Adhoc On-demand Distance Vector – Energy Efficient Approach

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ABSTRACT
As nodes of Mobile Adhoc Network (MANET) are mobile in nature, overall network lifetime is one of the key challenges in MANET. To improve overall network lifetime along with packet delivery fraction and normalized routing load, this paper proposed an optimised multihop routing protocol (OMR-AODV) as an extension of Adhoc On-demand Distance Vector (AODV) by introducing threshold limit on residual battery of mobile node during route establishment phase. AODV and OMR-AODV are simulated with various parameters using network simulator and results shows that OMR-AODV performs better than AODV for overall network lifetime along with packet delivery ratio and normalized routing load.

Keywords
MANET, AODV, Energy-Efficient Routing Algorithms

1. INTRODUCTION
A Mobile Adhoc Network (MANET) is a kind of self-configuring, self-organizing, infrastructure less network of mobile nodes interconnected with wireless links [1]. Each node of MANET is allowed to move freely anywhere and will therefore modifies its links to other nodes repeatedly. Each node is acting as a router and forward traffic irrespective to its own usage. The key problem in constructing a MANET is to prepare each node to retain information essential to route traffic consequently. These kind of networks may function independently or may be linked with Internet. They may encompass single or many heterogeneous transceivers between nodes that results in to a highly autonomous and dynamic topology. On top of a link layer, MANET has typically a routable networking environment [2]. As MANET is a kind of a peer-to-peer, self-healing and self-forming network, routine routing strategies for wired-network can not applicable to it directly.

Node mobility, limited resources, error prone channel, hidden and exposed terminals are key challenges required to consider during designing a routing protocol for MANET. As nodes are operated by battery, improving lifetime of battery is one of the primary objectives and extensive research work is going on to consider energy efficient network protocols for MANET. Each node in a MANET works as a router to establish communication between nodes and loss of few of nodes even because of energy exhaustion might cause disruption of service in network and forms partition in network. The orthodox on demand routing algorithms like AODV, DSR, LAR and ABR [3] are not aware of node's energy and begins connections among nodes by taking shortest routes which may result in a quick exhaustion of node's energy among routes used heavily in the network. This paper endeavors to extend popular on demand routing strategy named AODV. A modified route establishment procedure added to traditional AODV that increases lifetime of the node's battery and also improves normalized routing load along with packet delivery fraction.

Remaining paper is organized as follows. Review of different energy efficient routing protocols for MANET is highlighted in Section 2. Section 3 demonstrates proposed algorithm, Section 4 covers simulations and performance analysis and Section 5 concludes this paper.

2. RELATED WORK
Primary deployment consideration of MANET is related to improvement in network's lifetime which is restricted by energy in mobile nodes. Energy exhaustion of nodes can interrupt communication and even origin network partitions. Thus energy efficiency is critical for implementation of network protocols. Freshly diverse energy aware routing protocols have been suggested in order to attain energy conservation and improve network's lifetime. AODV based Energy Efficient Routing Protocol for Maximum Lifetime in MANET [4] proposed an enhanced AODV routing protocol that improves networks lifetime. MMRE-AOMDV [5] suggested multipath routing protocol for MANET that extends AOMDV routing protocol and it finds minimal node remaining energy of each route in process of selecting path and arrange multi-route by descending node remaining energy. Integrated Energy-Aware Mechanism for MANETs [6] suggested load balancing approach along with transmission power control as a technique to improve performance of on-demand routing with energy efficiency. SQ-AODV [7] suggested a cross layering approach to change information related to residual energy of mobile nodes to perform QoS. Adaptive link timeout with energy aware mechanism [8] proposed a new method for a path to set time-out. A path is considered out of order if a node leave by following the exhaustion of its energy. Energy aware routing for low energy ad hoc sensor networks [9] proposed a method that combines runtime battery capacity in routing protocol and the expectable propagation power loss obtained by sensing received signal power. Reducing message overhead of AODV routing protocol in urban area by using link availability prediction [10] suggested different types of the effort that aims to decrease overhead of AODV to achieve energy efficiency through expecting links availability. CPC-AODV [11] suggested an enhancement in AODV through cross-layer power control by considering mobile node's geographic location and energy of packet transmission. Modified Energy- Aware AODV Routing for Ad hoc Networks [12] proposed a mechanism of energy-aware routing named EAODV which is based on traditional AODV protocol with backup routing mechanism. The route which devotes a smaller amount of energy and owns greater capacity is selected by synthetic analysis. Minimum Energy Routing Schemes for a Wireless Ad Hoc Network [13] proposed minimum energy routing that addresses issues of related overheads, obtaining

precise power information, care of the minimum energy routes in existence of mobility and implements mechanism of transmission power control in IEEE 802.11 MAC protocol.

