Performance Analysis of MANET Routing Protocols under Dynamic Heterogeneous Conditions

M.Kumutha
Department of Computer Science, Sri Ramakrishna college of Arts and Science for women Coimbatore,India.

***Abstract*— Mobile Ad Hoc Networks (MANETs) are now a crucial communication paradigm in scenarios like disaster recovery, military operations, and remote area networking where fixed infrastructure is unavailable. Maintaining dependable and effective routing is extremely difficult due to the dynamic and decentralized character of MANETs, particularly in diverse environments where nodes vary in mobility, energy capacity, transmission range, and compute capability. Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), two popular MANET routing protocols, are thoroughly examined in this paper's performance study under dynamic heterogeneous situations.**

By modeling various network factors as node density, mobility patterns, and traffic load, the study assesses these protocols. To evaluate each protocol's adaptability and effectiveness, key performance measures such packet delivery ratio, end-to-end latency, throughput, and overhead for routing are examined. Furthermore, the effect of node heterogeneity on routing performance and network stability is investigated.

According to simulation data, the performance of AODV and DSR varies according to network conditions. Because of its routing table method, AODV performs better in highly dynamic settings, whereas DSR's the routing of sources strategy demonstrates efficiency in networks with reduced mobility. The results show that no single protocol is always the best, emphasizing the necessity of adaptive routing techniques that can react quickly to shifting network conditions.

This work enhances the understanding of MANET performance in heterogeneous settings and provides valuable insights for designing robust routing protocols suitable for next-generation wireless networks..

Keywords--Dynamic Source Routing, AODV and DSR, Delivery Ratio, end –to-end latency, throughput and overhead.

I. INTRODUCTION

Mobile Ad Hoc Networks (MANETs) are decentralized wireless networks that operate without fixed infrastructure and are widely used in applications such as disaster recovery and military communication. Due to dynamic topology and limited resources, efficient routing remains a major challenge in MANETs.

The Ad hoc On-Demand Distance Vector (AODV) protocol is a widely used reactive routing protocol that establishes routes only when required, thereby reducing routing overhead. It uses a route discovery process involving Route Request (RREQ) and Route Reply (RREP) messages to establish communication paths between nodes.

Once a route is established, data transmission begins, and route maintenance is handled using Route Error (RERR) messages in case of link failures. AODV also utilizes sequence numbers to ensure loop-free and up-to-date routing information. Despite its advantages, AODV may experience initial delays and control overhead, making performance evaluation under varying network conditions essential.

Routing is difficult in Mobile Ad Hoc Networks (MANETs), which are infrastructure-free wireless networks with configurable topology. In order to reduce routing overhead, the Dynamic Source Routing (DSR) protocol is a reactive routing technique that creates routes only when needed.

DSR employs source routing, which does away with the requirement for routing databases by including the entire path to the destination in packet headers. Route Ask for (RREQ), Route Reply (RREP), and Route Error (RERR) messages are used for route discovery and route management processes.

Mobile nodes that connect without established infrastructure make up Mobile Ad Hoc Networks (MANETs). Routing is an difficult task due to their constantly changing nature and limited resources. In heterogeneous contexts, where nodes have varying capacities like mobility, energy, and transmission range, the challenge gets more difficult.

Network performance is largely determined by routing protocols. Because they are upon request, reactive protocols like DSR (Dynamic Source Routing) and AODV (Ad hoc On-Demand Distance Vector) are frequently utilized. DSR employs source routing and route caching, whereas AODV uses routing tables with sequence numbers. Improving MANET efficiency requires assessing their efficiency under various network scenarios.

