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Performance of Routing Protocols for Mobile Adhoc and Wireless Sensor Networks: A Comparative Study

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***Abstract*- Mobile Ad hoc Networks (MANETs) as well as Wireless Sensor Networks (WSNs) suffer from various challenges like low bandwidth, overhead and velocity of nodes. This research contribution is the characterization study between MANETs and WSNs environment with respect to various routing protocols. This study investigates the routing protocols corresponding to packet delivery ratio, routing overhead, throughput and average to end-to-end delay. For MANETs, three protocols AODV, DSDV and TORA are selected and a performance study is done. The AODV perform better in MANETs and given better output, but performance of TORA is very poor and not reliable for MANETs. For WSNs, four protocols AODV, DSDV, TORA and LEACH are selected and evaluated. The AODV and LEACH both perform better but AODV is less reliable than LEACH because the result of AODV is fluctuated but LEACH shows stability. It is concluded that AODV shows better performance in both environments compared to DSDV and TORA. But average end-to-end delay is much higher in WSNs compared to MANETs.**

Index Terms- Mobile Ad hoc Networks (MANETs), Wireless Sensor Networks (WSNs), Routing Protocols, Simulation, Packet Delivery Ratio (PDR).

I. Introduction

Mobile Ad hoc Networks (MANETs) as well as Wireless Sensor Networks (WSNs) are the next generation wireless networks having some similarities and dissimilarities. They suffer from various factors like low bandwidth, high error rate, more frequent link breakage, end-to-end delay, and high loss of pocket etc.

The objective of this work is to focus on the core issues of routing mechanisms like average end-to-end delay, routing overhead, throughput, packet delivery ratio specifically for MANETs and WSNs. There are number of routing protocols available for both, MANETs and WSNs. It is aimed to evaluate the performance of one prominent on-demand reactive protocol AODV (Ad hoc On-demand Distance Vector), along with the one proactive protocol DSDV (Destination Sequence Distance Vector) and one adaptive routing protocol TORA (Temporarily Ordered Routing Algorithm) with the effect of similarities and dissimilarities of the performance of routing protocols of MANETs and WSNs. Our research efforts are focused on simulation experiments to explore several parameters such as traffic patterns, node density and initial pattern of nodes that may affect the routing performance.

This investigation study is done by using widely recognized and improved network simulator NS-2 version 2.29.3 for MANETs and the Mannasim incorporated with Network Simulator NS-2 version 2.29.3 for WSNs, with appropriate modification on NS-2 files and TCL scripts for fair performance evaluation and implementations of different routing protocols.

II. Problem Formation

A detailed investigation on MANETs and WSNs features has been carried out to identify the key aspects and gray areas of need for a research. Effort started with the study of background information of Wireless, Mobile Ad hoc and Wireless Sensor Networks. The MANETs and WSNs both are the wireless networks with some similarity like low bandwidth, high error rate, more frequent link breakage, end-to-end delay, loss of pockets, etc. with dissimilarity like node identification mechanisms, resources, communication paradigm, network implementation objectives, protocol design issues, etc.

TABLE 1. Comparing MANETS and WSNS

Parameter	Mobile Ad hoc Networks (MANETs)	Wireless Sensor Networks (WSNs)
No. of Nodes	Small to moderate	Large (>100)
Batteries	Replaceable and/or Rechargeable	Often irreplaceable
Redundancy	Low	High
Data Rate	High	Low

Both networks share some common routing protocols. A study with respect to concepts, characteristics current status application areas, and various routing algorithms and protocols has been carried out. With this study it is found that routing in MANETs and WSNs is very challenging and different due to the inherent characteristics that distinguish these networks from other wireless networks like cellular and mesh networks.

III. Experimental Results For MANETs

3.1 Simulation Environment

The evaluation of performance of MANETs routing protocols AODV, DSDV, and TORA are based on following metrics.

Simulation environment is as follows:

Parameter	Value
Simulation Time	100 Seconds
Pause Time	5 Seconds
Terrain Area	500m x 400m
Traffic Type	cbr
Maximum speed	8 m/s
No of Node	25, 50, 75, 100

3.2 Analysis and Results Comparison

In this section we evaluate the performance of AODV, DSDV and TORA protocols on the following parameters:

3.2.1 Packet Delivery Ratio /Packet Delivery Fraction (PDR/PDF)

The ratio between the number of packets that are received and the number of packets sent.

