The Comparative Study Some of Reactive and Proactive Routing Protocols in The Wireless Sensor Network

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Abstract

The wireless sensor network (WSN) consists mostly of a large number of nodes in a large area where not all nodes are directly connected. The applications of comprise a wide variety of scenarios.The mobile nodes are free to move because this network has self–structured topology. Routing protocols are responsible for detecting and maintaining paths in the network, and it classified into reactive (On–Demand), proactive (Table driven), and hybrid. In this paper represents a performance study of some WSN routing protocols: the Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector (AODV), and Destination-Sequenced Distance-Vector (DSDV). The comparison made according to important metrics like packet delivery ratio (PDR), total packets dropped, Average end-to-end delay (Avg EED), and normalized routing load under the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) traffic connection and with varying number of nodes, pause time; and varying speed. In this work used (NS–2.35) that installed on (Ubuntu 14.04) operating system to implementing the scenario. Conclude that the DSR has better performance in TCP connection; while the DSDV has better performance in UDP protocol.

Keywords: - WSN, AODV, DSR, DSDV, TCP, UDP.

الخلاصة

شبكة الاستشعار اللاسلكية تتكون من عدد كبير من العقد في مساحه واسعة حيث لا ترتبط جميع العقد مباشرة. وان تطبيقات الشبكه تشمل مجموعة واسعة من السيناريوهات. ان العقد المتنقلة في شبكات الاستشعار اللاسلكية تكون حره في التحرك، لأن هذا النوع من الشبكات تقوم ببناء هيكليتها بنفسها (self–structured). ان بروتوكولات التوجيه مسؤولة عن الكشف عن المسارات والحفاظ عليها في الشبكة، وتصنف إلى: تفاعلية (عند الطلب)، استباقية (حسب جدول)، وبروتوكولات التوجيه الهجينه. ان هذه الورقه البحثيه تمثل دراسة أداء لبعض بروتوكولات التوجيه: توجيه المصدر الحيوي (DSR)، المتجهات المخصصة عند الطلب عن بعد (AODV)، ومتجه المسافات المقطوعة الوجهة (DSDV). وأظهرت المقارنة التي أجريت وفقا لمقاييس هامة مثل نسبة تسليم الرزم، وإجمالي الحزم المفقوده، ومتوسط التأخر من طرف إلى طرف، والحمل على الشبكه وذلك يتم في إطار بروتوكول التحكم في الإرسال (TCP) وبروتوكول مخطط بيانات المستخدم (UDP) ومع تغيير عدد العقد المتحسسه، وتغيير الوقت بين كل ارسال وباستخدام سرع متفاوتة. تم استخدام برنامج المحاكاه (NS–2.35) وتم تثبيته على نظام التشغيل (Ubuntu 14.04) لتنفيذ السيناريو. استنتج أن DSR بروتوكول لديه أداء أفضل في اتصال TCP؛ في حين أن DSDV بروتوكول لديها أداء أفضل في بروتوكول UDP.

الكلمات المفتاحية :- شبكه الاستشعار اللاسلكيه، بروتوكول AODV، بروتوكولDSR ، بروتوكول DSDV، بروتوكول التحكم بالإرسال وبروتوكول مخطط بيانات المستخدم.

I. Introduction

WSNs are a specific class of networks; which is consisting of a group of tiny, relatively cheap, low power, and multifunctional units called sensor nodes. WSN is an active and important research area due to its wide range applications. WSN's has been used in areas such as environmental, industrial, social, security and military surveillance areas because it is comfortable and easy to use in the personal and professional life (Abu

Taleb *et.al.*, 2013). WSNs are able to communicate with each other through their having wireless channel. Simultaneously, every node is capable of working as a source or sink (Bijan *et.al.*, 2014). The sensor node consists of four basic units: the power unit; sensor unit; the processing unit and the transceiver unit. The sensor can connected to each other or directly to an external base station (BS). The sensor node component shown in Figure 1. That each sensor node includes power units, position finding system, processing, transmission, and sensing. In addition, the figure 1 presents the communication structure of the WSN; a sensor node are dispersed in sensor field. The nodes relate to sensing for the manufacture of better information about the physical environment. Every sensor node builds the resolution for its work; where it has information and knowledge of communications, computing and power resources. The sensor nodes have the ability to collect and distribute data to adjacent sensors or return to an external BS. The BS may be a mobile node or fixed node that can connect the WSN to the existing communications infrastructure or to the Internet, hence that the user has access to the data reported (Jamal *et.al.*, 2005**).**