3. OPTIMISED MULTIHOP ROUTING FOR AODV

The primary objective of proposed algorithm (OMR-AODV) is to improve overall network lifetime. It also focuses on improvement of packet delivery fraction and normalized routing load. It provides optimized multihop routing by considering residual energy between pair of source and destination nodes. To establish a path to destination, source starts process of route discovery and broadcasts route request packet (RREQ) to all its neighbors same like AODV as illustrated in Fig 1 and Fig 4 respectively. Upon receiving RREQ packet, an intermediate node in AODV sets reverse path entry in its routing table to remember path of source node and re-broadcast same to all its neighbors further as illustrated in Fig 2. When an intermediate node in OMR-AODV receives RREQ, it evaluates its residual energy with predefined threshold value. If it exceeds threshold value, then it re-broadcast RREQ to all its neighbors else node determines that its residual energy is not adequate to participate and node discards received RREQ packet as illustrated in Fig 5. Described process repeats in both AODV and OMR-AODV till Destination receives RREQ. Once destination node receives first RREQ packet, it transmits a route reply packet (RREP) to source node in AODV as illustrated in Fig 3 which always focuses on shortest path while in OMR-AODV it focuses on stronger path as illustrated in Fig 6. Once source node receives RREP, it initiates transmission of actual data packets similarly in AODV and OMR-AODV.

