(a), the only difference is the pause time. In fig 4(b) the pause time is considered to be 1 – 5 sec. It is observed that Average PDR depends not only on speed of nodes, but also on its Pause time. As the speed of nodes are increased in the considered scenario Average PDRdecreases. Fig 4(b) shows that Average PDR is high when nodes speed in the considered network is less, i.e. when the nodes speed are considered to be 0.03 m/sec maximum average PDR is 93.8907% for ART = 5 sec and DPC = 2. But when the nodes speed is changed to 3.0 m/sec the average PDR drops, the maximum average PDR in this scenario is 90.0114% for ART = 3 sec and DPC = 1.

But once the speed of the nodes was considered to be 13 m/sec it was observed that average PDR was drop upto 75%, the maximum average PDR in this scenario recorded was 75.2779% for ART = 1 sec and DPC = 1, less amount of average PDR occurred in this scenario is due to nodes speed, since now the nodes are moving with sufficient amount of speed due to which a situation might have occur in the network when route break and new route discovery might have occur, due to which many packet in the network may not have been received in the required simulation time. The same situation happens when nodes speed 55 m/sec and 75 m/sec is considered. It is also observed that, maximum average PDR for 55 m/sec is recorded 51.724% for ART = 1 sec and DPC = 2.In case of 75 m/sec average PDR recorded is 46.0980% for ART = 1 sec and DPC = 1.

Fig 4(c) consists of five cases of different constant nodes speed (i.e. 0.01-1 m/sec, 1-10 m/sec, 10-20 m/sec, 50-70 m/sec and 70-100 m/sec)with Pause time 1-5 sec,In fig 4(c) it is observed that Average PDR get decreased with increase in nodes speed. Since pause time of 1-5 sec is considered in the scenario. Average PDR is better for low speed range scenarios (0.01-1, 1-10, 10-20 m/sec) because route in these speed scenarios and pause time are able to be in active state for sufficient amount of time, which contribute in high average PDR, the critical value for minimum and maximum PDR in these speed range can be clearly seen in table 4(c). Whereas when the nodes speed is high (50-70 and 70-100 m/sec) and pause time of 1-5 sec is considered Average PDR gets drops abruptly, this might be due the frequent movement of nodes due to which the packets in the network are not properly able to reach the destined nodes in the given simulation time.

Fig 4(d) is similar to fig 4(c) the only difference is the pause time. In fig 4(d) the pause time is considered to be 0 sec. It is observed the average PDR depends on three major factors, firstly, on the nodes speed, secondly on the specific value of ART and thirdly on the pause time. From the figure it is observed that Average PDR is better when nodes speeds are low i.e. 0.01-1, 1-10 and 10-20 m/sec. for these speed scenarios, nodes are able to get sufficient time to be in active range with other nodes since they are provided with low speed. Whereas when the nodes speed is increased upto 50-70 and 70-100 m/sec, average PDR drops due to high speed and sins ether is no considered pause time therefore nodes are continuously moving, this increases the possibility of route break which may contribute in low average PDR for higher nodes speed scenarios.

C. Average Throughput Vs Delete Period (DP) for Different values of ART and DPC at Different SpeedScenarios and Pause Time