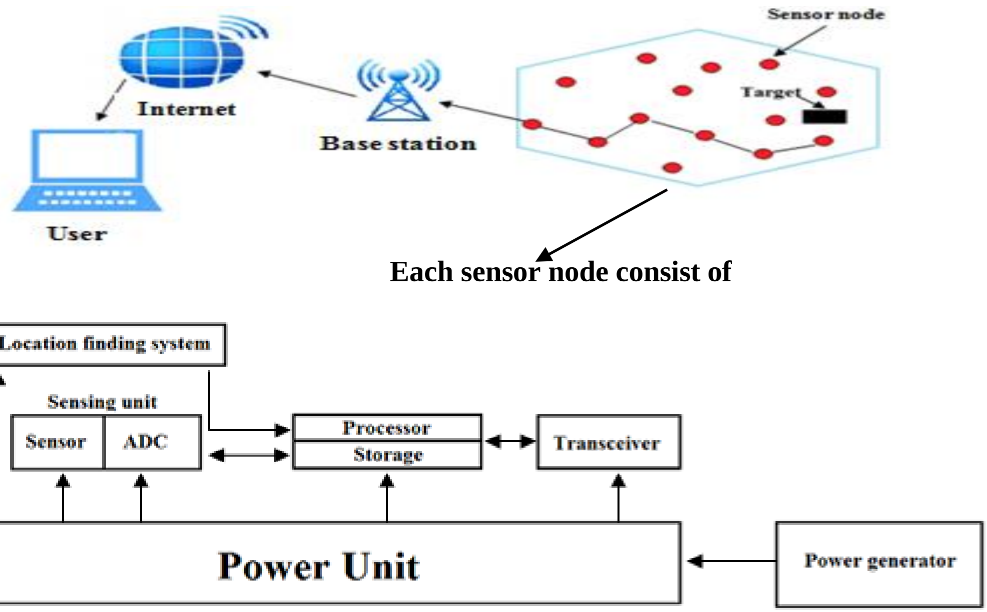


Figure 1 Components of sensor node (Jamal *et.al.*, 2005).

II. Literature review

This paper relates to the following works:

(Adel, 2012) presents the performance evaluation and comparison of AODV and DSDV protocols in WSN according to the PDR, throughput, and end to end delay in various environment using IEEE 802.11 Media Access Control (MAC) layer and Transmission Control Protocol (TCP) ,User Datagram Protocol (UDP) traffic pattern in every experiments. The overall observation shows the AODV routing protocol is better performance in terms of packet delivery fraction and throughput but suffers from delay.

(Paul *et.al.*, in 2014)the authors evaluates the performance of Ad hoc On-demand Multipath Distance Vector Routing (AOMDV), AODV, DSR and DSDV by using routing matrices such as average end to end delay (Average End to End) , PDR, loss packet ratio (LPR), and with varying pause time and number of node under TCP. They used (NS2-35) program for wireless sensor network. The obtain results that the DSR is the better protocol in compared with the others.

(Gaber *et.al.,* 2015) they presents a systematic performance study of AODV, DSR and OLSR routing protocols with mobile sensor nodes by comparing main matrices such as end-to-end delay, routing overhead, load, total packets dropped, route discovery time, and number of hops per route in the Network. The research is implemented and simulated using OPNET Modeler simulator. The simulation results shows that the AODV and DSR have similar behavior but with performance differentials resulted from the differences in protocol mechanics. In addition, AODV and DSR are suffering from high end-to-end delay in compared to the OLSR protocol.

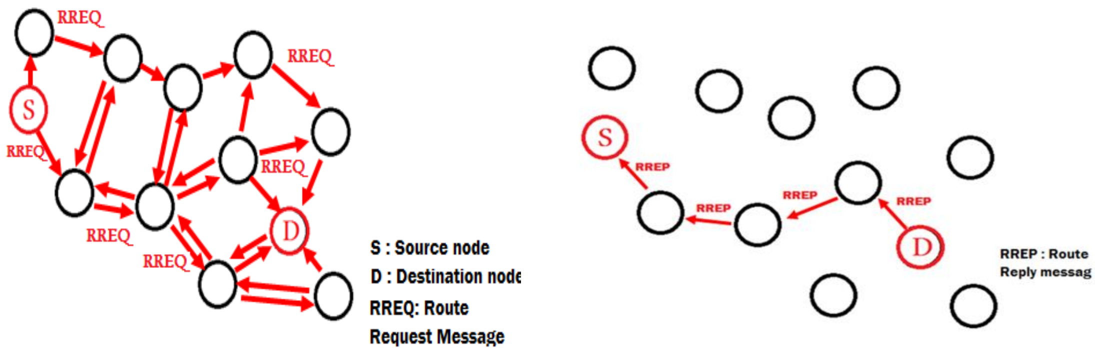
III. Routing protocols type in WSN

Routing is a process of generating paths from the source to the destination, with the ability to use medium nodes to reach the final destination (Gaber *et.al.,* 2015). An appropriate routing protocol is required to implement and manage various network control functions; traditional routing protocols are not suitable for WSN, This is because routing in the wireless network differs from traditional routing in fixed networks in different ways (Popa *et.al.,* 2007). The routing protocols could be categorized according the basis of the route process to: hybrid, reactive (on–demand) and proactive (table driven) (Gaber *et.al.,*2015).

1. AODV

The first example of reactive routing protocol is the Ad-hoc On-Demand Distance Vector is that use on–demand method to discover and create routes(Hussein, 2014), and the protocol is one of the most frequently used protocol assigned for MANET and WSN [Perkins *et.al.,* 2003). AODV is one of a most well-known protocol and has included a great deal of importance by the researchers and a scientific community. In the near future, the protocol will appear in the list of protocols to be standardized. AODV is the combination of DSR and DSDV protocols. AODV use the hop–by–hop routing and sequence numbers from DSDV protocol, and it works on–demand mechanism for path detection and path maintenance from DSR protocol (Goswami *et.al.,* 2012). AODV stores routes as long the source require them, and is considers one of the chief routing protocols that setup the shortest path (Gaber *et.al.,* 2015).