TABLE 2. PACKET DELIVERY RATIO FOR MANETS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA
25	99.78	78.77	82.91
50	99.73	83.53	99.89
75	99.67	91.47	84.57
100	99.08	77.75	98.24

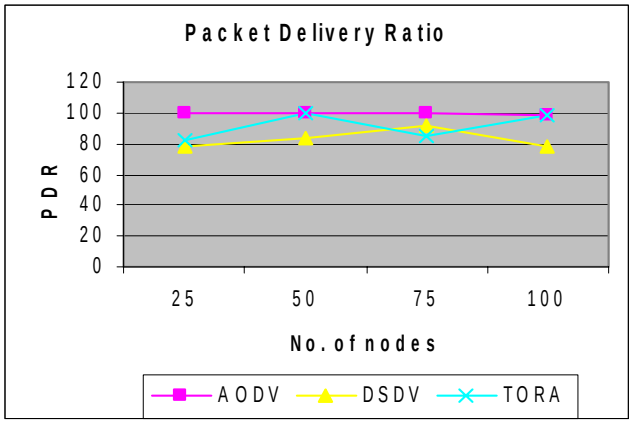

Figure 1. Comparison of the three protocols of MANETs with respect to PDF

Result:

- In AODV, the PDR decreases smoothly with less difference as well as number of nodes increases. As well as AODV gives better PDR as compare to DSDV and TORA.
- In DSDV, the PDR increases at network size 25, 50 and 75 but decreases at network size 100, so that carrying some fluctuation.
- In TORA, the PDR are fluctuated and gives a zigzag curve, because at network size 25 to 50 there is increase but at network size 50 to 75 there is decrease and for network size 75 to 100 there is again increase so we can't clearly say that PDR increases or decreases with respect to network size.

3.2.2 Routing Overhead (ROH)

The routing overhead measures by the total number of control packets sent divided by the number of data packets delivered successfully.

TABLE 3. ROUTING OVERHEAD FOR MANET ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA
25	1.002	1.27	1.21
50	1.002	1.2	1
75	1.003	1.09	1.18
100	1.009	1	1.02

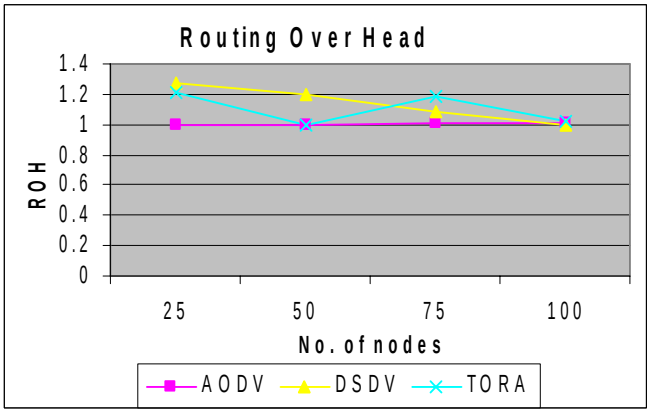

Figure 2. Comparison of the three protocols of MANETs with respect to Routing Overhead

Result:

- In AODV, the ROH increases with very small differences as number of nodes increases.
- In DSDV, the ROH smoothly decreases as number of nodes increases.
- In TORA, gives a zigzag curve for ROH, because at network size 25 to 50 there is decrease but at network size 50 to 75 there is increase and for network size 75 to 100 there is again decrease so we can't clearly say that ROH increases or decreases with respect to network size.

3.2.3 Throughput

Throughput is the total of all bits (or packets) successfully delivered to individual destinations over total-time / total-time (or over bits-total / total time) and result is found as per KB/Sec.

