https://dx.doi.org/10.22161/ijaers.4.4.15 *ISSN: 2349-6495(P) | 2456-1908(O)*

Efficiency and Performance analysis of routing protocols in WSN

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Abstract— *Routing is very important in data communication, especially in Wireless Sensor Network (WSN). In WSN, every node acts as a router, forwarding data packets to other nodes. There are various kinds of routing protocol and they act different in different scenario by their specialty. Routing protocols performance can be vary with various parameters such as speed time, seed time, pause time, number of node and network topology. In this paper, we discuss several routing protocols such as Ad Hoc On Demand Distance Vector (AODV),Ad hoc On-demand Multipath Distance Vector (AOMDV),Dynamic Source Routing (DSR),Destination-Sequenced Distance-Vector Routing (DSDV)and different connection types such as TCP, Constant Bit Rate (CBR) for WSN. In this research, we analyzed performance of routing protocols by considering different scenarios and metrics. We compare protocols performance by using several metrics such as Packet Delivery Ratio (PDR), Loss Packet Ratio (LPR) and Average End to End Delay (E2E) with varying pause time and speed time. We use network simulator NS2.35 for compare and analyze WSN protocol performance.*

Keywords---Routing protocols, Proactive and Reactive routing, Performance analysis, Wireless sensor network.

I. INTRODUCTION

WSN is very popular network topology nowadays. It does establish network autonomously without human interaction [1].In wireless network every distributed autonomous device using sensors to monitor physical or environmental conditions[2]. Routing pro tocol establishes a link to send data from source to destination node. In WSN it is not possible to establish fixed path or route infrastructure between two nodes because nodes could be moveable [3].

Routing protocol is very important because it provides all the information about the network and routers and store information into the routing table. According to this routing table information routing algorithm compute its routing decisions to calculate the best path from source to destination. Routing protocol is basically designed for the dynamic network environment. In routing every node makes its own routing decision by using a routing protocol to find out the next node. This process is repeated until the packet is reached to the destination. Every routing information is stored in the routing table and according to routing algorithm its find out the shortest path. Routing table can synchronize by two ways one is static and other is dynamic routing. In static routing every router is configured by manually and set the list of destination and next hop/node. It is possible in static network, however, difficult in dynamic routing. Dynamic network may change or update frequently. Therefore, it is complicated to establish fixed/static routing path. For this reason dynamic routing uses a routing protocol that update routing table frequently and determine the best path to send data packet from source to destination.

The remainder of the paper is organized as follows: Section 2 shortly describes about related work related to performance evaluation of protocols. Section 3 discusses about routing protocol of AODV, AOMDV, DSR and DSDV. Section 4 presents two connection types. Section 5 describes the performance metrics and network parameter simulations. Section 6 describes implementation and simulation results. Section 7discuss performance analysis and Section 8concludes the paper with conclusion.

II. RELATED WORK

In literature, several papers discussed related to WSN performance evaluation of AODV, AOMDV, DSR and DSDV protocols.

In paper [1]authors discuss about performance evaluation of quality of service in DS-AODV in MANET. Also they focused on using a reactive routing approach, AODV, to discover the delay-aware routes during its route discovery phase.

In paper [3] two protocol AODV and DSDV have been simulated using NS-2 package and compared in terms of packet delivery fraction, end to end delay and throughput in different environment; varying period of pause time and number of expired nodes. In paper [5] authors focused on routing, protocols, their challenges and issues. The purpose of this paper is to explore different challenges and issues of routing algorithms in a classified way for IP network and ad hoc network.

In paper [9], performance is analyzed of WSN according to End-to-End delay, Number of packet received, Loss Packet ratio and Average end to end delay. Authors analyzed performance of 50,100,150 nodes using simulation area 1200m*1200m and size of packets is 512 bytes. In paper [19] authors consider analysis performance of WSN according to End-to-End delay, Number of packet received, Packet drop ratio and Energy consumption of the Network. They analyzed performance of 50 nodes, using simulation area 100m*100m and size of packets is 100 bytes. In [20,21] authors discussed intelligent transportation protocol systems.

III. ROUTING PROTOCOL

Internet Engineering Task Force (IETF) has been proposed various protocols into two categories of routing used in ad hoc network are proactive routing and reactive routing. In reactive routing protocols route are established only when source and destination want to communicate each other. But in proactive routing protocol every node maintains one or more routing tables the entire topology of the network to communicate with another node [4].

Destination Sequenced Distance Vector (DSDV) is one of the proactive routing algorithm and Ad hoc On Demand distance Vector (AODV), Ad hoc On demand Multipath Distance Vector (AOMDV), Dynamic Source Routing (DSR) are the reactive routing algorithm [5].

