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Performance Evaluation of AOMDV Routing Protocol with Internet of Things

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Abstract— Internet of things (IOT) is contains two words i.e. "Internet" which is a global dynamic interconnected networks and "Things" which shows some objects or devices. Internet of Things (IOT) refers to the dynamic network interconnecting people and things. It is usually a dynamic global network with self-configuring capabilities based on standard and interoperable communication protocols. IOT is rather a new concept in IT field. However, the research of routing protocols with Internet of Things is still an issue in many factors, while route designing is an important part in the research of routing with Internet of Things. Considered dissertations by various authors in the study of Internet of things (IOT), Routing protocols, MANET and AOMDV. All the research papers considered in this paper literature survey works on the comparative analysis on performance of networks with Internet of things.

Keywords— Internet of things, Routing, Protocols, AODV, AOMDV, Ad-hoc Network, Mobile Network, MANET, Wireless Network, Reactive protocol, On-demand.

1. INTRODUCTION

1.1 Mobile Ad Hoc Network (MANET)

Mobile Ad hoc Network (MANET) is a self-organizing and infrastructure-less multi-hop network which contains several wireless mobile nodes, such as Personal Digital Assistants, laptops, etc. Each node in MANET is both a host and a router; a source node therefore can reach the destination node directly or by intermediate nodes [5].

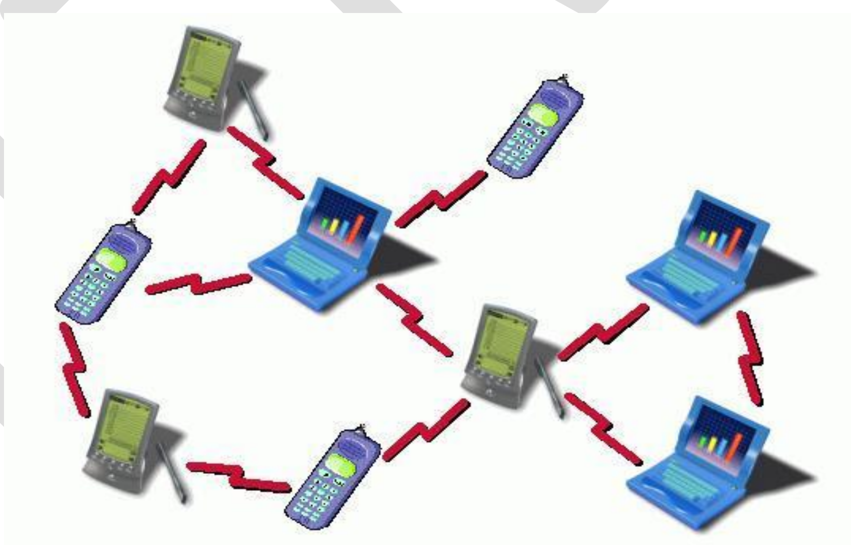

Figure 1.1 Mobile Ad hoc Network

The message passing between nodes in MANET is done by using multi-hop paths. Every node in the MANET shares the wireless medium. The topology of the network changes dynamically. In MANET, nodes are free to move anywhere which is the reason of frequent breaking of communication link. [14][15]

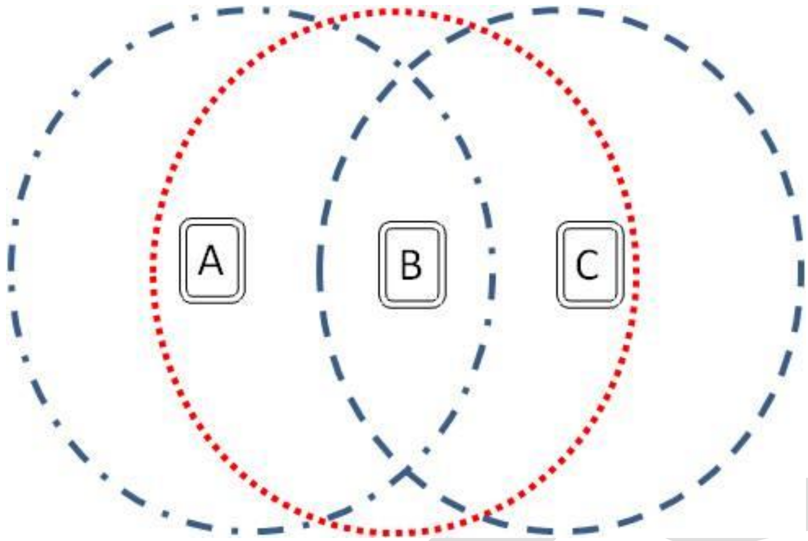

Figure 1.2 A MANET of three nodes, where nodes A & C must discover the route through B in order to communicate.