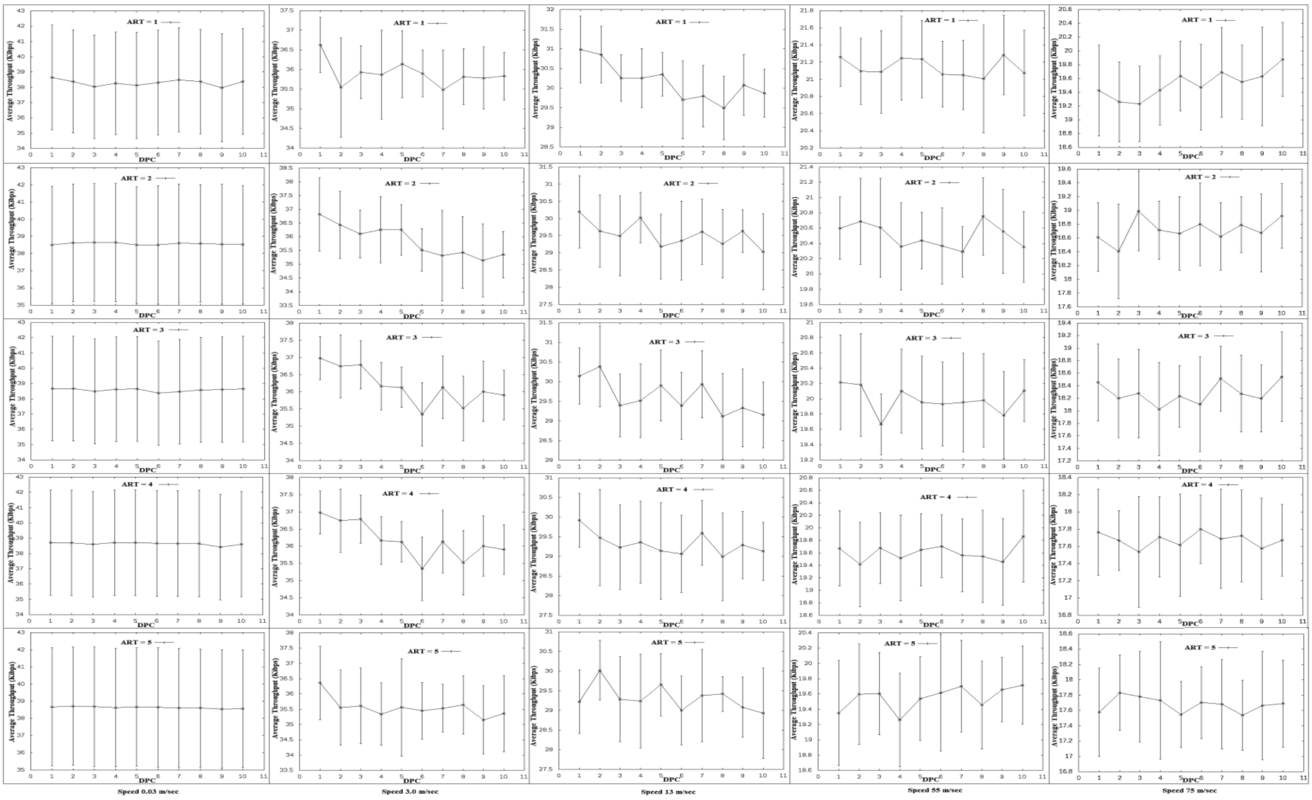

Fig 5 (a) Average Throughput Vs Delete Period Constant for Different values of ART at Constant Speed Scenarios with Pause time = 0 Sec

Pause Time	Speed		DPC (Delete Period Constant) 1	2	3	4	5	6	7	8	9	10
Pause Time = 0 Sec	0.03 m/sec	ART 1	38.6506	38.3835	38.0409	38.2569	38.1282	38.3147	38.4920	38.3743	37.9756	38.3858
		ART 2	38.5112	38.6318	38.6418	38.6403	38.5031	38.5100	38.6023	38.5960	38.5433	38.5199
		ART 3	38.6683	38.6611	38.4809	38.6283	38.6493	38.3862	38.4655	38.5886	38.5999	38.6373
		ART 4	38.7122	38.6928	38.6029	38.7036	38.7062	38.6643	38.6538	38.6549	38.4260	38.6054
		ART 5	38.6745	38.7182	38.6816	38.6357	38.6700	38.6461	38.6111	38.5994	38.5558	38.5696
	3 m/sec	ART 1	36.626	35.5403	35.931	35.8675	36.1362	35.8984	35.4842	35.8173	35.7846	35.8309
		ART 2	36.8173	36.4355	36.1007	36.2544	36.2545	35.5216	35.3153	35.4305	35.1407	35.3484
		ART 3	36.9811	36.7447	36.7825	36.1673	36.1300	35.3460	36.1347	35.5208	36.0098	35.9063
		ART 4	36.6996	35.4680	35.5069	35.7991	35.7520	35.5369	34.9810	34.2004	35.0014	34.3511
		ART 5	36.3632	35.5561	35.6098	35.3437	35.5633	35.4474	35.5317	35.6407	35.1493	35.3562
	13 m/sec	ART 1	30.9798	30.8551	30.2573	30.2517	30.3535	29.7030	29.7953	29.4922	30.0800	29.8712
		ART 2	30.1970	29.6358	29.4932	30.0253	29.1810	29.3583	29.6159	29.2679	29.6342	29.0322
		ART 3	30.1438	30.3880	29.3949	29.5196	29.9042	29.3872	29.9356	29.1171	29.3348	29.1542
		ART 4	29.9187	29.4773	29.2302	29.3603	29.1395	29.0603	29.5987	28.9928	29.2883	29.1302
		ART 5	29.2216	30.0199	29.2849	29.2359	29.6537	28.9997	29.3766	29.4168	29.0831	28.9281
	55 m/sec	ART 1	21.2596	21.0924	21.0856	21.2462	21.2362	21.0594	21.0521	21.0041	21.2836	21.0751
		ART 2	20.5970	20.6880	20.6040	20.3600	20.4370	20.3660	20.2890	20.7530	20.5560	20.3540
		ART 3	20.2140	20.1820	19.6650	20.1020	19.9520	19.9300	19.9510	19.9790	19.7830	20.1060
		ART 4	19.6721	19.4144	19.6733	19.5163	19.6489	19.7048	19.5597	19.5412	19.4551	19.8642
		ART 5	19.3508	19.5956	19.6047	19.2580	19.5390	19.6149	19.7016	19.4551	19.6578	19.7158
	75 m/sec	ART 1	19.426	19.2610	19.2300	19.4280	19.6340	19.4720	19.6880	19.5490	19.6310	19.8760
		ART 2	18.6125	18.4064	18.9878	18.7143	18.6666	18.7977	18.6221	18.7916	18.6726	18.9203
		ART 3	18.4533	18.2005	18.2754	18.0257	18.2317	18.1041	18.5135	18.2741	18.1974	18.5438
		ART 4	17.7633	17.6681	17.5343	17.7093	17.6142	17.799	17.6878	17.7232	17.5742	17.6716
		ART 5	17.5774	17.8315	17.7793	17.7319	17.5478	17.7036	17.6835	17.5364	17.6645	17.6893