II. LITERATURE REVIEW

A. Tamrakar, S. Bhattacharya and S. Jain, "A Scheme to Eliminate Redundant Rebroadcast and Reduce Transmission Delay Using Binary Exponential Algorithm in Ad-Hoc Wireless Networks", International Journal of Scientific Research in Network Security and Communication, Vol.2(2), pp.1-5, 2014.
B. Parasher, Y. Rathi, "A_AODV: A Modern Routing Algorithm for Mobile Ad-Hoc Network" in: International Research Journal of Engineering and Technology (IRJET) Vol 2(1), e-ISSN: 2395 - 0056, p-ISSN: 2395-0072, 2015.
C. Pandey,S. Solanki, R. Dubey, "Improved Performance of AODV Routing Protocol with Increasing Number of Nodes using Traveling Salesman Problem" ,International Journal of Computer Applications , Vol. 98, pp. 0975 – 8887, 2014.
D. Vajed, S. Jamali, "Performance Comparison of AODV, DSDV, DSR and TORA Routing Protocols in MANETs" in: International Research Journal of Applied and Basic Sciences.Vol. 3(7), pp. 1429-1436, 2012.
E. Pal, P. Sharma, N. Kaurav and S.L. Mewada, "Performance Analysis of Reactive and Proactive Routing Protocols for Mobile Ad-hoc –Networks", International Journal of Scientific Research in Network Security and Communication, Vol.1(1), pp.1-4, 2013 .
F.Internet Engineering Task Force, "MANET working group charter Available"from: IETF MANET group Character Sector , 2010.
G. Majumder and S.K. Sarkar, "Performance analysis of AODV and DSR Routing Protocols in Hybrid Network Scenario", Proc. IEEE transactions on networking, pp. 1-4 , 2009.

III. METHODOLOGY

Configuring the Simulation
Simulation is used to assess the effectiveness of AODV and DSR routing protocols in dynamic diverse environments. The nodes in the network have different: Mobility rates

Energy levels, transmission ranges, traffic loads, and simulation parameters

Parameter	Value
Simulation Area	1000 m × 1000 m
Number of Nodes	25, 50, 75, 100
Mobility Model	Random Waypoint
Node Speed	1 – 20 m/s
Traffic Type	CBR (Constant Bit Rate)
Packet Size	512 bytes
Simulation Time	100 seconds
Routing Protocols	AODV, DSR
MAC Protocol	IEEE 802.11
Transmission Range	250 m
Initial Energy	100 Joules
Propagation Model	Two-Ray Ground
Queue Type	DropTail
Antenna Type	Omni-directional

formulas
1. Packet Delivery Ratio (PDR)
PDR = Pr / Ps × 100
Where:
Pr = Packets received
Ps = Packets sent
2. End-to-End Delay
D=∑(treceive – tsend) / N
Where:
N = Total packets received
3. Throughput
Throughput=Total bits received/Simulation time
4. Routing Overhead
RO=Control packets/Data packets
Sample Calculation
Assume:
Packets Sent = 1000
Packets Received = 920
PDR Calculation
PDR = 92 / 1000 × 100 = 92%
Total Data Received = 4,000,000 bits
Simulation Time = 100 sec

1) Throughput Calculation

Throughput=4,000,000 / 100 = 40,000 bps

Nodes	Protocol	PDR (%)	Delay (ms)	Throughput (kbps)	Overhead
25	AODV	95	120	45	0.25
25	DSR	93	110	42	0.20
50	AODV	92	150	40	0.30
50	DSR	89	140	38	0.28
100	AODV	88	200	35	0.40
100	DSR	82	180	30	0.35

IV. OBSERVATION

In large networks, AODV has a greater PDR When node density is low, DSR operates better. Node mobility causes a delay to rise. In heterogeneous situations, throughput decreases.

It is found that AODV outperforms DSR in terms of packet delivery ratio, especially since the number of nodes rises. This is due to the fact that AODV uses sequence numbers to keep up-to-date routing information, which reduces packet loss. On the other hand, stale route caching entries and larger packet headers cause DSR performance to decline on bigger networks.

Complete Latency

As the number of nodes and mobility rise, both protocols experience an increase in end-to-end latency. However, because of its route caching approach, which avoids frequent path discovery, DSR exhibits somewhat reduced latency in smaller networks. However, in dynamic environments, AO DV typically experiences greater delays during route discover stages.