TABLE 4. THROUGHPUT FOR MANETS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA
25	76.3	59.55	42.75
50	76.65	64.02	50.91
75	75.38	69.48	36.87
100	77.38	58.33	42.23

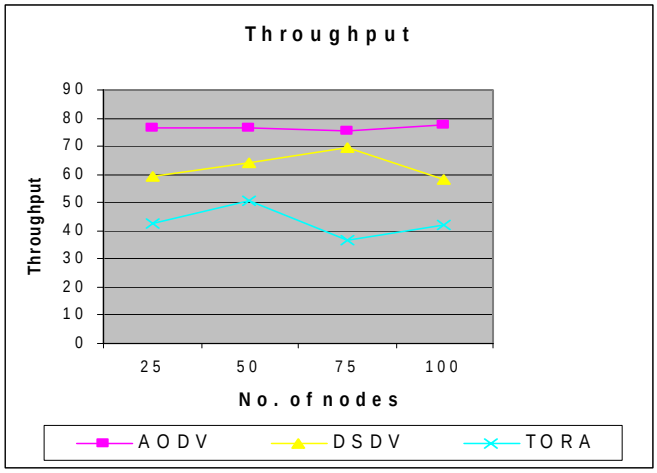

Figure 3. Comparison of the three protocols of MANETs with respect to Throughput

Result:

- In AODV, the throughput increases with respect to number of nodes increases at all point except to 75. AODV's throughput is less fluctuated and better as compare to DSDV and TORA.
- In DSDV, the throughput increases with respect to number of nodes increases at all point except to 100.
- TORA gives once again a zigzag curve for throughput like PDR.

3.2.4 Average End-to-End Delay

This delay includes processing and queuing delay in each intermediate node i.e. the time elapsed until a demanded route is available. Unsuccessful route establishments are ignored.

TABLE 5. AVERAGE END-TO-END DELAY FOR MANETS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA
25	14.09	10.99	11.49
50	15.01	8.72	8.17
75	15.92	7.67	16.43
100	15.46	53.73	15.87

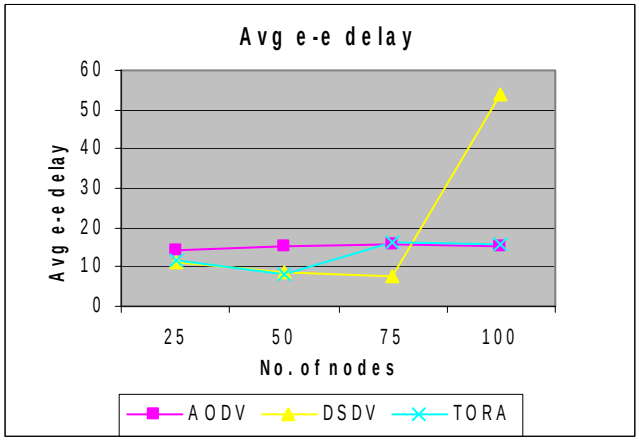

Figure 4. Comparison of the three protocols of MANETs with respect to Average End-to-End Delay

Result:

- In AODV, the average end-to-end delay increases with less difference smoothly with respect to number of nodes increase and perform better as compare to DSDV and TORA.
- In DSDV, the average end-to-end delay decreases when the number of node increases, it is less as compare to AODV but not at all network size. That is much high than other at network size 100.
- Once again TORA gives a fluctuated result.

3.3 Discussion on Results

In this part we have analyze and present well rounded review for some popular routing protocols of MANETs (AODV, DSDV and TORA). According to results of practical works, we can clearly said that the routing protocols AODV gives less fluctuation results and better performance as compare with DSDV and TORA, with respect to some identified parameters of routing protocol such as PDR/PDF, Routing Over Head, Throughput and Average end-to-end delay. So it is clear that under these characteristics AODV giving best output as compared to the others and TORA perform poor and having no reliability as compared to DSDV and AODV for MANETs.

IV. EXPERIMENTAL RESULTS FOR WSNS

4.1 Simulation Environment

The evaluation of performance of WSNs routing protocols AODV, DSDV, TORA are based on following metrics

Simulation environment is as follows:

Parameter	**Value**
Simulation Time	100 Seconds
Terrain Area	500m x 400m
Time Intervals	20 Seconds
Traffic Type	udp
No of Node	25, 50, 75, 100

4.2 Analysis and Results Comparison

In this section we evaluate the performance of AODV, DSDV, TORA and LEACH protocols on the following parameters for WSNs:

4.2.1 Packet Delivery Ratio (PDR)

The ratio between the number of packets that are received and the number of packets sent.