Table 5 (a) Average Throughput Vs DPC for Different values of ART at various Speed Scenarios with Pause time = 0 Sec

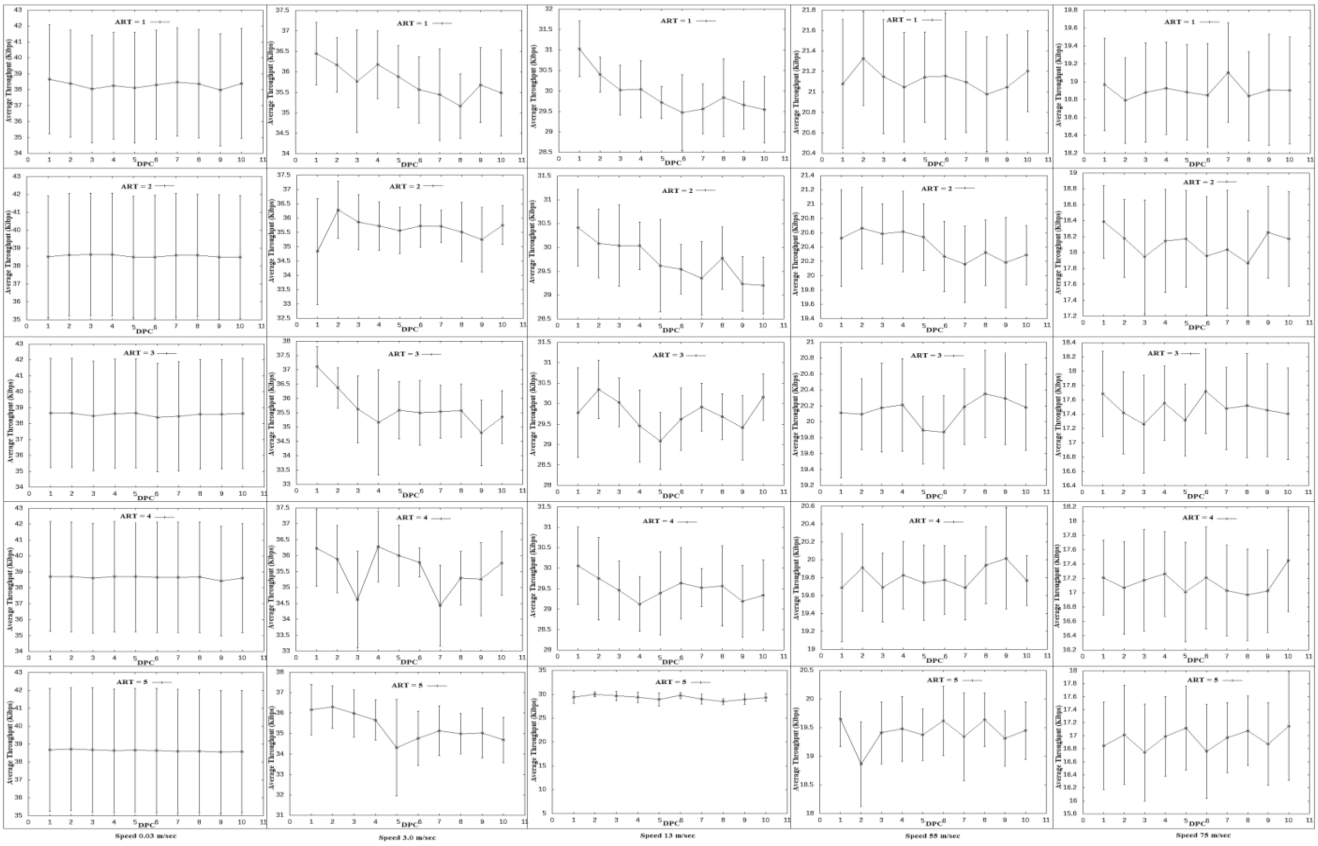

Fig 5 (b) Average Throughput Vs Delete Period Constant for Different values of ART at Constant Speed Scenarios with Pause time = 1 - 5 Sec