Figure 2 appear flow chart and the phases of AODV protocol respectively. When a source node requires to send a data packet to the destination and does not have any path in the routing table; so that the source nodes broadcasts a route request packet (RREQ) to the destination node to every adjacent node; in addition each RREQ-message contains a unique ID, which allows the nodes to ignore duplicate RREQ-messages Which have been traded with before. The reverse path is created or updated by the destination node When the RREQ flooding from the source node and arrives at the destination node, also it unicasts a route reply packet (RREP) message which made increased the sequence number to the opposite path. When the RREP-message arrives at the source node along with the reverse route it creates or updates the forward route and communications started. Each node for local connectivity broadcasts a Hello packet message periodically. It broadcasts the RREP-message with time to live (TTL=1) as the Hello packet. When the node does not receive any packets from one of the neighbors within a few seconds, it's assumed to break the link to the neighbors. If there is any link failure in the network, then the node propagates a Route Error (RRER) message(Khosrozadeh *et.al.,* 2011).



a. Route Discovery **b. Route Maintenance**

Figure 2 Routing Phases of the AODV protocol a. Route Discovery, b. Route Maintenance (Khosrozadeh *et.al.*, 2011).

2. DSR

Another example of reactive routing protocols is Dynamic Source Routing (DSR) is that works like AODV (Kumar *et.al.*, 2010). The protocol is based on the link state algorithm that means each node is able maintain the better way to the destination node. The source node defines the complete path of the destination node from one hop to other, also used the source routing method where the paths are stored in the path cache. If any change accrue in the network topology, the network will get information by flooding. If there is any link failure in the network, then the node propagates a RRER message (Johnson *et.al.*,1996).

3. DSDV

An example of proactive routing protocol is Destination-Sequenced Distance-Vector (DSDV) protocol. The routing table is maintains by each node, which contain a list of all possible destinations corresponding the number of hops to the network. Routing table data is exchange between adjacent nodes and routing data is up-dated with a new data by each node. If the package cannot find its destination, then the packages were stored temporarily. Then the data packets are unable to receive until the delivery report appears from the destination (Bijan *et.al.,* 2014).

IV. Simulation Tool

This work performed using Network Simulator (NS-2.35) under Linux (ubuntu14.04) operating system. NS-2.35 is an open source simulator program and the aim of a simulation is provide educational support for research in networks. NS2 is providing two languages: object-oriented variant of the tool command language (OTcl) and C ++ language. Figure 3 appears the NS2 simulator.

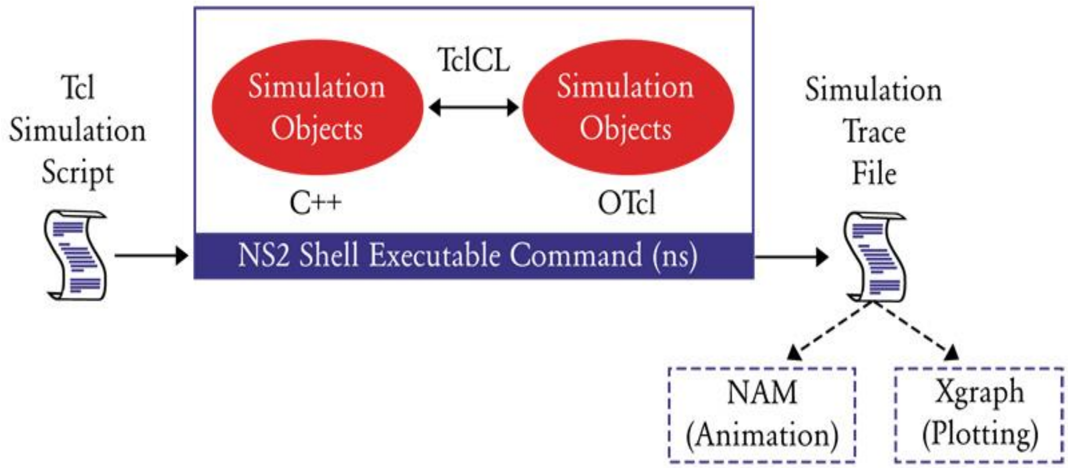


Figure 3 NS2 Simulator (Genita *et.al.*, 2015).

The layered architecture of NS2 is shown in figure 4. The event scheduler is implemented and almost all the components of the network are in C ++ language and can be accessed for the tool command language (Tcl), so the lowest level of NS2 is implemented by C++, the level of Tcl script is top notch to create simulation material much easier to perform. These all things combined as so-called NS-2 software. After created the trace file, we can use scripting languages like AWK (Aho-Weinberger-Kernighan) script to calculate performance metrics. AWK script is used to calculate the average PDR, throughput, normalized routing load and average EED delay from the source node to the destination node (Genita *et.al.*, 2015).