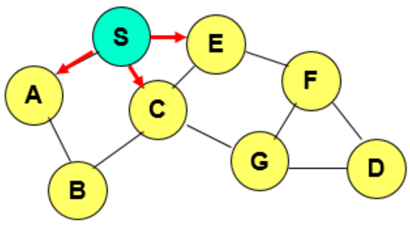

Fig 1: AODV: Source initiates RREQ

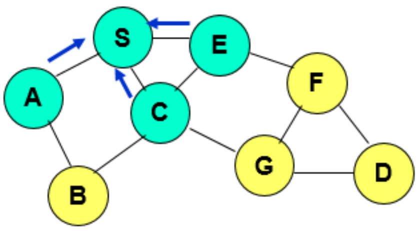

Fig 2: AODV: Intermediate nodes establish reverse path to Source

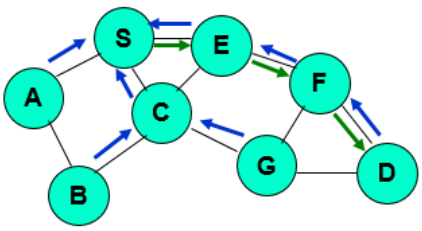

Fig 3: AODV: Source selects path to Destination

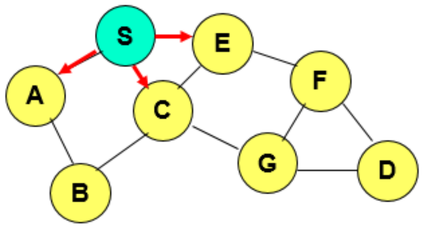

Fig 4: OMR-AODV: Source initiates RREQ

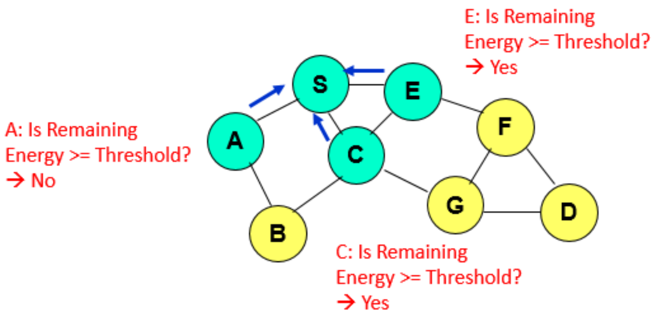

Fig 5: OMR-AODV: Intermediate node checks remaining energy with threshold value

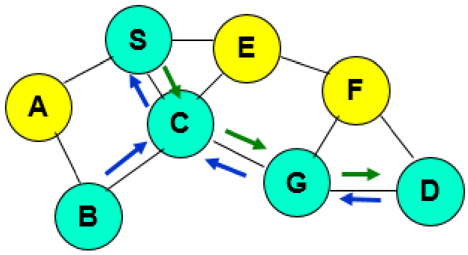

Fig 6: OMR-AODV: Source selects path to Destination

4. SIMULATION AND RESULTS

Simulation of AODV and OMR-AODV carried out using ns-2 simulator. The mobility model used in each simulation is random direction. In each simulation, nodes are placed randomly within L X L area initially. Data rate of simulations is set to 2 Mb/sec and data packet size is 64 bytes. Free space propagation model has been used and each simulation is run for node movement speed ranges from 1 m/s to 10 m/s. Ten simulation runs are completed with different initial configuration and its results are averaged to produce resulting graphs for each movement speed. Each simulation run for 300 seconds. Table 1 shows detailed simulation parameters used to produce resulting graphs. The primary objective of these simulations is to express that OMR-AODV performs superior than traditional AODV in case of average network life time. It also focuses about an enhancement on normalized routing load along with packet delivery fraction.

Table 1: Simulation parameters for AODV and OMR-AODV

Parameter	**Value**	
Number of Nodes	50	100
Room Size	1000 X 1000 meter^2	1500 X 1500 meter^2
Number of Nodes	250	500
Room Size	2400 X	3450 X

	2400 meter^2	3450 meter^2
Maximum Connection	20	
Transmission Range	250m	
Bandwidth	2 Mbps	
Node Movement Speed	1,5 & 10 m/s	
Mobility Model	Random Direction	
Nodes Placement	Random	
Routing Protocol	AODV	
Packet Size	64 Bytes	
Simulation Time	300 Seconds	
Packet Rate	4 Packets/sec	
Pause Time	10 ms	
Initial Energy	100 J	
txPower	1.5 w	
rxPower	1 w	
idlePower	0.1 w	
sleepPower	0.5 w	

Fig 7 to 10 shows achieved packet delivery fraction for nodes 50, 100, 250 and 500 versus node movement speed from 1 to 10 ms respectively. Higher node mobility results in more frequent path breaks and to resolve it further, source has to reinitiate route discovery process to reach at destination which results in poor packet delivery fraction as more time wasted to repair braked routes. As node mobility increases, packet delivery fraction decreases due to more path breaks that demonstrated in Fig 7 to 10 respectively. Similarly if nodes are increased then ideally more time requires to establish route to destination that results slightly reduction in packet delivery fraction as shown in Fig 7 to 10. Packet delivery fraction increases significantly in OMR-AODV as compare to AODV because AODV focuses on shortest path while OMR-AODV focuses on stronger path.

Fig 11 to 14 shows achieved normalized routing load for nodes 50, 100, 250 and 500 versus node movement speed from 1 to 10 ms respectively. Higher node mobility results in more frequent path breaks and to resolve it further, source has to reinitiate route discovery process to reach at destination which results in higher normalized routing load as more routing packets needed to repair braked routes. As node mobility increases, normalized routing load increased due to more path breaks that demonstrated in Fig 11 to 14 respectively. In case if intermediate node loses its energy then again source has to reinitiate route discovery to same destination that adds more routing packets in network. Similarly if nodes are increased then ideally more time requires to establish route to destination for both new routes and maintenance of existing route that results slightly increment in normalized routing load as shown in Fig 11 to 14. Network routing load decreases remarkably in OMR-AODV as compare to AODV due to less number of path breaks because OMR-AODV selects intermediate nodes with better residual energy.

Fig 15 to 18 shows achieved average remaining energy for nodes 50, 100, 250 and 500 versus node movement speed from 1 to 10 ms respectively. Higher node mobility results in more frequent path breaks and to resolve it further, source has to reinitiate route discovery process to reach at destination which results in depletion of energy level as node has to process more routing packets needed to repair braked routes or to establish a fresh route. As node mobility increases, average remaining energy decreased due to more path breaks that demonstrated in Fig 15 to 18 respectively. In case if intermediate node loses its energy then again source has to reinitiate route discovery to same destination and node has to process additional routing packets which reduces its own energy level. As OMR-AODV focuses on stronger paths by checking threshold value of each intermediate node, overall network lifetime increases as compared to AODV. Average remaining energy of network increased significantly in OMR – AODV as compare to AODV as OMR-AODV considers remaining energy of each node participating in establishment of route and avoids node with critical state in participation of route.