TABLE 6. PACKET DELIVERY RATIO FOR WSNS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA	LEACH
25	75.85	62.37	10	71.41
50	81.89	67.36	15.26	71.51
75	75.24	76.16	59.49	72.67
100	75.84	65.14	58.43	75.92

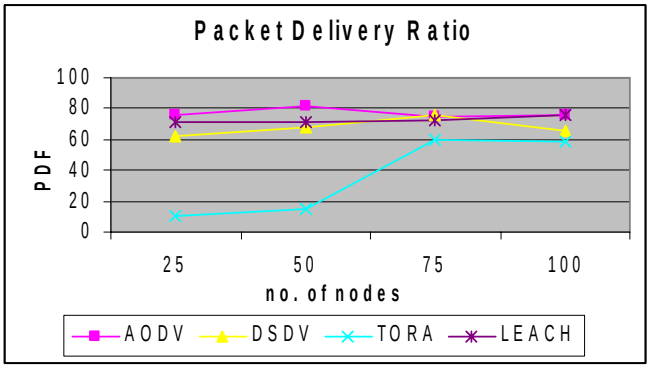

Figure 5. Comparison of the four protocols of WSNs with respect to PDF.

Result:

- In WSNs, it is not possible to say clearly that the PDR in AODV are decreases or increases with respect to number of nodes, because at network size 25 to 50 there is increase but at network size 50 to 75 there is decrease and for network size 75 to 100 again increase, but PDR are higher than DSDV and TORA and LEACH, but LEACH shows stability as compared to others.
- In DSDV, the PDR increases smoothly as number of nodes increases except network size 100.
- In TORA, the PDR increases smoothly with large difference as well as number of nodes increases except network size 100, also when the number of node becomes less than 50 the PDRs are less than 20 percents.
- In LEACH, the PDR increases as number of nodes become larger.

4.2.2 Routing Overhead (ROH)

The routing overhead measures by the total number of control packets sent divided by the number of data packets delivered successfully.

TABLE 7. ROUTING OVERHEAD FOR WSNS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA	LEACH
25	1.32	1.61	9.9	1.4
50	1.22	1.48	6.55	1.39
75	1.33	1.31	1.68	1.376
100	1.32	1.53	1.7	1.32

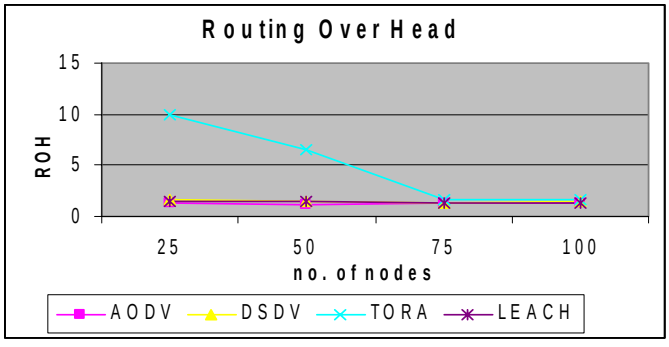

Figure 6. Comparison of the four protocols of WSNs with respect to Routing Overhead

Result:

- In AODV, the result of ROH is much close with '1' compares to all other routing protocols. But fluctuate, at some point that is, it increases at some points and decreases at other points like PDR.
- In DSDV, the ROH decreases as number of nodes increases except network size 100 as like PDR.
- In TORA, the ROH is high in comparison to others.
- In LEACH, the ROH decreases smoothly when the number of nodes increases.

4.2.3 Throughput

Throughput is the total of all bits (or packets) successfully delivered to individual destinations over total-time / total-time (or over bits-total / total time) and result is found as per KB/Sec.