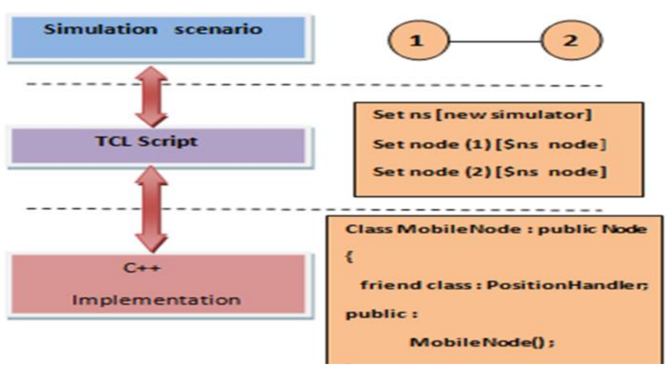


Figure 4 Layered structure of NS2 (Genita *et.al.*, 2015).

V. Research methods and proposed system

- **Performance Metrics & Network Parameters**

The metrics utilized to evaluate the performance of protocols in network according to identified parameters to show the behavior of the simulated scenarios. In this research, we use the performance metrics such as: Avg EED, normalized routing load, average throughput, drop packet and PDR.

a. **Drop packets**: The communication occur by sending packets between the source node and a destination node inside the network; therefore, through a communications, some packets are dropped in the receiver side and these packets called drop packet. A Drop packet can occur due to congestion, delays, and link failure. The following formula represented the dropped packet (Varshney *et.al.*, 2016):

$$Drop\ Packet = \frac{\sum_{p=1}^{n} S_p - \sum_{p=1}^{n} R_p}{\sum_{p=1}^{n} S_p} \quad \text{....... (1)}$$

Where:

S_p:- packets send, R_p:- packet receive.

b. **Average End-to-End Delay (Avg EED):** can be define as, the overall time that data packet are required to send from the source node to the destination node. Following equation represented the EED (Salih , 2017):

$$Average\ EED = \frac{\sum Packet\ Delay}{total\ no.of\ recived\ packet} \quad \text{...... (2)}$$

Where:

Packet Delay = $T_r(d) - T_t(s)$

$T_r(d)$: The received time in the destination-node.

T_t (s): The transmission time in the source-node.

c. **Throughput:** A term of the number of packets received during the simulation time. Throughput can be represented by the following formula (Varshney *et.al.*, 2016):

$$Throughput = \frac{\sum_{p=1}^{n} R_p}{Total\ time} \quad \text{.......... (3)}$$

The throughput are evaluated after run the simulation (10) times and a results are obtained as the average.

d. **Packet Delivery Ratio (PDR):** Is the ratio of a successful receipt of the packets. The successful number of R_p at the destination node to the number of S_p from source node, following equation represented PDR (Varshney *et.al.*,2016):

$$PDR = \frac{R_p}{S_p} \times 100\ \% \quad \text{........ (4)}$$

e. **Normalized Routing Load:** is a number of routing packets for every packet of data delivered by destination (Nikam *et.al.*,2016).

$$Normalized\ Routing\ Load = \frac{Total\ number\ of\ Routing\ packet}{Total\ number\ of\ recived\ packets} \quad \text{........ (5)}$$

In the implementation used random mobile nodes for our simulation purpose. To measure the performance, we used Network Simulator (NS-2.35).The same scenario for each protocol DSR, AODV and DSDV was used. Table (1) shows the simulation parameter.

Table 1 Simulation Parameters.

Parameters	Values
Simulation area	1200 m *1200 m
Simulation time	200 Sec
Number of nodes	50,100,150
Routing protocol	AODV, DSR, DSDV
Node speed	10,20,30,40,50 m/sec
Pause Time	10,20,30,40,50 sec
Buffer size of the node	1000 Packets
Packet length	512 Bytes
Channel Bandwidth	20 Mb/s
Bit rate	2 Mb/s
Radio Propagation Model	Two-Ray-Ground model
Channel Type	Wireless Channel
Traffic Type	TCP, UDP
Antenna model	Omni directional antenna
MAC layer	IEEE 802.11
Interface queue type	Queue/Drop Tail

A different scenario is implemented to study the behavior of proactive and reactive routing protocol like DSR, DSDV, and AODV and then made comparison according to routing metrics. A first scenario has 50 nodes, the second scenario has 100 nodes and the last scenario has 150 nodes; all of these are implemented under the TCP and UDP traffic connection with pause time and varying speed. Figure 5 presents the NAM for 100 nodes.