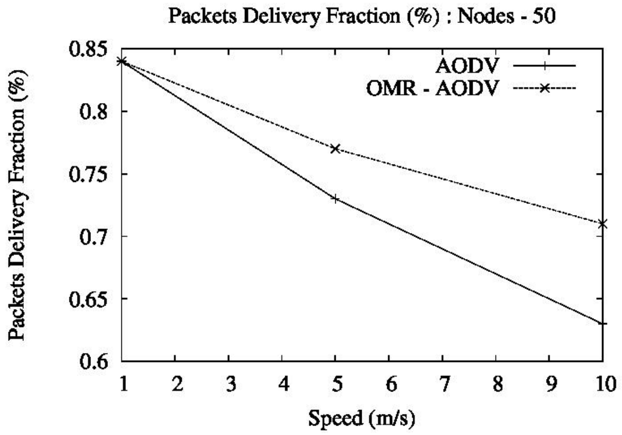

Fig 7: Packet Delivery Fraction (50 nodes)

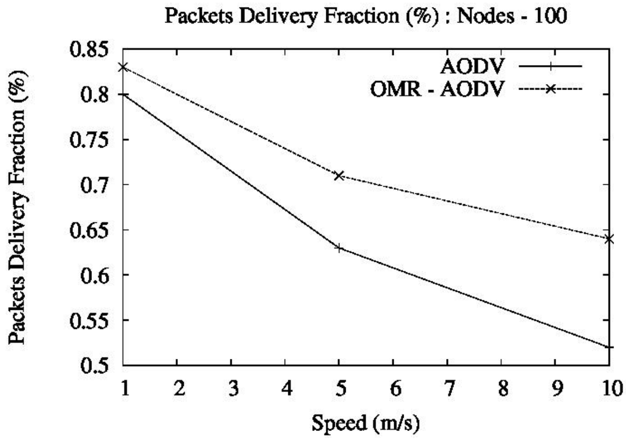

Fig 8: Packet Delivery Fraction (100 nodes)

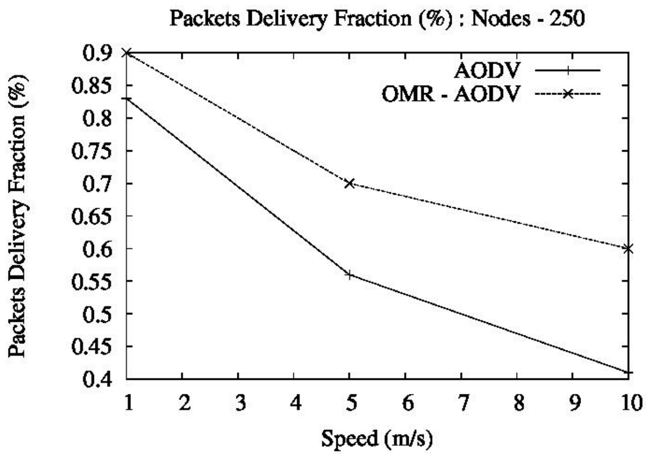

Fig 9: Packet Delivery Fraction (250 nodes)

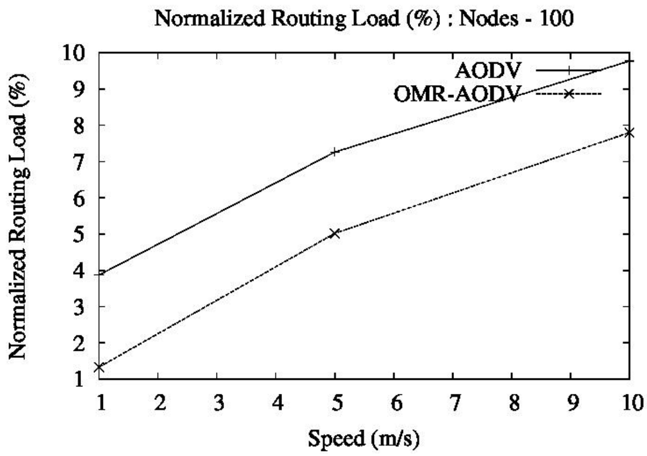

Fig 12: Normalized Routing Load (100 nodes)