Throughput

Because AODV can swiftly create new routes, it exhibits improved throughput performance in highly dynamic and congested networks. Due to frequent path failures and higher overhead, DSR indicates lower throughput in diverse situations but performs well in low mobility scenarios.

4. Routing Overhead

DSR generally produces lower routing overhead in smaller networks because it avoids periodic updates and uses cached routes. However, as network size increases, the overhead rises due to larger packet headers. AODV generates higher control overhead due to the use of RREQ, RREP, and RERR messages, especially in highly mobile scenarios.

2) 5. Impact of Heterogeneity

Heterogeneous conditions significantly affect the performance of both protocols. Nodes with different transmission ranges and energy levels lead to unstable links and uneven traffic distribution. This results in:

- Increased packet loss
- Higher delay
- Reduced throughput

AODV handles heterogeneity better due to its dynamic route maintenance, while DSR struggles due to dependency on cached routes.

3) 6. Effect of Node Density

As the number of nodes increases:

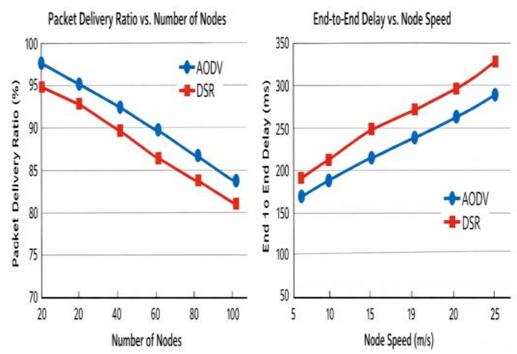
- Network connectivity improves initially
- But congestion and collision also increase
- Performance degradation is observed beyond a threshold

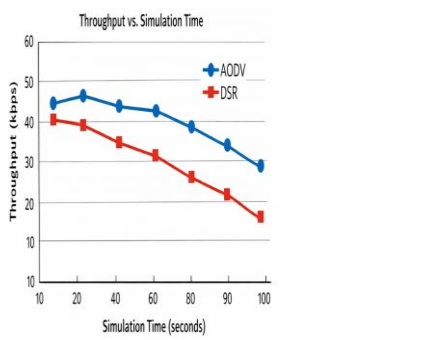
AODV adapts better in dense networks compared to DSR.

4) 7. Effect of Mobility

High mobility causes frequent link breakages:

- AODV quickly recovers using route maintenance
- DSR performance decreases due to outdated cached routes





V. RESULTS AND DISCUSSION

The performance of AODV and DSR routing protocols was evaluated under dynamic heterogeneous conditions using key metrics such as Packet Delivery Ratio (PDR), End-to-End Delay, Throughput, and Routing Overhead.

The results indicate that AODV achieves higher PDR compared to DSR, particularly as node density increases. This is due to its use of sequence numbers and routing tables, which help maintain fresh and reliable routes. In contrast, DSR experiences a reduction in PDR in larger networks due to stale route cache entries and increased packet header size.

In terms of end-to-end delay, DSR performs slightly better in low-density and low-mobility scenarios because it utilizes cached routes, reducing route discovery time. However, as mobility increases, delay rises significantly for both protocols, with AODV showing relatively stable performance due to its efficient route maintenance mechanism.

Throughput analysis shows that AODV outperforms DSR in highly dynamic environments. Frequent link failures in heterogeneous conditions affect DSR more severely, resulting in reduced throughput. AODV adapts better by quickly establishing new routes.

Regarding routing overhead, DSR generates lower overhead in smaller networks due to its on-demand nature and route caching. However, as network size grows, the overhead increases because of larger packet headers. AODV incurs higher control overhead due to frequent RREQ, RREP, and RERR messages, especially in high mobility scenarios.

Overall, the results demonstrate that network heterogeneity significantly impacts routing performance, causing increased delay, packet loss, and overhead. AODV performs more consistently in dynamic environments, while DSR is better suited for smaller and less dynamic networks.