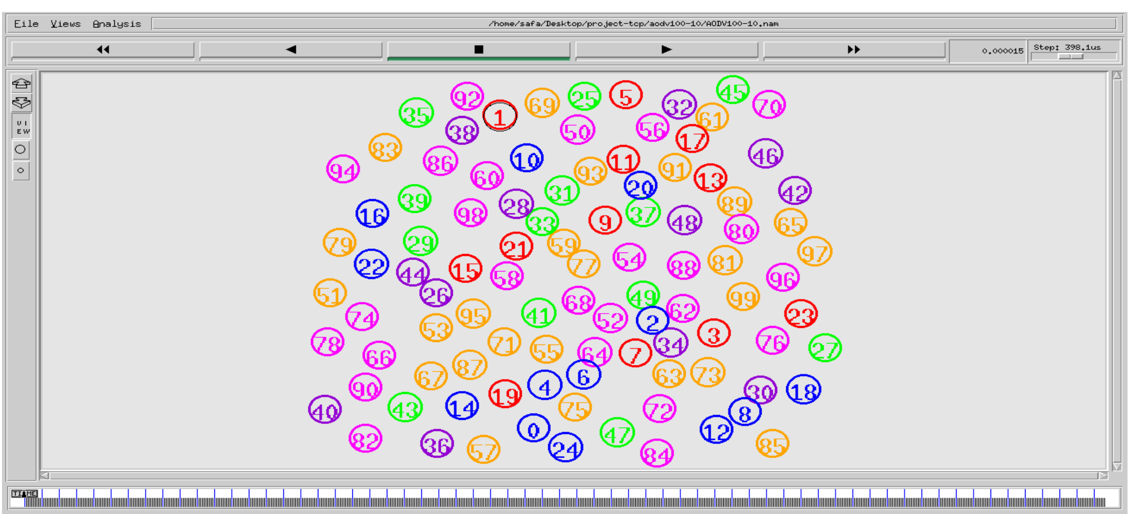
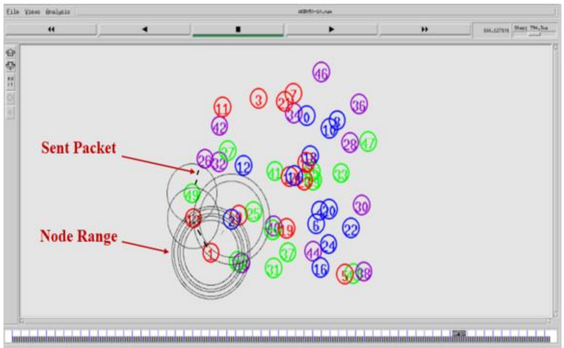
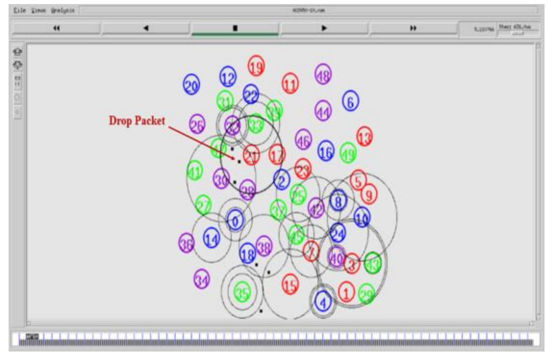


Figure 5 NAM window for 100 nodes.

Figure 6 shows the node range, the shape of the packet sent and present the shape of droped packets.



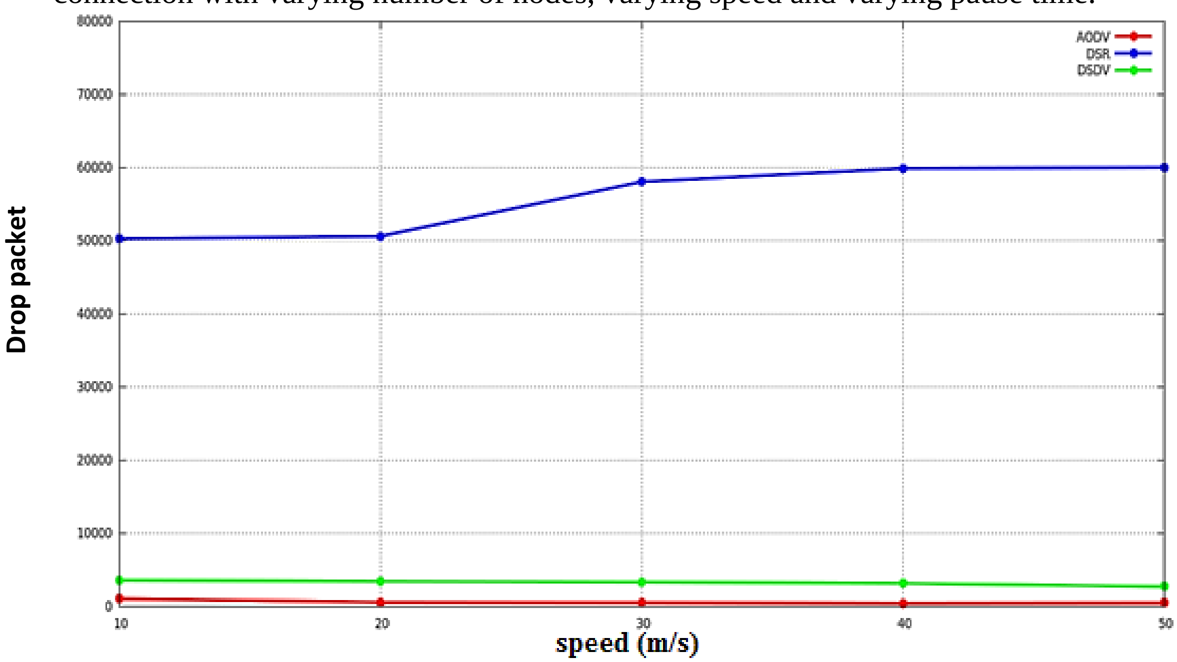
a. NAM window present drop packets.