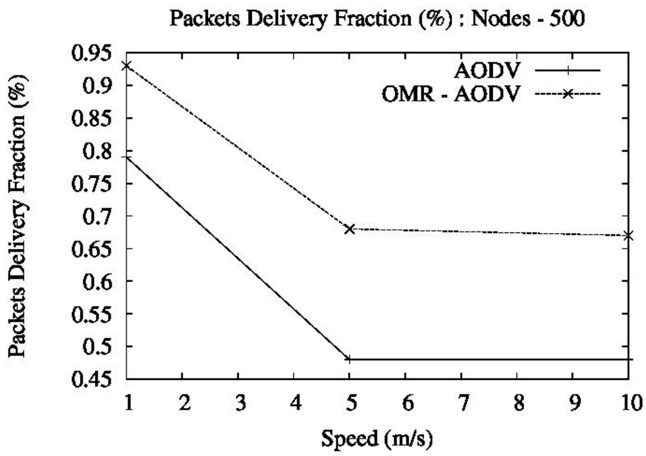

Fig 10: Packet Delivery Fraction (500 nodes)

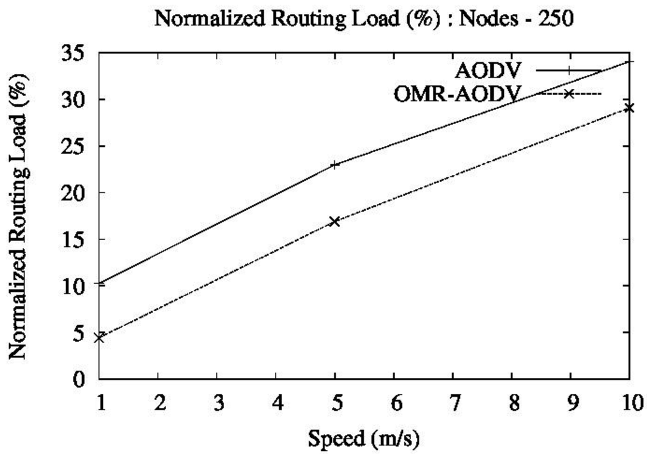

Fig 13: Normalized Routing Load (250 nodes)

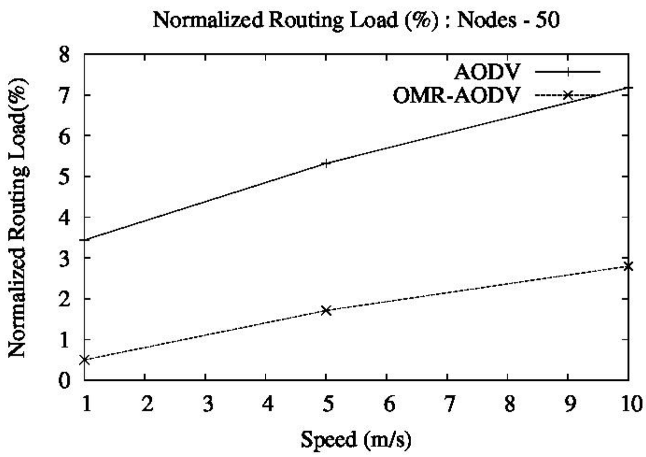

Fig 11: Normalized Routing Load (50 nodes)

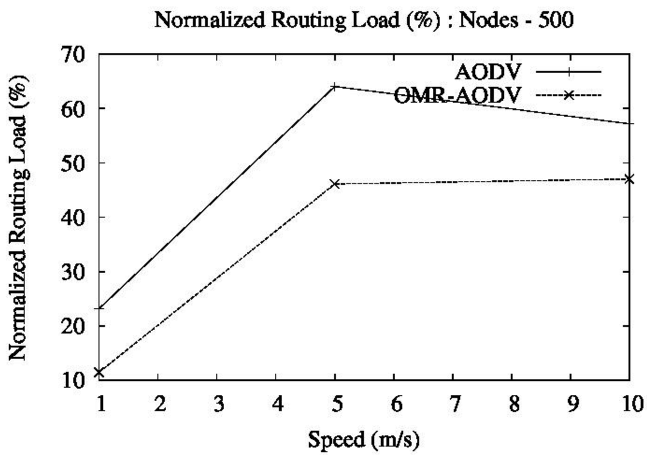

Fig 14: Normalized Routing Load (500 nodes)