Pause Time	Speed		DPC (Delete Period Constant) 1	2	3	4	5	6	7	8	9	10
Pause Time 1 – 5 Sec	0.03 m/sec	ART 1	38.6508	38.3835	38.0419	38.2551	38.1264	38.3083	38.4828	38.3743	37.9755	38.3961
		ART 2	38.5112	38.6299	38.6488	38.6467	38.5032	38.5081	38.6004	38.596	38.5049	38.4988
		ART 3	38.6683	38.6599	38.481	38.6284	38.6464	38.3807	38.459	38.5888	38.5999	38.6364
		ART 4	38.7123	38.6931	38.6031	38.7038	38.6941	38.6646	38.6594	38.6716	38.4261	38.6055
		ART 5	38.6746	38.7181	38.6816	38.6357	38.6699	38.6481	38.6083	38.5995	38.5587	38.5754
	3 m/sec	ART 1	36.4485	36.1728	35.7684	36.1774	35.881	35.5632	35.4428	35.1652	35.6791	35.4839
		ART 2	34.8325	36.2826	35.861	35.7217	35.5659	35.7234	35.7089	35.5095	35.2448	35.7521
		ART 3	37.1168	36.3704	35.6197	35.1641	35.5878	35.4956	35.5398	35.5773	34.7974	35.345
		ART 4	36.2307	35.8926	34.6131	36.2801	36.0059	35.7868	34.4295	35.2957	35.2593	35.7652
		ART 5	36.1701	36.2951	35.9792	35.6557	34.3051	34.7685	35.1386	34.9946	35.0241	34.687
	13 m/sec	ART 1	31.029	30.4005	30.0206	30.0414	29.715	29.4696	29.5608	29.8363	29.6511	29.5433
		ART 2	30.4145	30.0819	30.0405	30.0346	29.617	29.5429	29.353	29.7754	29.2369	29.2038
		ART 3	29.7794	30.3485	30.0334	29.4556	29.086	29.6184	29.9186	29.6801	29.4103	30.1615
		ART 4	30.0606	29.7475	29.4621	29.123	29.3876	29.6343	29.5253	29.5632	29.189	29.3427
		ART 5	29.3898	29.99	29.6643	29.342	28.8983	29.7202	29.026	28.4396	28.9494	29.3326
	55 m/sec	ART 1	21.0778	21.3274	21.1493	21.0464	21.1444	21.1553	21.0968	20.9789	21.0482	21.2035
		ART 2	20.5262	20.666	20.5858	20.6161	20.5382	20.2688	20.1592	20.3229	20.1861	20.2876
		ART 3	20.1141	20.0966	20.1784	20.2125	19.895	19.87	20.1901	20.352	20.2925	20.1823
		ART 4	19.6883	19.912	19.6914	19.8264	19.7454	19.7763	19.6876	19.9405	20.0166	19.7671
		ART 5	19.6478	18.8608	19.4101	19.4807	19.3741	19.619	19.3425	19.6398	19.3135	19.4479
	75 m/sec	ART 1	18.9697	18.7917	18.8799	18.9288	18.8826	18.8483	19.1049	18.839	18.9087	18.9029
		ART 2	18.386	18.1752	17.9454	18.1443	18.1721	17.9556	18.0371	17.8661	18.2539	18.1721
		ART 3	17.6844	17.4198	17.2598	17.5561	17.3158	17.7205	17.4797	17.5214	17.4552	17.4059
		ART 4	17.2105	17.0691	17.1761	17.2634	17.0088	17.2091	17.0284	16.9713	17.0235	17.4487
		ART 5	16.8467	17.0147	16.7444	16.989	17.1185	16.7606	16.972	17.0783	16.8752	17.1501

Table 5 (b) Average Throughput Vs DPC for Different values of ART at various Speed Scenarios with Pause time = 1 - 5 Sec