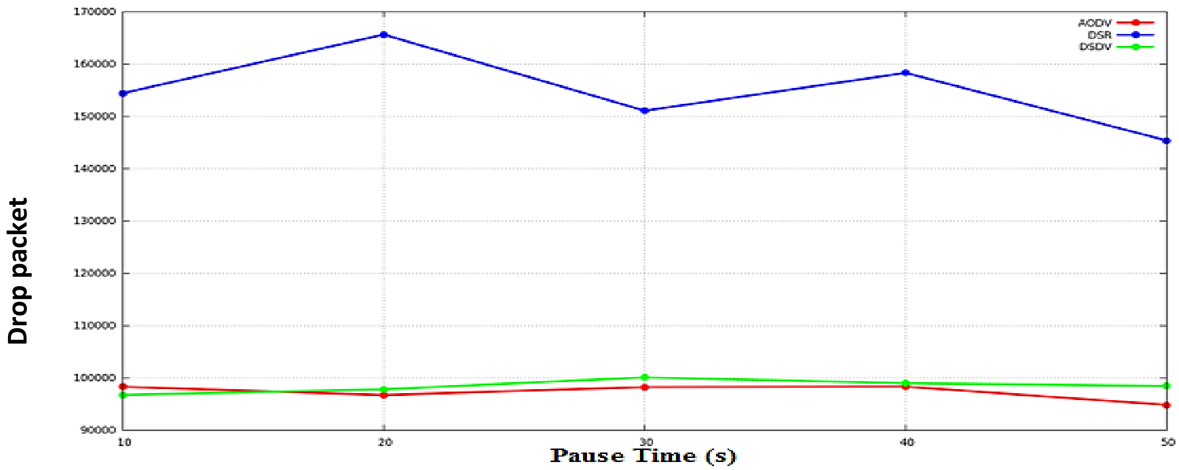
b. NAM window for node rang and sent packets.

Figure 6 NAM window a. NAM of sent packet and node range for simulation, b. shape of Drop packets of the nodes

The Gnuplot graph is used to graph the results of the work. Figure 7 shows the Gnuplot graph of packet drop performance of protocols under TCP and UDP traffic connection with varying number of nodes, varying speed and varying pause time.



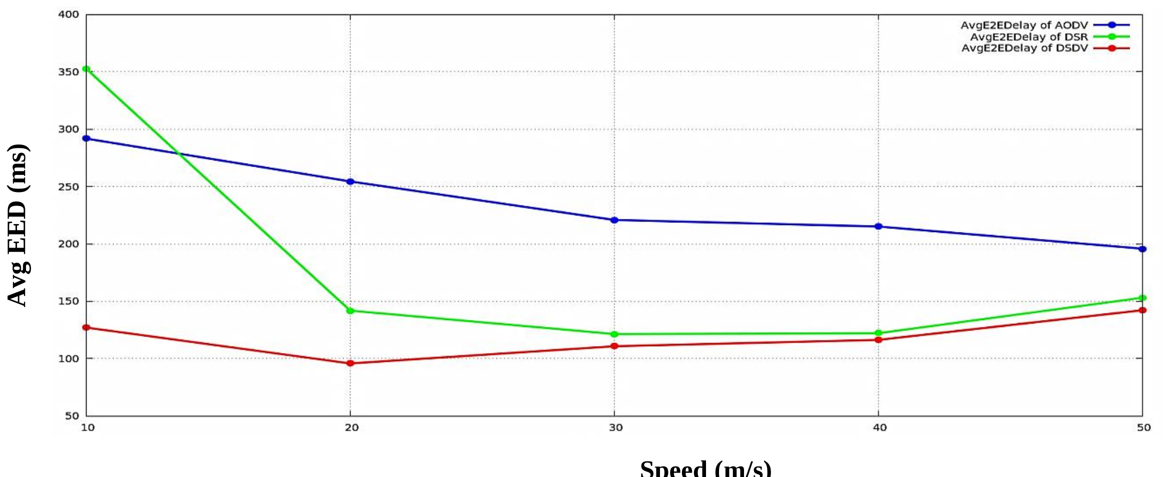
a. Drop packets vs. speed of protocols with 50 nodes and TCP traffic connection.