3.1 AODV

AODV [6] is an Ad Hoc on Demand Distance Vector routing protocol is a best example of reactive routing protocol. Only when source node wants to send packet to destination node then AODV establish a route. AODV contain routing table to check route for sending message. It's also has ability to unicast and multicast routing. AODV is different from other on demand routing protocols because it used destination sequence number (DestSeqNum). For route discovery AODV used route Request (RREQ) and Route Reply (RREP) messages also used HELLO message for maintenance route.

3.2 AOMDV

AOMDV [7] that means Ad hoc On-demand Multipath Distance Vector Routing is one of the best examples of multipath routing protocol. AOMDV create multipath for backup route purpose. For data sending purpose it's discover several paths from source to destination. If existing path become down its used backup path to stable network. By sending temporary massage backup path are kept stable. Destination node also replies multiple RREQs to the source for acknowledgment.

3.3 Dynamic Source Routing (DSR)

DSR is a reactive routing protocol [8]. Link state algorithm is used into DSR protocol. That means best route from source to destination are saved into every node. For any kind of change into network topology, the whole network will get the information by flooding. Node generates an error message when any failure occurred into link.DSR stored all intermediate nodes ID in the packet header and stores all routing information of multiple paths, if there has multiple paths to go to the destination [9].

3.4 Destination-Sequenced Distance-Vector Routing (DSDV)

DSDV [10] is a Proactive routing protocol. It used on Bellman-Ford routing algorithm for exchanges the messages within the neighbor nodes. Every node maintains a routing table of the entire possible destination and keeps the record of all number of hops in the network. If any kinds of update occurred into network, then every neighbor nodes exchange routing table and routing data are updated with new data. Loop free paths and low latency for real time application is one of the best advantages of DSDV routing protocol. DSDV doesn't support Multi path routing that's why unused paths occupy a significant part of the available bandwidth.

IV. CONNECTION TYPE

For our experimental purpose we used two types of traffic: Transmission Control Protocol (TCP) Traffic and constant-bit-rate traffic (CBR).

4.1 Transmission Control Protocol (TCP) Traffic

Transmission Control Protocol (TCP) is one of the valuable protocols of the internet protocol suite. It's complemented the Internet Protocol (IP) by implementation originated in the initial network [11].That means connection of TCP is an oriented, reliable, flow control, avoid overloading and conforming transport protocol [12]. TCP uses acknowledgement, time outs and retransmission process. In TCP, destination node gives feedback or positive acknowledgments. That means successful transmission of packets from source to destination. Timeouts system required that data to be successfully delivered between the source to the destination. If any acknowledgement is not received during a certain period of time then the system become time out and then TCP send the data again.

https://dx.doi.org/10.22161/ijaers.4.4.15 *ISSN: 2349-6495(P) | 2456-1908(O)*

4.2 Constant Bit Rate (CBR) Traffic

Constant bit rate means the data are sent at a fixed bit rate [13]. In the network fixed bit rate are supplied. Between two nodes establishment phase of connection is not required, also the receiving or destination node don't send any acknowledgment or "hello" message. Traffic is flowing only from source to destination without giving any feedback or acknowledgment from the destination.

V. PERFORMANCE METRICS&NETWORK PARAMETERS SIMULATIONS

There have been many performance metrics are available for measure network performance. According to this metrics we can evaluate the performance of network. For example we can say: Quality of Service (QoS), Packet Delivery Ratio (PDR), Average end-to-end delay, Loss Packet Ratio (LPR). For our experiment purpose we use three performance metrics. These are Packet Delivery Ratio (PDR), Average end-to-end delay, Loss Packet Ratio (LPR).

5.1 Packet Delivery Ratio (PDR)

Packet delivery ratio is the ratio of delivery packets which is send by the source node and received by the destination node. When packet delivery ratio is high then we can say that performance is better.

5.2 Average end-to-end delay (E2E)

Average time delay (how much time needed?)For send data packet from the source node & received by the destination node. Total time difference over the total number of packet received is dividing with single packet send and received time (which was stored before) give the average end-to-end delay for the received packets. When average end-to end delay is less than the performance is better.

5.3 Loss Packet Ratio (LPR)

Loss Packet means, Packet can't reached the destination from the source. Loss Packet Ratio means, number of packets that can't receive by destination or that never reached the destination which is send by the source. Normally when Loss Packet Ratio (LPR) is lower than the performance is better.