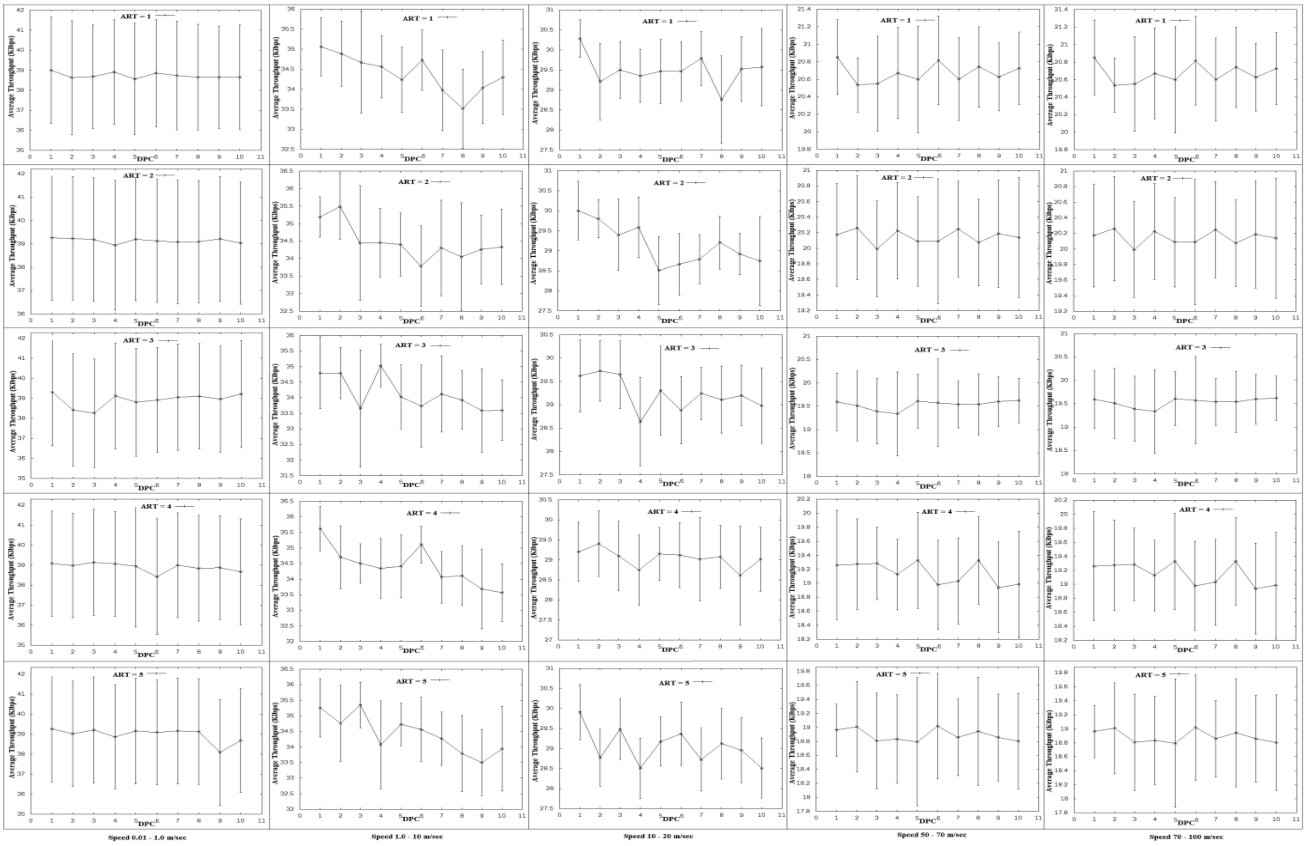

Fig 5 (c) **Average Throughput Vs Delete Period Constant for Different values of ART at Variable Speed Scenarios with Pause time = 1 - 5 Sec**

Pause Time	Speed		DPC (Delete Period Constant) 1	2	3	4	5	6	7	8	9	10
Pause Time = 1 – 5 Sec	0.01–1.0 m/sec	ART 1	39.0121	39.0483	38.0109	38.85	38.6342	38.9821	38.4083	38.5188	38.6528	38.8544
		ART 2	39.2697	39.2083	39.0973	38.8879	38.9688	38.7153	39.0857	39.1463	39.0788	39.1825
		ART 3	38.9653	39.0748	38.9725	38.9605	38.8751	38.9998	38.2836	39.1017	38.909	38.8311
		ART 4	39.3231	38.9700	39.2824	39.044	39.0092	38.4736	39.2088	39.0585	38.8911	38.1345
		ART 5	39.3106	38.7430	39.2439	39.2031	39.0837	39.2329	38.7043	39.0491	38.5468	38.6281
	1.0-10 m/sec	ART 1	35.0943	34.5405	34.3617	33.8189	34.3233	34.4488	34.1992	34.2392	33.2554	33.6153
		ART 2	35.0894	35.3328	34.6522	33.7131	33.9926	34.0081	33.3784	33.8722	33.6551	34.4537
		ART 3	35.0589	34.6131	34.9222	34.8327	34.7861	33.9108	32.7939	34.1623	32.9993	32.8506
		ART 4	35.4053	33.5988	34.3782	33.1269	33.9389	33.6849	34.1914	34.3404	33.5059	33.9021
		ART 5	35.5669	34.4029	34.6178	34.0308	33.6876	33.599	33.0010	32.8665	32.7786	33.7175
	10-20 m/sec	ART 1	30.2124	30.1112	29.3829	29.3051	28.9712	29.1937	29.1797	27.5058	28.7085	29.0523
		ART 2	29.2516	29.7811	29.3488	28.9515	29.1225	29.2403	28.3685	28.4822	28.8382	28.7768
		ART 3	29.9153	29.1098	28.7158	28.9749	28.9828	28.3937	27.7679	28.4118	29.1032	27.9316
		ART 4	29.0896	28.9526	27.5321	28.7155	28.302	28.1705	28.3493	28.2102	28.8166	28.575
		ART 5	28.5656	29.1319	28.4461	28.8515	28.5187	28.4696	28.241	28.6424	27.8639	27.6898
	50-70 m/sec	ART 1	20.6061	20.4011	20.4722	20.6985	20.6268	20.303	20.4434	20.5613	20.5207	20.4064
		ART 2	20.0029	20.0524	19.5512	19.4933	19.8722	19.9066	19.8651	19.7968	19.6995	19.5962
		ART 3	19.6822	19.6808	19.4911	19.7336	19.2049	19.2693	19.3859	19.5365	19.6585	19.8419
		ART 4	18.967	19.2342	19.0521	19.0607	18.7882	18.7616	18.9697	19.0993	19.1155	19.4710
		ART 5	18.5999	18.6981	18.9747	18.7891	19.0624	19.0228	18.7918	18.5806	18.5563	18.8375
	70-100 m/sec	ART 1	18.3398	18.0304	18.1075	18.1185	18.1493	18.2465	18.0484	18.3317	18.5297	18.1658
		ART 2	18.092	17.7237	17.7155	17.6419	17.7449	17.5669	17.5946	17.5653	17.6837	17.4397
		ART 3	17.0644	17.0442	17.0441	17.1437	16.9555	16.8925	17.1418	17.2887	16.9744	17.2990
		ART 4	16.6987	16.5978	16.5424	16.7441	16.7969	16.1965	16.8109	16.7656	16.8951	16.8778
		ART 5	16.4195	16.3432	16.6478	16.0041	16.4732	16.3511	16.3965	16.5187	16.357	16.8730