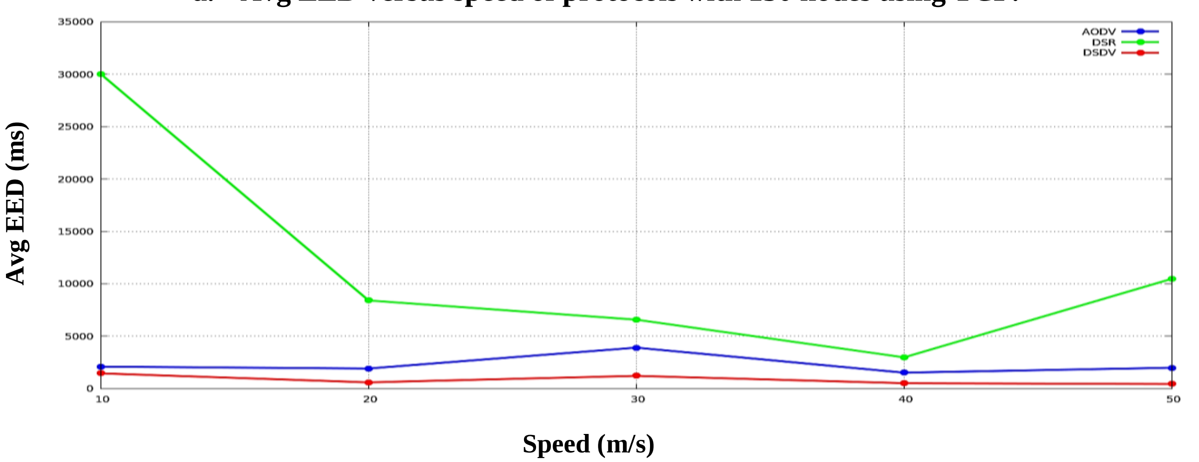
b. Drop packets vs. pause time of protocols with 150 nodes using UDP traffic connection.

Figure 7 drop packets performance for AODV, DSR and DSDV protocols.

Figure 8 appears the graph of a performance of the Avg EED of three protocols under the same environments.



a. Avg EED versus speed of protocols with 150 nodes using TCP.



b. Avg EED versus pause time of protocols with 150 nodes using UDP.

Figure 8 Normalized Routing Load performance for protocols.

VI. Results

Table 2, Table 3 and Table 4 presents simulation results for AODV, DSDV and DSR routing protocols with TCP and varying speed respectively.

Table 2 Simulation Results of AOdV with TCP Traffic Connection.

Node	Speed (m/s)	Packet Sent (packet)	Packet Receive (packet)	Drop packet (packet)	PDR (%)	Average Throughput (Kbps)	Normalized routing load	Average EED (ms)
50	10	16855	15830	1025	93.91	337.52	1.158	216.188
	20	47353	46772	581	98.77	961.36	0.19	124.545
	30	43907	42381	1526	96.52	890.3	0.187	150.685
	40	36355	35924	431	98.81	823.8	2.081	214.819
	50	52990	52508	482	99.09	1083.93	2.452	210.314
100	10	27377	26239	1138	95.84	551.75	0.335	150.703
	20	28256	27566	1690	97.55	571.38	0.11	254.981
	30	22644	21343	1301	94.26	450.04	8.475	184.444
	40	26585	25409	1176	95.58	459.95	9.118	179.688
	50	23322	22661	661	97.17	472.04	11.819	201.642
150	10	33842	33172	670	98.02	685.64	0.302	291.777
	20	45593	44802	791	98.27	927.18	0.831	254.417
	30	34173	33563	610	98.21	694.41	2.015	220.875
	40	27270	26683	587	97.85	548.61	2.056	200.125
	50	26408	24724	1684	93.62	529.34	1.802	135.812

Table 3 Simulation Results of DSR with TCP traffic connection.

Node	Speed (m/s)	Packet Sent (packet)	Packet Receive (packet)	Drop packet (packet)	PDR (%)	Average Throughput (Kbps)	Normalized routing load	Average EED (ms)
50	10	27882	27606	2766	99.01	470.11	0.000	164.066
	20	69495	18908	50587	27.21	297.32	0.001	134.82
	30	74438	16397	58041	22.03	337.95	0.002	123.15
	40	76208	16326	59882	21.42	336.69	0.007	143.963
	50	75609	15593	60016	20.26	109.22	0.005	139.926
100	10	96757	10573	86184	10.93	218.69	0.025	291.234
	20	88464	11188	77276	12.65	231.90	2.319	184.359
	30	108050	12056	95994	11.16	249.68	0.000	123.44
	40	70307	11815	58492	16.81	446.00	5.387	282.368
	50	69930	10661	59269	15.25	346.97	0.077	139.272
150	10	42342	8026	4316	18.96	167.62	0.025	352.651
	20	6227	1583	4644	25.42	132.75	0.003	141.806
	30	5300	2149	3151	40.55	352.75	0.002	121.427
	40	8868	2928	5940	33.02	60.75	0.073	122.116
	50	6029	1673	4356	27.75	34.95	0.040	153.066

Table 4 Simulation Results of DSDV with TCP traffic connection.