TABLE 8. THROUGHPUT FOR WSNS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA	LEACH
25	2.2	2.14	0.35	2.19
50	2.84	2.69	1.03	2.85
75	5.78	5.83	35.16	5.36
100	5.36	5.11	73.15	7.17

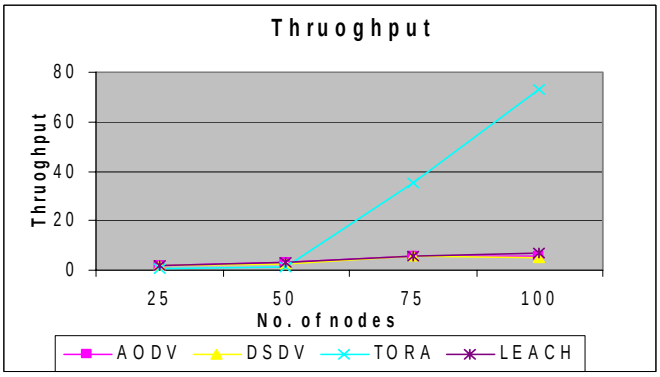

Figure 7. Comparison of the four protocols of WSNs with respect to Throughput

Result:

- In AODV, the throughput increases with respect to number of nodes increases except network size 100, but very slowly because delay is very high.
- In DSDV, the throughput increases with respect to number of nodes increases except network size 100, similar to AODV.
- In TORA, the throughput is very low at network size 25 and 50, but increases rapidly after network size 50.
- In LEACH, the throughput is very low but increases with increase in network size.

4.2.4 Average End-to-End Delay

This delay includes processing and queuing delay in each intermediate node i.e. the time elapsed until a demanded route is available. Unsuccessful route establishments are ignored.

TABLE 9. AVERAGE END-TO-END DELAY FOR WSNS ROUTING PROTOCOLS

NO. OF NODE	AODV	DSDV	TORA	LEACH
25	3634.95	10220.6	2.14	3509.5
50	3964.67	5004.98	4.1	6288.29
75	5709.74	7606.03	11232.4	8409
100	9158.19	7703.19	12153.1	8356.16

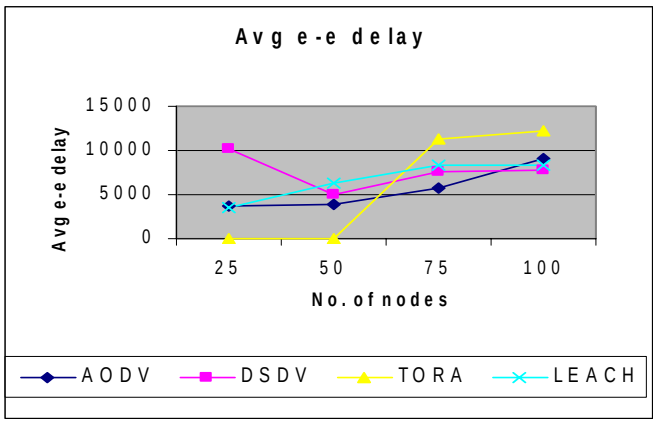

Figure 8. Comparison of the four protocols of WSNs with respect to Average End-to-End Delay

Result:

- In AODV, the average end-to-end delay become very high and increases when the number of nodes increases.
- In DSDV, the average end-to-end delay become very high and increases when the number of node increases except at network size 25.
- In TORA, the average end-to-end delay increases with respect to number of nodes, but the difference becomes large at some network size and small for other.
- In LEACH, the average end-to-end delay become very high and increases when the number of node increases, but better as compare to others.

4.3 Discussion on Results

In WSNs it is difficult to say which protocol is better between AODV and LEACH, because both are given better performance with respect to different parameters. The AODV gives better but fluctuated result for Packet Delivery Ratio (PDR) and Routing Overhead (ROH) and LEACH gives better performance and no fluctuation for Throughput Average end-to-end delay. So under these parameters the result of our practical work is that AODV and LEACH giving best output as compared with DSDV and TORA.

V. Conclusion

As we mentioned earlier, for MANETs we have selected three routing protocols AODV, DSDV and TORA and present a comparative performance study among them. Based on our practical results it is concluded that the AODV perform better in MANETs and gives better output and performance. TORA is very poor not reliable for MANETs.

On the other hand four routing protocols for WSNs are selected; these are AODV, DSDV, TORA and LEACH and studied their performance. The result of our work done is that AODV and LEACH both perform better but AODV is less reliable than LEACH because the result of AODV is fluctuated but that of LEACH is not. According to practical results the routing protocol AODV gives the better performance for both MANETs and WSNs. AODV, DSDV and TORA perform better and take less time in MANETs with respect to WSNs, and TORA performs better in WSNs as compare to MANETs.

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