VI. IMPLEMENTATION& SIMULATIONS RESULTS

We use g Network simulator (NS) version 2.35 under Linux (Ubuntu) platform for our all simulation work [14, 15]. NS2 software is open source simulator software and main goal of NS2 simulator is to provide educational support for research in networking. NS2 provide two language: object oriented language C++ & Object oriented variant of Tool Command Language (OTCL) [16, 17, 18]

We use wireless node random waypoint mobility model for our simulation purpose by Network Simulator NS-2. 35 [9-13]. We employ same scenario and same metrics for every protocol (AODV, AOMDV, DSR and DSDV) to measure the performance.

6.1 Parameters of Simulations

For our experiment purpose, we used 1200 x 1200 size environment. Number of node is 100 with constant Seed time 1.0 and variable Speed time 10s, 20s, 30s and variable Pause time is 10s, 20s, and 30s. We did the simulation for simulation time 200s. The network parameters which we used for our simulation purpose shown in the table 1.

Table.1: Simulation Parameters

Parameter	Value
Protocols	AODV, AOMDV, DSR, DSDV
Simulation Area	1200*1200
Packet Size	512
Simulation Time	200s
Pause Time	10s,20s,30s
Speed Time	10s,20s,30s
Seed Time	1.0
Number of Nodes	100
Traffic generation	TCP, CBR
Mobility Model	Random Waypoint
Network Simulator	NS 2.35

6.2 Simulation Results

Connection types TCP & CBR are used in our simulation purpose. Performance of routing protocols AODV, AOMDV, DSR & DSDV has been compared with varying Pause time 10s, 20s, 30s and variable Speed time 10s, 20s, 30s according to constant number of nodes 100. Mobility Model is Random Waypoint and seed time is 1.0 (fixed). We do compare AODV, AOMDV, DSR & DSDV protocols according to packet delivery ratio (PDR), average end-to-end delay, Loss packet ratio (LPR). By using Table and Graphs we show all the simulation output.

https://dx.doi.org/10.22161/ijaers.4.4.15 ISSN: 2349-6495(P) | 2456-1908(O)

Table.2: Variations of PDR, LPR AND E2E with Speed Time & Pause Time for AODV

AODV								
Number of Node	**Speed Time**	**Pause Time**	**Pkt Types**	**Pkt Sent**	**Pkt Receive**	**LPR**	**PDR**	**E2E**
100	**10**	**10**	TCP	27836	26652	4.251688461	95.74831154	101.44795
			CBR	4828	4591	4.918711815	95.08128818	75.1822
		20	TCP	21381	20540	3.93340	96.06660	112.454
			CBR	4817	4561	5.31451	94.68549	102.81
		30	TCP	30102	28997	3.672452454	96.32754755	98.3092
			CBR	4811	4604	4.302192663	95.69780734	85.32735
	20	**10**	TCP	34291	32765	4.45015	95.54985	90.4419
			CBR	4840	4621	4.52479	95.47521	47.5544
		20	TCP	32958	31792	3.53784	96.46216	99.765
			CBR	4818	4590	4.7325	95.26775	85.1383
		30	TCP	38824	37454	3.52875	96.47125	84.1644
			CBR	4806	4648	3.28756	96.71244	67.8447
	30	**10**	TCP	27476	26009	5.340927702	94.6590723	105.02145
			CBR	4825	4503	6.672883639	93.32711636	77.7462
		20	TCP	20662	19253	6.81928	93.18072	119.601
			CBR	4811	4386	8.83392	91.16608	107.938
		30	TCP	29743	28353	4.671687456	95.32831254	101.8827
			CBR	4808	4517	6.062181553	93.93781845	87.89135

Table3: Variations of PDR, LPR AND E2E with Speed Time & Pause Time for AOMDV

AOMDV								
Number of Node	**Speed Time**	**Pause Time**	**Pkt Types**	**Pkt Sent**	**Pkt Receive**	**LPR**	**PDR**	**E2E**
100	**10**	**10**	TCP	22682	21448	5.440317425	94.55968257	109.0034
			CBR	4807	3237	32.65730629	67.34269371	41.83105
		20	TCP	31163	29589	5.05086	94.94914	88.8379
			CBR	4830	3701	23.37474	76.62526	26.6085
		30	TCP	32879	31316	4.755242628	95.24475737	77.39245
			CBR	4827	3541	26.63904713	73.36095287	31.13315
	20	**10**	TCP	14202	13308	6.29489	93.70511	129.169
			CBR	4785	2774	42.02717	57.97283	57.0536
		20	TCP	32709	31257	4.43915	95.56085	72.5143
			CBR	4825	2894	40.02073	59.97927	37.0094
		30	TCP	34596	33043	4.48896	95.51104	65.947
			CBR	4825	3382	29.90674	70.09326	35.6578
	30	**10**	TCP	26197	25143	4.023361454	95.97663855	97.51785
			CBR	4805	2690	44.01664932	55.98335068	48.08455
		20	TCP	38192	36978	3.17868	96.82132	65.8667
			CBR	4825	2606	45.98964	54.01036	39.1155
		30	TCP	36394	35010	3.801450789	96.19854921	65.90685
			CBR	4825	2994	37.94818653	62.05181347	37.38665