Figure above shows a simple example of a mobile ad-hoc network with three nodes Node A, Node B, and Node C. Assuming, Node A and Node C are not within range of each other to exchange information; however the Node B can be used to forward data packets between Node A and Node C as Node B is within the range of both Node A and Node C. The Node B will act as a router and these three nodes together form a mobile ad-hoc network having the path named as A-B-C. [16]

In a multi-hop path, if a single node goes away from the coverage of either of its two nearest nodes or the complete route may fails. In a network of mobile nodes the link breaks due to the mobility of individual nodes. Node speed is directly proportional to the number of broken links. The multi hop path must be free from route failure for a successful transmission of data packet from any source to any destination. Therefore, whenever a route breaks in the network a fresh route must to be established quickly so as to make the data packet reach at the destination successfully. So the route failure indirectly varies the end to end delay as far as a successful packet delivery is concerned. [10]

Various factors on which the performance of a MANET depends includes network size, mobility model, type of routing protocol, speed etc. and can be described in terms of end to end delay, throughput, packet delivery ratio. [10]

1.2 MANET Routing Protocols

Routing is defined as “the process of moving a packet of data from source to destination by establishing the routes which the data packets follow”. Routing is generally performed by a dedicated device called a router. The routing involves two activities:

1. Determining optimal routing paths.
2. Transferring the information groups (called packets) through an internetwork. This is called as packet switching. [18]

Routing protocols use a number of metrics to compute the best path for routing the data packets to its destination such as number of hops. In the process of path determination routing algorithms initialize and maintain routing tables, which contain the total route information for the data packets. [18]

Routing protocols can be classified into three different categories:-

a. Proactive Routing

b. Reactive Routing

c. Hybrid Routing [10]

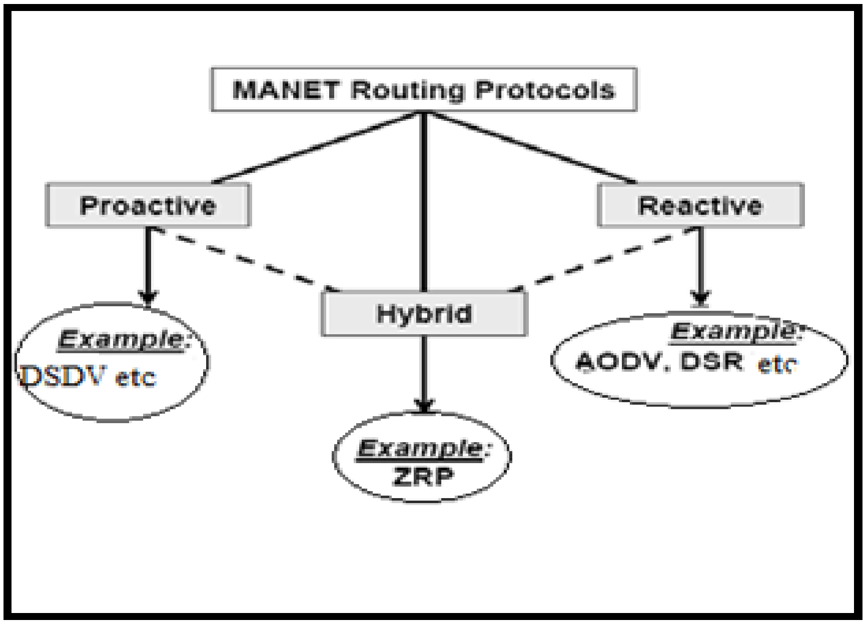

Figure 1.3 Classification of MANET Routing Protocols [16]

1.2.1 Proactive Routing Protocols

Proactive Routing protocols are often called as "Table-Driven" routing protocols that periodically update the routing table by continuously learning the topology of the network by exchanging topological information among the network nodes. For message passing, the route is already known and can be immediately used. The delay in communication is minimized and nodes are able to quickly determine which nodes are present or reachable in the network. The examples of such proactive routing protocols are DSDV (Destination Sequence Distance Vector), FSR (Fisheye State Routing) etc. [10] [11]