Node	Speed (m/s)	Packet Sent (packet)	Packet Receive (packet)	Drop packet (packet)	PDR (%)	Average Throughput (Kbps)	Normalized routing load	Average EED (ms)
50	10	40630	37077	3553	91.26	765.52	0.171	133.794
	20	39384	36002	3382	91.41	744.55	0.178	141.966
	30	40518	37217	3301	91.85	887.33	0.172	119.47
	40	52929	49822	3107	94.13	828.55	0.196	141.271
	50	40174	37509	2665	93.37	775.18	0.168	152.475
100	10	29959	22138	7821	73.89	456.67	0.453	166.878
	20	37344	28306	9038	75.79	584.91	0.926	92.1499
	30	31397	23472	7925	74.76	515.85	0.808	217.103
	40	28216	20422	7794	72.38	527.24	0.558	162.459
	50	34623	26833	7790	77.5	553.34	0.844	148.744
150	10	20864	5514	15350	26.43	124.37	2.659	127.068
	20	22675	7635	15040	33.67	212.73	2.324	95.7603
	30	37399	22844	14555	61.08	336.43	4.890	121.754
	40	21862	7588	14274	34.71	175.34	2.783	106.327
	50	28640	16623	12017	58.04	683.78	1.932	152.157

Table 5, Table 6 and Table 7 presents simulation results for AODV, DSDV, and DSR protocols with different pause time and speed (10 m/s) and with UDP traffic connection.

Table 5 Simulation Results of AODV with UDP traffic connection.

Node	Speed (m/s)	Packet Sent (packet)	Packet Receive (packet)	Drop packet (packet)	PDR (%)	Average Throughput (Kbps)	Normalized routing load	Average EED (ms)
50	10	100000	3772	96228	3.77	674.57	0.362	1043.77
	20	100000	2892	97108	2.89	675.51	0.582	1669.81
	30	100000	4167	95833	4.17	675.21	0.631	941.919
	40	100000	3149	96851	3.15	335.55	0.983	1607.37
	50	100000	4804	95196	4.80	306.80	0.376	1269.9
100	10	100000	1672	98328	0.96	299.94	5.980	2436.35
	20	100000	3498	96502	3.49	324.7.2	3.340	1990.71
	30	100000	1531	98469	1.53	217.39	8.202	3545.15
	40	100000	3270	96730	3.27	224.80	3.879	717.234
	50	100000	2140	97860	2.14	224.61	6.991	1908.33
	10	100000	1691	98309	1.69	306.46	8.919	2095.34
	20	100000	3283	96717	3.28	335.01	3.676	1921.5
	30	100000	1754	98246	1.05	306.17	9.261	3908.64
	40	100000	1676	98324	1.68	353.52	14.022	1521.1
	50	100000	5167	94833	5.17	334.89	1.982	1995.83

Table 6 Simulation Results of DSR with UDP traffic connection.

Node	Speed (m/s)	Packet Sent (packet)	Packet Receive (packet)	Drop packet (packet)	PDR (%)	Average Throughput (Kbps)	Normalized routing load	Average EED (ms)
50	10	78499	1844	76655	2.35	207.65	8.137	513.93
	20	46528	1837	44691	3.95	332.41	3.077	679.409
	30	144900	1785	43115	1.23	332.78	4.613	1297.28
	40	68690	1869	40821	2.72	314.27	4.112	930.884
	50	39461	1912	37549	4.85	32.57	5.991	635.748
100	10	198978	1460	197518	0.73	209.26	12.446	13215.1
	20	67051	2142	164909	3.195	221.66	3.684	4064.35
	30	134223	1689	132534	1.26	256.69	7.742	5465.12
	40	164519	1201	163318	0.73	675.08	13.601	1960.64
	50	110882	1536	109346	1.39	674.33	16.240	815.97
150	10	155797	1365	154432	0.88	675.56	784.818	30020.02
	20	185735	114	165621	0.06	675.24	286.4096	8413.05
	30	153316	2242	151074	1.46	675.25	100.674	6578.9
	40	160392	2091	158301	1.30	674.70	142.713	2982.84
	50	146388	1012	145376	0.69	675.34	303.436	10481.3

Table 7 Simulation Results of DSDV with UDP traffic connection.

Node	Speed (m/s)	Packet Sent (packet)	Packet Receive (packet)	Drop packet (packet)	PDR (%)	Average Throughput (Kbps)	Normalized routing load	Average EED (ms)
50	10	53709	340	3243	0.63	642.94	0.751	644.223
	20	53740	7145	46595	13.29	644.39	0.371	310.905
	30	53489	1076	52413	2.01	644.03	2.227	473.656
	40	54155	3781	50374	6.98	643.76	0.810	270.563
	50	54061	264	53797	0.48	630.84	2.163	221.458
100	10	100495	966	99529	0.96	636.45	5.181	1440.35
	20	100500	3447	97053	3.43	639.83	2.054	598.818
	30	100493	755	99738	0.75	636.40	9.571	1116.12
	40	100494	3943	96551	3.92	639.52	1.813	500.775
	50	100484	3230	97254	3.21	638.34	2.164	312.999
150	10	100752	4001	96751	3.97	675.56	4.233	1457.93
	20	100771	2958	97813	2.94	675.24	4.6614	600.512
	30	100760	686	100074	0.68	675.25	9.940	1216.87
	40	100741	1782	98959	1.77	674.70	7.034	517.443
	50	100746	2305	98441	3.29	675.34	5.564	441.03

VII. Conclusion

The main concluding observations are the DSR has better performance in TCP traffic connection, while the DSDV has better performance in UDP protocol.

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