https://dx.doi.org/10.22161/ijaers.4.4.15 *ISSN: 2349-6495(P) | 2456-1908(O)*

Table.4: Variations of PDR, LPR AND E2E with speed time & pause time for DSR

DSR								
Number of Node	**Speed Time**	**Pause Time**	**Pkt Types**	**Pkt Sent**	**Pkt Receive**	**LPR**	**PDR**	**E2E**
100	10	10	TCP	33526	33301	0.67260227	99.32739773	286.0805
			CBR	4797	4304	10.28660761	89.71339239	201.6955
		20	TCP	51437	51176	0.50742	99.49258	275.701
			CBR	4786	4619	3.48934	96.51066	48.853
		30	TCP	42229	41964	0.627523414	99.37247659	316.9975
			CBR	4808	4603.5	4.253327787	95.74667221	107.776
	20	10	TCP	15616	15426	1.21670	98.78	296.46
			CBR	4809	3989	17.05136	82.94864	354.538
		20	TCP	11388	11167	1.94064	98.05936	665.343
			CBR	4814	3756	21.97757	78.02243	1464.92
		30	TCP	33022	32753	0.81461	99.18539	358.294
			CBR	4830	4588	5.01035	94.98965	166.699
	30	10	TCP	22196	21795	1.808843737	98.19115626	291.3705
			CBR	4808	3566	25.83194676	74.16805324	589.5535
		20	TCP	28777	28164	2.13017	97.86983	286.281
			CBR	4807	3143	34.61618	65.38382	824.569
		30	TCP	30899	30458	1.42720756	98.57279244	322.2875
			CBR	4818	3865	19.77793919	80.22206081	495.634

Table.5: Variations of PDR, LPR and E2E with speed time & pause time for DSDV

DSDV								
Number of Node	**Speed Time**	**Pause Time**	**Pkt Types**	**Pkt Sent**	**Pkt Receive**	**LPR**	**PDR**	**E2E**
100	10	10	TCP	22711	22020	3.042511503	96.9574885	65.0067
			CBR	4793	1892	60.52576674	39.47423326	28.18215
		20	TCP	12315	11842	3.84084	96.15916	81.0275
			CBR	4784	2191	54.20151	45.79849	30.2092
		30	TCP	17498	16952	3.120267451	96.87973255	78.0724
			CBR	4784	2108	55.93060926	44.06939074	44.3043
	20	10	TCP	33108	32199	2.74556	97.25444	48.9859
			CBR	4802	1593	66.82632	33.17368	26.1551
		20	TCP	35900	34983	2.55432	97.44568	50.0487
			CBR	4822	2409	50.04148	49.95852	78.02243
		30	TCP	22682	22063	2.72904	97.27096	75.1173
			CBR	4785	2026	57.65935	42.34065	58.3994
	30	10	TCP	24750	23955	3.212121212	96.78787879	53.86835
			CBR	4822	1573	67.3683119	32.6316881	40.91105
		20	TCP	16392	15711	4.15447	95.84553	58.7508
			CBR	4842	1554	67.90582	32.09418	55.667
		30	TCP	19537	18887	3.327020525	96.67297947	66.93405
			CBR	4813	1790	62.81292199	37.18707801	57.0332

https://dx.doi.org/10.22161/ijaers.4.4.15 *ISSN: 2349-6495(P) | 2456-1908(O)*

6.3 Performance Graphs

We generated the graph based on our simulation result Data in network simulator NS-2.35. This shows the differences of performance between AODV, AOMDV, DSR and DSDV. The graph is given below.