Table 5 (c) **Average Throughput Vs DPC for Different values of ART at various Speed Scenarios with Pause time = 1 - 5 Sec**

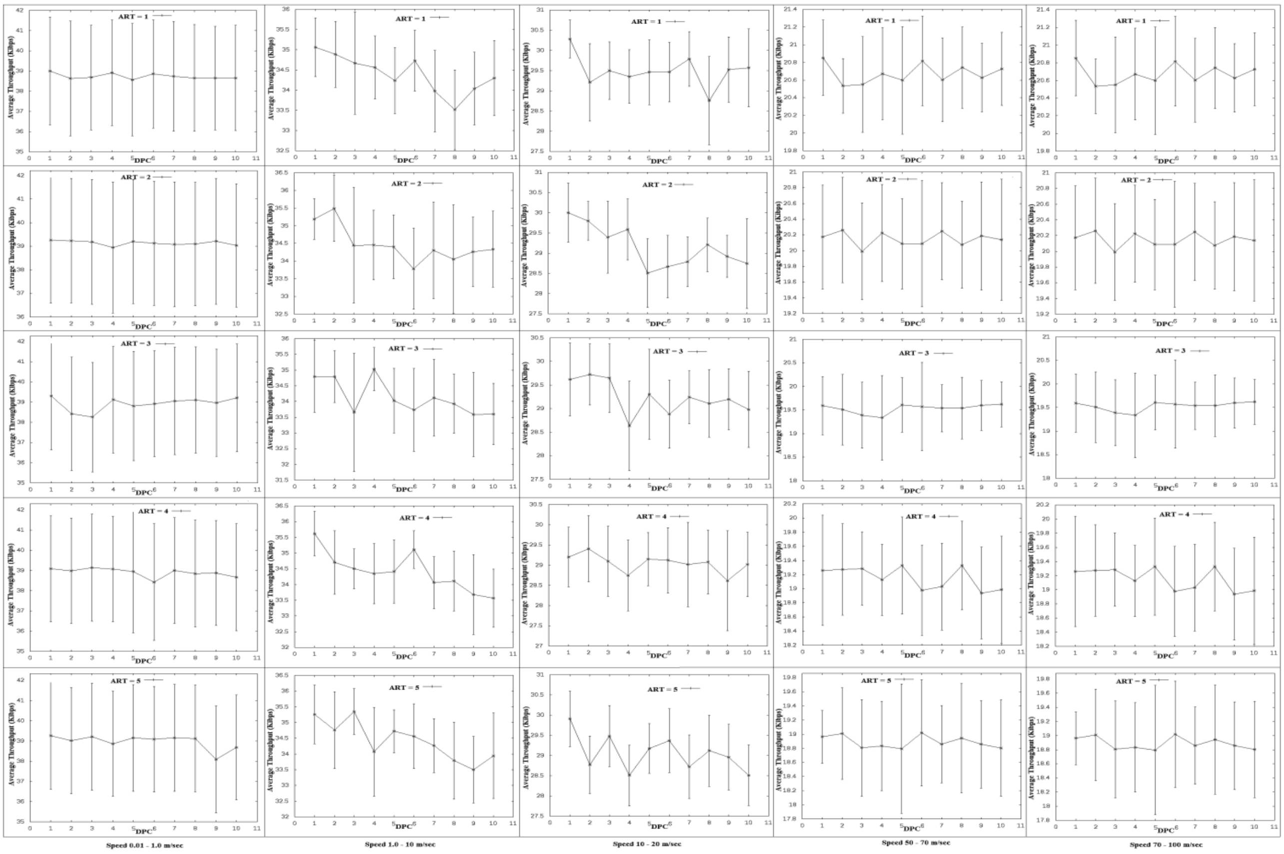

Fig 5 (d) Average Throughput Vs Delete Period Constant for Different values of ART at Variable Speed Scenarios with Pause time = 0 Sec