VI. FUTURE ENHANCEMENT

Although AODV and DSR perform effectively under certain conditions, several improvements can be made to enhance routing performance in heterogeneous MANETs:

- Adaptive Routing Protocols: Develop protocols that dynamically adjust based on network conditions such as mobility, node density, and energy levels.
- Energy-Aware Routing: Incorporate energy metrics to prolong network lifetime by avoiding low-energy nodes.
- Hybrid Approaches: Combine reactive and proactive techniques to balance delay and overhead.
- Machine Learning Integration: Use AI-based techniques to predict link failures and optimize route selection.
- Mobility Prediction Models: Improve route stability by predicting node movement patterns.
- Security Enhancements: Implement secure routing mechanisms to protect against attacks such as black hole and wormhole attacks.

These enhancements can significantly improve the reliability and efficiency of MANET routing protocols in real-world heterogeneous environments.

VII. CONCLUSION

This paper presented a performance analysis of AODV and DSR routing protocols under dynamic heterogeneous conditions in MANETs. The study evaluated key performance metrics including packet delivery ratio, end-to-end delay, throughput, and routing overhead.

The results show that AODV performs better in highly dynamic and dense networks, while DSR is more efficient in low mobility and smaller networks. Heterogeneous conditions, such as variations in node mobility, transmission range, and energy, have a significant impact on overall network performance.

It is concluded that no single routing protocol is optimal for all scenarios. Therefore, there is a need for adaptive and intelligent routing mechanisms that can dynamically respond to changing network conditions. Future research should focus on developing hybrid and AI-based routing solutions to enhance performance in heterogeneous MANET environments.

REFERENCES

[1] C. E. Perkins and E. M. Royer, “Ad-hoc On-Demand Distance Vector Routing,” *Proc. IEEE Workshop on Mobile Computing Systems and Applications*, New Orleans, LA, USA, 1999, pp. 90–100.

[2] D. B. Johnson, D. A. Maltz, and Y.-C. Hu, "The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks," *IETF RFC 4728*, 2007.

[3] E. M. Royer and C. K. Toh, "A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks," *IEEE Personal Communications*, vol. 6, no. 2, pp. 46–55, Apr. 1999.

[4] S. R. Das, C. E. Perkins, and E. M. Royer, "Performance Comparison of Two On-Demand Routing Protocols for Ad Hoc Networks," *Proc. IEEE INFOCOM*, Tel Aviv, Israel, 2000, pp. 3–12.

[5] T. Clausen and P. Jacquet, "Optimized Link State Routing Protocol (OLSR)," *IETF RFC 3626*, 2003.

[6] P. Samar and S. B. Wicker, "On the Behavior of Communication Links of a Node in a Multi-Hop Mobile Environment," *Proc. ACM MobiHoc*, 2004, pp. 145–156.

[7] J. Broch, D. A. Maltz, D. B. Johnson, Y.-C. Hu, and J. Jetcheva, "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols," *Proc. ACM MobiCom*, 1998, pp. 85–97.

[8] S. Corson and J. Macker, "Mobile Ad Hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations," *IETF RFC 2501*, 1999.

[9] M. Abolhasan, T. Wysocki, and E. Dutkiewicz, "A Review of Routing Protocols for Mobile Ad Hoc Networks," *Ad Hoc Networks Journal*, vol. 2, no. 1, pp. 1–22, 2004.

[10] A. Boukerche, B. Turgut, N. Aydin, M. Z. Ahmad, L. Bölöni, and D. Turgut, "Routing Protocols in Ad Hoc Networks: A Survey," *Computer Networks*, vol. 55, no. 13, pp. 3032–3080, 2011.

[11] H. Bai, M. Atiquzzaman, and D. Lilja, "Wireless Mesh Networks: A Survey," *Computer Networks*, vol. 47, no. 4, pp. 445–487, 2005.

[12] S. Kumar, R. Ranjan, and S. K. Das, "Performance Evaluation of Routing Protocols in MANET under Heterogeneous Conditions," *International Journal of Computer Networks*, vol. 7, no. 3, pp. 45–52, 2015.