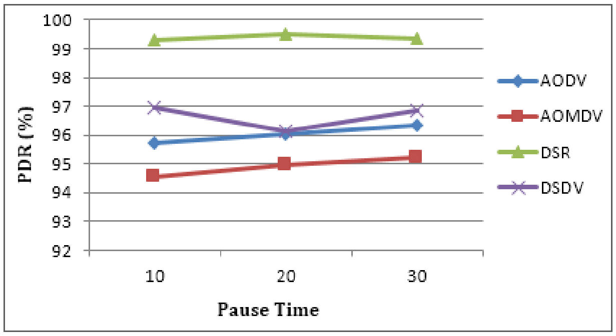

Fig.1: PDR of Speed time 10 using TCP

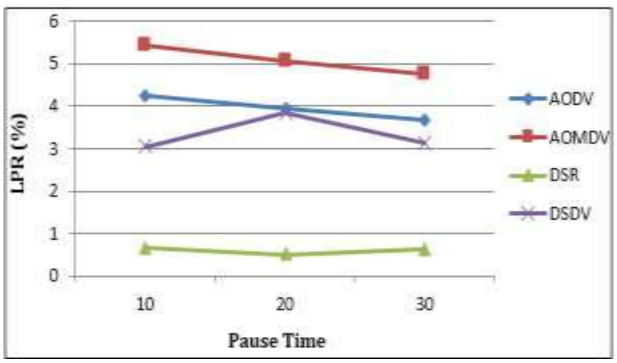

Fig.2: LPR of Speed time 10 using TCP

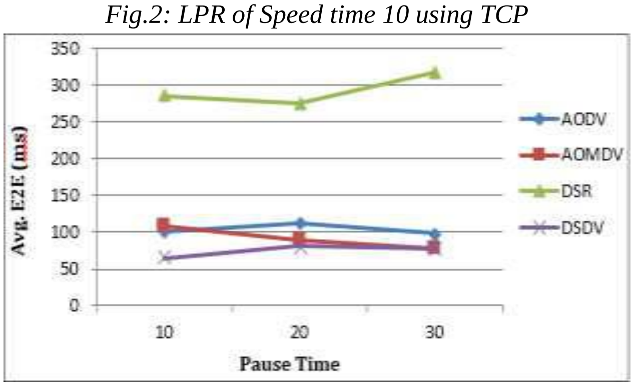

Fig.3: E2E delay of Speed time 10 using TCP

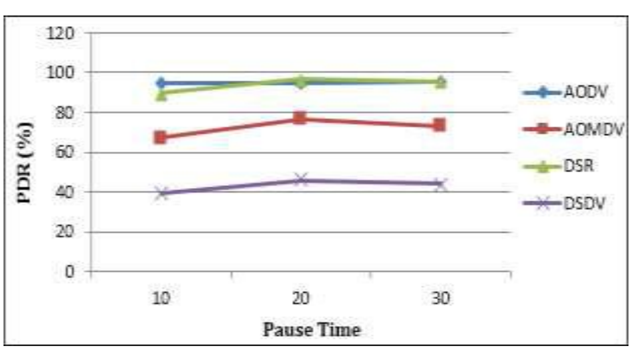

Fig.4: PDR of Speed time 10 using CBR

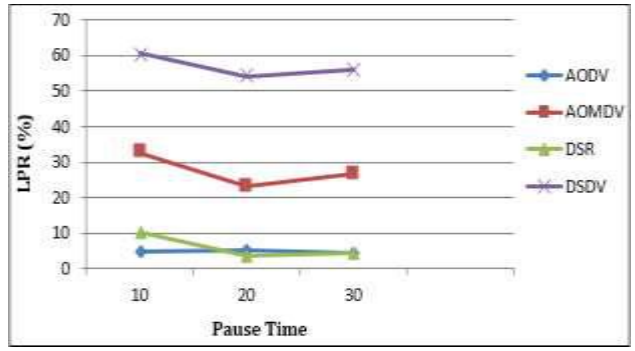

Fig.5: LPR of Speed time 10 using CBR

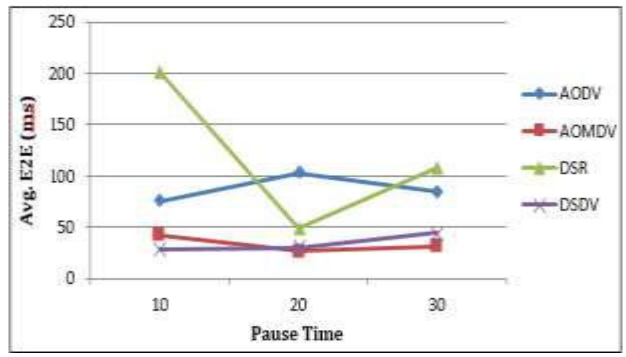

Fig.6: E2E delay of Speed time 10 using CBR

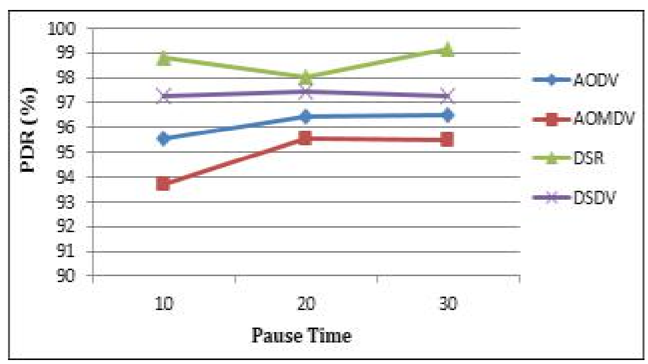

Fig.7: PDR of Speed time 20 using TCP

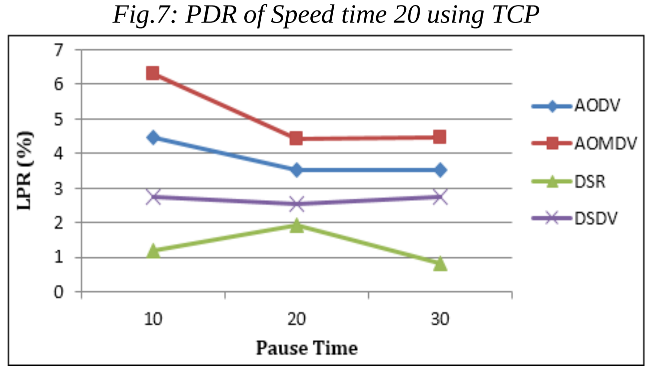

Fig.8: LPR of Speed time 20 using TCP

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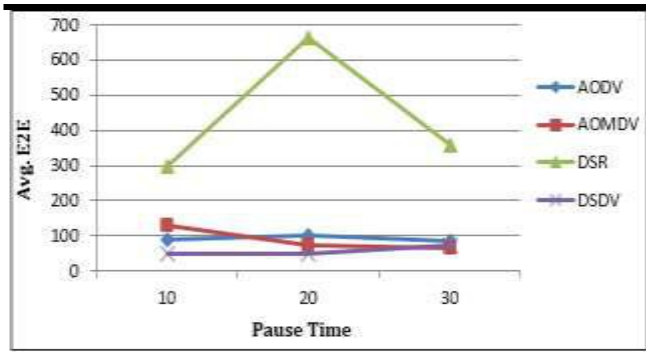