Pause Time	Speed		DPC (Delete Period Constant)									
			1	2	3	4	5	6	7	8	9	10
Pause Time = 0 Sec	0.01– 1.0 m/sec	ART 1	38.9958	38.626	38.6772	38.9131	38.5701	38.8554	38.7391	38.6567	38.651	38.6553
		ART 2	39.2591	39.2388	39.1844	38.9419	39.2027	39.1321	39.0796	39.0999	39.2134	39.0397
		ART 3	39.3060	38.4209	38.2551	39.1152	38.7998	38.9166	39.061	39.098	38.9589	39.2162
		ART 4	39.0811	38.9862	39.1438	39.0713	38.9423	38.4279	39.0006	38.8469	38.8772	38.6727
		ART 5	39.2709	39.0201	39.2045	38.8620	39.1511	39.0861	39.1516	39.1295	38.0909	38.6818
	1.0- 10 m/sec	ART 1	35.0596	34.8881	34.671	34.5594	34.2361	34.729	33.9706	33.5148	34.0391	34.2959
		ART 2	35.1885	35.4897	34.4490	34.4554	34.4054	33.7847	34.3055	34.0582	34.2642	34.3395
		ART 3	34.7970	34.7940	33.6527	35.0271	34.0294	33.7336	34.1207	33.9295	33.5854	33.6022
		ART 4	35.6207	34.7036	34.5004	34.3473	34.4153	35.1084	34.063	34.1126	33.6779	33.5682
		ART 5	35.2618	34.7579	35.3472	34.0697	34.7243	34.5646	34.2661	33.7887	33.5007	33.9449
	10-20 m/sec	ART 1	30.2814	29.2107	29.4984	29.3534	29.4615	29.4662	29.7860	28.7559	29.5223	29.5693
		ART 2	30.0018	29.8025	29.3967	29.5872	28.5066	28.6686	28.788	29.2066	28.9196	28.7479
		ART 3	29.6194	29.7253	29.6491	28.6365	29.3049	28.8823	29.2423	29.1126	29.1991	28.9840
		ART 4	29.2046	29.4066	29.0987	28.7423	29.1485	29.1187	29.0165	29.0818	28.6138	29.0194
		ART 5	29.9098	28.7735	29.4849	28.5051	29.1727	29.3676	28.7227	29.1186	28.9592	28.5126
	50-70 m/sec	ART 1	20.8522	20.5335	20.5511	20.6715	20.5966	20.8152	20.6033	20.7417	20.6273	20.7270
		ART 2	20.1737	20.2617	19.9916	20.2253	20.0878	20.0885	20.245	20.0755	20.1866	20.1376
		ART 3	19.5925	19.5100	19.3920	19.3352	19.6107	19.5745	19.5405	19.5433	19.5997	19.6213
		ART 4	19.2586	19.2728	19.2836	19.1266	19.3274	18.9779	19.0307	19.3289	18.9372	18.9872
		ART 5	18.9617	19.0091	18.8058	18.8320	18.7941	19.0193	18.8587	18.9431	18.8552	18.8009
	70-100 m/sec	ART 1	18.4807	18.6148	18.3213	18.4099	18.4847	18.5922	18.2794	18.3599	18.5172	18.6784
		ART 2	17.835	17.6609	17.6879	17.794	17.8157	17.7299	17.7867	17.7177	17.8955	17.8370
		ART 3	17.2357	17.3227	17.2652	16.9594	17.1175	17.4127	17.198	17.2311	17.2213	17.7266
		ART 4	16.9738	16.9488	16.9569	16.8557	16.8938	16.986	16.8294	17.2340	16.8343	17.1939
		ART 5	16.5182	16.5366	16.4981	16.4707	16.6538	16.688	16.7627	16.6201	16.5434	16.5019

Table 5 (d) Average Throughput Vs DPC for Different values of ART at various Speed Scenarios with Pause time = 1 - 5 Sec

The considered Simulation scenario consist of five source and destination pair (flows), therefore network throughput of five flows will be,

$$\text{Network Throughput} = \frac{\frac{\text{Sum of (Total Bytes Recieved at each flow)} * 8}{\text{Time of last packet Rx} - \text{time of the first packet Tx}}}{1024} \quad (x)$$

Hence Average Throughput based of 10 simulation runs will be,

$$(\text{Average Throughput}) = \frac{\text{Network throughput for (run 1+run 2+run 3 ....+ ..+run 10)}}{10} \quad (xi)$$

Fig 5(a), 5(b), 5(c) and 5(d) show the variation in Average Throughput Vs Delete Period constant (DPC), for ART = 1, 2, 3, 4 and 5 sec. for various Speed and Pause Time Scenarios. Fig.5(a) consists of five cases of different constant nodes speed (i.e. 0.03 m/sec, 3 m/sec, 13 m/sec, 55 m/sec and 75 m/sec)with Pause time 0 sec. From the considered figure, it is observe that Average Throughput decreases with increase in nodes speed, when the speed of the nodes are considered to be 0.03 m/sec and 3 m/sec, the average throughput of the network is fairly good, when the nodes speed are 0.03 m/sec maximum average throughput of ~38 kibps is observed for all the value of ART for overall range of DPC, the maximum average throughput is recorded when ART = 4 sec and DPC = 1 which is 38.7122 kibps, when the nodes speed are 3 m/sec maximum average throughput of ~36 kibps is observed and its recorded to be 36.9811 kibps for ART = 3 and DPC = 1. Since in these two scenarios the speed of the nodes are quite low which gives nodes fair chance to participate in route formation through which maximum amount of packets are transmitted, since the situation of route break and new route discovery is quite low in these speed scenarios therefore the possibility of maximum packet delivery is possible which results in high throughput of the network. When the speed of the nodes are increased to 13 m/sec it is observed that overall network throughput decreases, in this scenario the maximum value of through put is observed to be 30.9798 kibps for ART = 1 sec and DPC =, in thisscenario it is also observed that due to the movement of nodes fair possibility of route break and new route discovery is increased which results in packet drop in the network, which finally concludes in low network throughput.The same condition appears to be happening in the case when nodes speed are considered to be 55 m/sec and 75 m/sec. the maximum average throughput of 21.2596 kibps is observed when ART = 1 sec and DPC = 1when speed of the nodes are 55 m/sec, and when the speed of the nodes are considered to be 75 m/sec a maximum throughput of 19.426 kibps is observed for ART = 1 sec and DPC = 1.