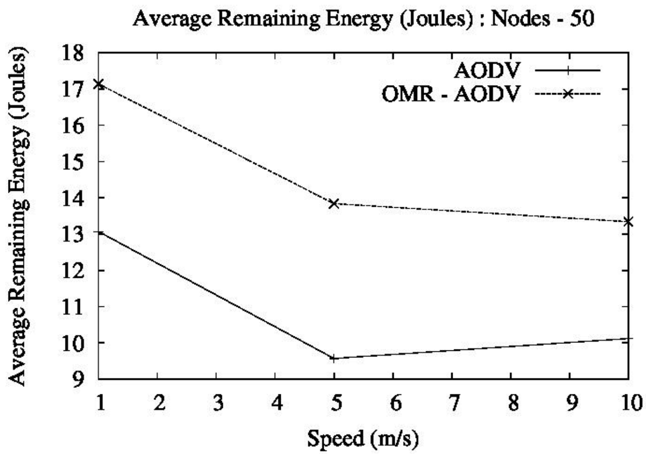

Fig 15: Average Remaining Energy (50 nodes)

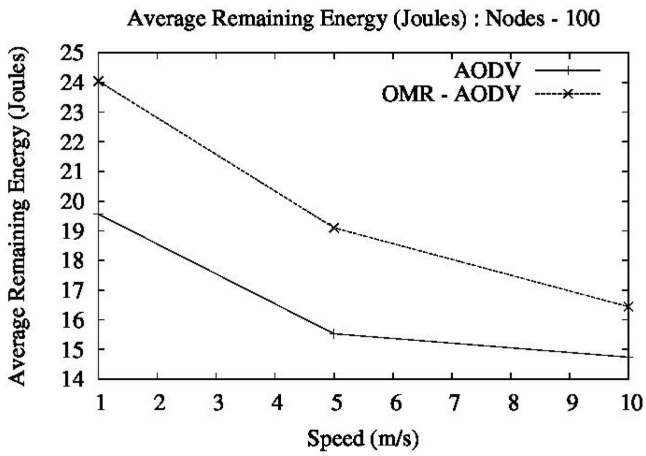

Fig 16: Average Remaining Energy (100 nodes)

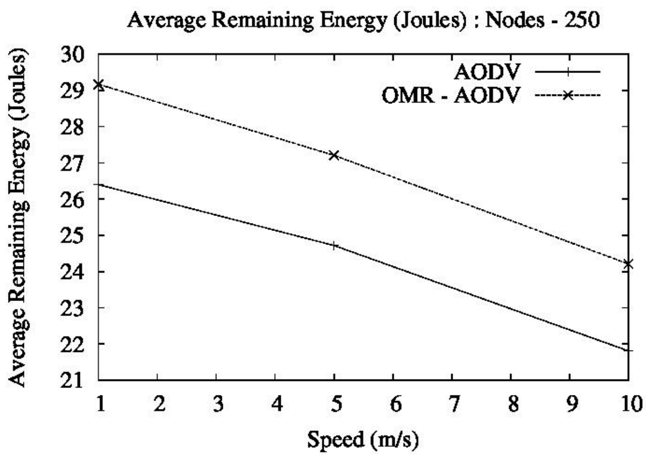

Fig 17: Average Remaining Energy (250 nodes)

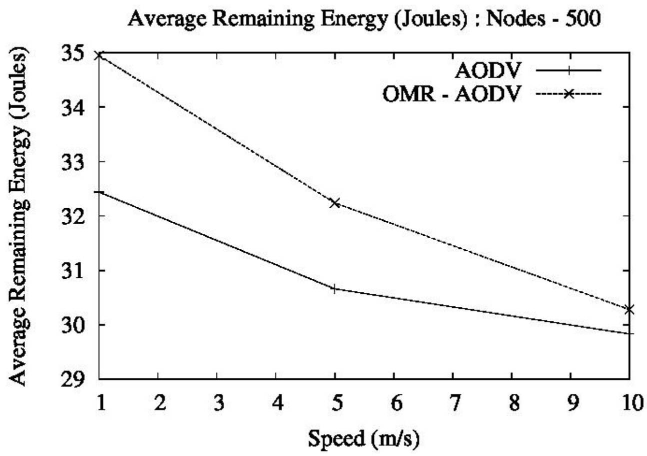

Fig 18: Average Remaining Energy (500 nodes)

5. CONCLUSION

As nodes in MANET are equipped with battery, energy efficiency is one of the key considerations for establishment of routing mechanism. This paper has proposed OMR-AODV as an extension of AODV by considering residual energy of each intermediate node during route establishment process. Proposed change resulted in stronger path between source and destination as compare to shortest path in AODV that improves overall network life time along with better packet delivery fraction and normalized routing load because it avoids node with critical energy level to take part in route from source to destination.

6. ACKNOWLEDGMENTS

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