Fig.9: E2E delay of Speed time 20 using TCP

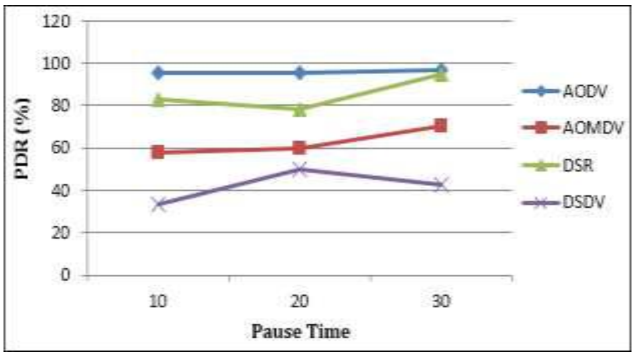

Fig.10: PDR of Speed time 20 using CBR

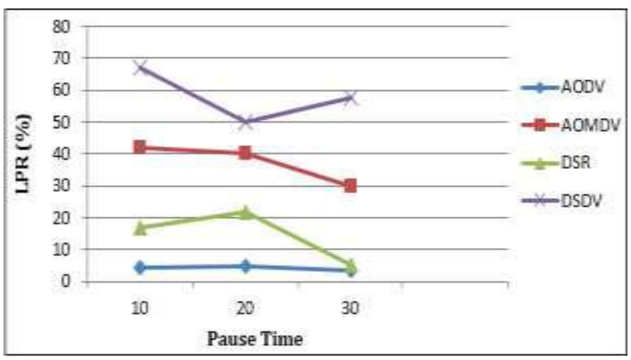

Fig.11: LPR of Speed time 20 using CBR

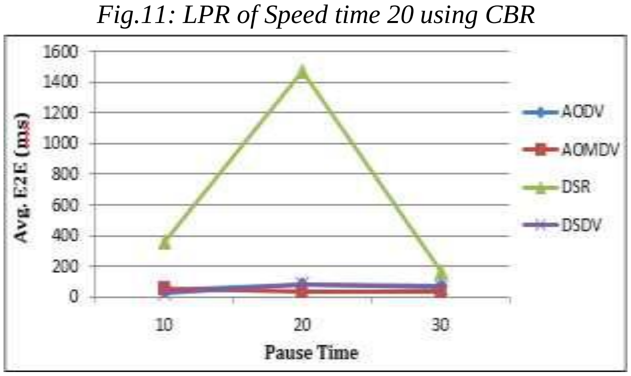

Fig.12: E2E delay of Speed time 20 using CBR

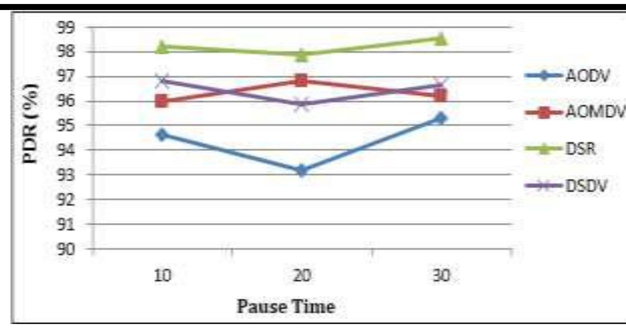

Fig.13: PDR of Speed time 30 using TCP

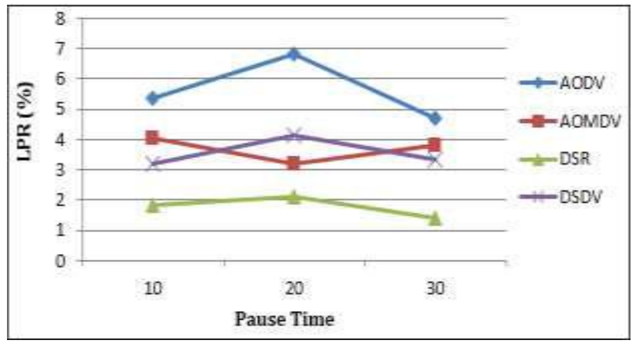

Fig.14: LPR of Speed time 30 using TCP

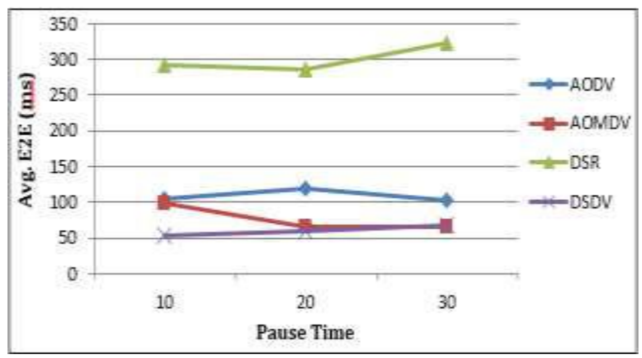

Fig.15: E2E delay of Speed time 30 using TCP

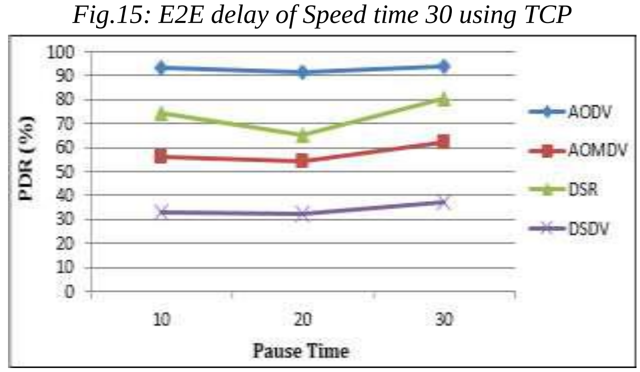