Fig 5(b)is similar to fig 5(a) the only difference is the pause time. In fig 5(b) the pause time is considered to be 1 – 5 sec. It is observed that Average throughput depends not only on speed of nodes, but also on its Pause time. As the speed of nodes are increased in the considered scenario Average throughputdecreases. Fig 5(b)also shows that Average throughput is high when nodes speed in the considered network is less which can be clearly observed through figure 5(b) and Table 5(b). From the figure it is observed that when nodes speed is low (i.e. 0.03, 3 and 13 m/sec) and pause time of 1-5 sec is considered the performance of average throughput is better, but it drops when the nodes speed of 55 m/sec and 75 m/sec is considered.

Fig.5(c) consists of five cases of different constant nodes speed (i.e. 0.01 - 1 m/sec, 1 -10 m/sec, 10-20 m/sec, 50-70 m/sec and 70-100 m/sec)with Pause time 0 sec. From the considered figure, it is observed that Average throughputdepends not only on speed of nodes, but also on its Pause time. In the considered scenario pause time is considered to be 1 -5 sec. form the considered figure it is also observed that Average Throughput decreases with increase in nodes speed, high Average Throughput is achieved with nodes speed 0.01-1m/sec, 1-10 m/sec, which is recorded to be ~39.3231 kibps (0.01-1 m/sec) and 35.5669 kibps (when the speed of nodes are1-10 m/sec). Whereas when the speed of the nodes are 10 – 20 m/sec maximum average throughput of 30.2124 kibps is observed for ART = 1 sec and DPC = 1. From the above three speed scenarios it is quite clear that when the nodes speed is low, high average throughput is achieved. Whereas once the speed of nodes is increased up to 50-70 and 70-100 m/sec the average throughput drops. The suggested condition to achieve high throughput in these two speed scenarios is to set the ART value to 1 sec and DPC to 1.

Fig 5(d)is similar to fig 5(c) the only difference is the pause time. In fig 5(d) the pause time is considered to be 0 sec.

From Fig 5(d) it is observed that increase in nodes speed the Average throughput decreases. It is also observed that when the speed of the nodesis considered to be 0.01-1 m/sec, 1- 10 m/sec and 10 – 20 m/sec, the average throughput is quite better, in case of 0.01-1 m/sec speed scenario maximum average throughput of ~ 39 kibps is achieved and specially when ART = 1 sec and DPC = 1, a gradual decrease of average throughput is seen when nodes speed are considered to be 1 -10 m/sec and 10 – 20 m/sec, in case of 1-10 m/sec maximum average throughput of 35.6207 kibps is recorded for ART = 4 sec and DPC = 1. And when the nodes speed is considered to be of 10 – 20 m/sec maximum average throughput of 30.2814 kibps is recorded for ART = 1 sec and DPC = 1.But when high nodes speed of 50-70 and 70-100 m/sec is considered with pause time of 0 sec. it is observed that average throughput decreases abruptly, It is also observed that to achievebetter throughput in these two speed scenarios that value of ART=1 sec and DPC = 1 should be considered. From fig 5(d) it can be concluded that the average throughput of a particular mobile ad hoc network directly depends on the speed of the nodes and pause time. As the speed of the nodes are increased the average throughput drops, the best condition to achieve high average throughout in high speed mobile ad hoc network is to use AODV routing protocol with its route maintenance parameters i.e. ART and DP set to the lowest values. Table 5(d) provides the best combination of ART and DPC for attaining best value for average throughput.

VII. CONCLUSION

The considered article mainly focuses on the performance of route maintenance parameter of AODV routing protocol (i.e. ART and DPC). The performance of ART and DPC has been investigated at different Nodes Speed and different pause time in the considered network. During the simulation and analysis it is observed that the performance of ART and DPC strictly depends on the speed of nodes, pause time and specific value of ART and DPC. The main observations are as follows.

- From the analysis it is quite obvious that when speed of the nodes in the considered network is low, then the variation in ART and DPC does not create an effective change in performance matrices, whereas, when the nodes speed is increased, frequent change in network topology occurs which an be clearly observedfrom the graphs and tables provided in this article.
- During the analysis over ART and DPC, it can be clearly seen that, for low Average End to End Delay it is recommended to choose higher value of ART i.e. ART = 5 sec with DPC = 2 for low speed range, whereas for high speed range ART = 5 sec with DPC = 3 sec should be considered.
- To achieve high Average Throughput and high Average PDR for low speed range scenario then the recommended value for ART = 1 or 2 sec with DPC = 4 or 5.To achieve high Average Throughput and high Average PDRfor high speed range scenario then the recommended value for ART = 1 or 2 sec with DPC = 2 or 3.
- From the study of various graphs, tables and figures in the considered article, itcan be concluded that to haveLow Average End to End Delay, high values of ART (i.e. 4 and 5 sec) should be considered. And to achieve high average throughput and high average PDR it is recommended to consider low values of ART (i.e. 1, 2 and 3 sec) in all the considered speed and pause time scenarios.

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