Fig.16: PDR of Speed time 30 using CBR

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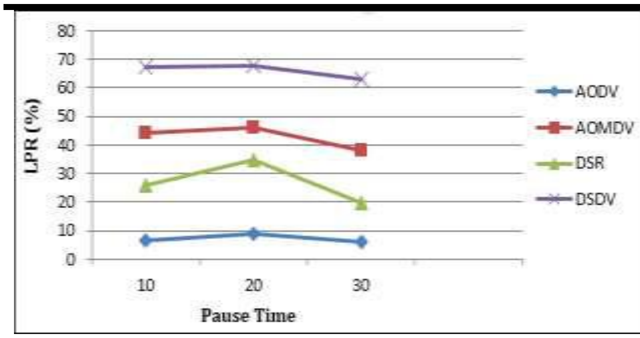

Fig.17: LPR of Speed time 30 using CBR

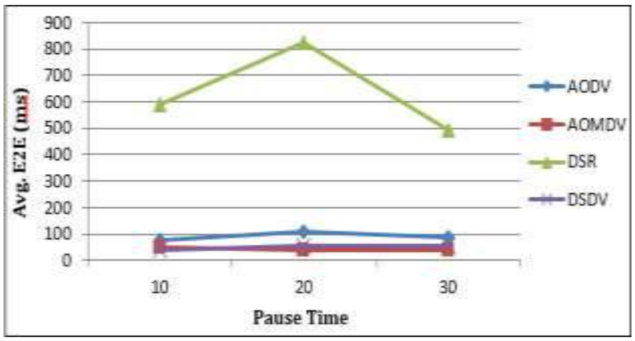

Fig.18: E2E delay of Speed time 30 using CBR

VII. PERFORMANCE ANALYSIS

The analysis performance of AODV, AOMDV, DSR and DSDV results have been shown in several tables. We consider 10 is the low speed, 20 is the average speed and 30 is the high speed. As the same time 10 is the low pause time 20 is the average pause time and 30 is the high pause time.

The standard for PDR values (approx.) defines below:
High: >95%
Average: =90% to 95%
Low: <90 %
The standard for E-to-E values (approx.) defines below:
High: >150ms
Average: = 50ms to 150ms
Low: <50ms
The standard for LPR values (approx.) define below:
High: > 4% , Average: = 2.5% to 4% , Low: < 2.5%

By using this approximate parameter we summarize the performances between AODV, AOMDV, DSR and DSDV. After performance analysis of AODV, AOMDV, DSR & DSDV by using Performance analysis table we shown our decision below.

Table.6: Packet Delivery Ratio (PDR) with respect to speed time & pause time for TCP & CBR connections

Packet Delivery Ratio (PDR)									
Speed Time	Pause Time	AODV		AOMDV		DSR		DSDV	
		TCP	CBR	TCP	CBR	TCP	CBR	TCP	CBR
10	10	High	High	Avg	Low	High	Low	High	Low
	20	High	Avg	Avg	Low	High	High	High	Low
	30	High	High	High	Low	High	High	High	Low
20	10	High	High	Avg	Low	High	Low	High	Low
	20	High	High	High	Low	High	Low	High	Low
	30	High	High	High	Low	High	Low	High	Low
30	10	Avg	Avg	High	Low	High	Low	High	Low
	20	Avg	Avg	High	Low	High	Low	High	Low
	30	High	Avg	High	Low	High	Low	High	Low

Table.7: Loss Packet Ratio Respect to Speed Time & Pause Time for TCP & CBR

Loss Packet Ratio (LPR)									
Speed Time	Pause Time	AODV		AOMDV		DSR		DSDV	
		TCP	CBR	TCP	CBR	TCP	CBR	TCP	CBR
10	10	High	High	High	High	Low	High	Avg	High
	20	Avg	High	High	High	Low	Avg	Avg	High
	30	Avg	High	High	High	Low	High	Avg	High
20	10	High	High	High	High	Low	High	Avg	High

	20	Avg	High	High	High	Low	High	Avg	High
	30	Avg	Avg	High	High	Low	High	Avg	High
30	10	High	High	High	High	Low	High	Avg	High
	20	High	High	Avg	High	Low	High	High	High
	30	High	High	Avg	High	Low	High	Avg	High

Table.8: Average End-To-End Delay (E2E) With Respect To Speed Time & Pause Time for TCP & CBR Connections

Average end-to-end Delay (E2E)									
Speed Time	**Pause Time**	**AODV**		**AOMDV**		**DSR**		**DSDV**	
		TCP	CBR	TCP	CBR	TCP	CBR	TCP	CBR
10	10	Avg	Avg	Avg	Low	High	High	Avg	Low
	20	Avg	Avg	Avg	Low	High	Low	Avg	Low
	30	Avg	Avg	Avg	Low	High	Avg	Avg	Low
20	10	Avg	Low	Avg	Avg	High	High	Low	Low
	20	Avg	Avg	Avg	Low	High	High	Avg	Avg
	30	Avg	Avg	Avg	Low	High	High	Avg	Avg
30	10	Avg	Avg	Avg	Low	High	High	Avg	Low
	20	Avg	Avg	Avg	Low	High	High	Avg	Avg
	30	Avg	Avg	Avg	Low	High	High	Avg	Avg

VIII. CONCLUSION

In this article, four protocols AODV, AOMDV, DSR and DSDV are compared based on connection type TCP and CBR according to PDR, LPR and average end-to-end delay. According to the all simulation and graphical results, which are simulated by using NS2 simulator, we observed packet delivery ratio of DSR is high at TCP platform on the other hand packet delivery ratio of AODV is high at CBR platform. Loss packet ratio of DSR is very low at TCP platform also CBR platform DSR and AODV are same. But average end-to-end delay is low of AOMDV for both TCP and CBR platform.In addition, we can say that DSR is the best solution at TCP platform and CBR platform AODV is better from others protocol.This resultwill help the designers and engineersfor implement in real life of wireless sensor network and also further research and development of these protocols.

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