1.2.2 Reactive Routing Protocols

Reactive Routing protocols are often called as "On-Demand" routing protocols. When a node wants to forward the packet form source to destination, it establishes route for that destination based on the current network situation. [10]

1.2.3 Hybrid Routing Protocols

Hybrid Routing protocols combine the advantages of proactive and reactive routing schemes. All the nodes in a network are divided into several zones. Communication within the zone is implemented using proactive routing whereas for communication with node out of the zone reactive routing used. The various protocols lies under this category include ZRP, LANMAR, and HSR etc. [10]

1.3 Ad-Hoc On-Demand Multipath Distance Vector Routing (AOMDV)

AOMDV is a multi-path routing protocol and is an extension to AODV. It also provides two main services i.e. route discovery and maintenance. Unlike AODV, every RREP is being considered by the source node and thus multiple paths discovered in one route discovery. It is the hop-by-hop routing protocol in which the intermediate node maintains multiple path entries in their respective routing table. As an optimization measure, by default the difference between primary and an alternate path is equal to 1 hop. The routing table entry at each node also consists of a list of next hop along with the corresponding hop counts. Every node maintains an advertised hop count for the destination. Advertised hop count defined as the "Maximum hop count for all the paths". Advertised hop count is used to sent route advertisements of the destination. An alternate path to the destination is accepted by a node if the hop count is less than the advertised hop count for the destination. [19]

Table 1.1 Routing table entry structure in AODV

Destination	Sequence number	Hop count	Next hop	Timeout

Table 1.2 Routing table entry structure in AOMDV

Destination	Sequence number	Advertised hop count		Route list	
		Next hop1 Next hop2	Last hope1 Last hope2	Hop Count1 Hop Count2	Timeout1 Timeout2

1.4 Introduction to Internet Of Things (IOT)

Internet of Things (IOT) refers to the dynamic network interconnecting people and things. It is generally a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols. In the IOT, smart objects/things are active participants in information where they are enabled to communicate and interact among themselves and also with the environment by exchanging data and information and effects IOT by running processes that have trigger actions and create services with/without human intervention directly [2].

Internet of things (IOT) is contains two words i.e. “Internet” which is a global dynamic interconnected networks and “Things” which shows some objects or devices. It is a self-configuring wireless network of sensors whose idea would be to interconnect everything [1] [6].

Internet of things connects all the objects/things to the internet. The information sensing devices connect things with the purpose of intelligent identification and management. Wireless technology and the internet are used majorly in the making of IOT. [6]

IPv6 has a very significant role in IOT, by using its huge bulk of address space through which one can easily allocate a unique IP address to things on this planet and could transfer the data over network [6].

Nowadays the world is entirely dependent on the information provided on internet, which is captured by taking images or through text. This needs the major involvement of a human being for collection of the information but problem is that people have limited time and less accuracy, which leads to inappropriate and inconsistent data. Hence, such a system is needed which can automatically collect the data and transfer it to the internet without any human to machine interaction [6].

2. LITERATURE SURVEY

A number of journals and research papers published have been studied. The various aspects of the problem were studied.

Buta Singh et al. (2017) analyzed the performance of MANET on the basis of routing protocol used and mobility model employed. This performance evaluation was done for AOMDV (Ad-hoc On-demand Multipath Distance Vector) routing protocol for different mobility models in MANET and later compared with AODV (Ad-hoc On-demand Distance Vector) routing protocol. This paper conclude the result that AOMDV performs better than AODV in all mobility models due to its multipath route selection mechanism which helps it to recover the broken links between source and destination and enabling selection of more reliable route between two communicating nodes. [10]

Amol Dhumane et. al (2016) Nodes in IoT endure constant movement that may result into out of order interconnectivity between the devices which may come across dynamic topology changes. Due to these dynamic topological changes and inadequate resources available in the IoT devices, routing of data has become a big challenge in front of the present research community. This dissertation emphasizes on routing of data in IoT. The main aim is not only to compare, analyze and strengthen the past research work but also to welcome their findings and talk about their applicability towards the IoT [26].

Hou Songfan, Wu Muqing, Liao Wenxing, Wang Dongyang (2015) This dissertation presents an investigation with a goal to compare the performance of two characteristic routing protocols, AODV and DSR, in real multi-hop environment. Apart from testing the end-to-end packet loss, delay and routing path parameters, the performance of DSR and AODV routing protocols with factors of some applications based on Internet of Things (IoT), such as Radio Frequency Identification (RFID) service, voice service and temperature monitoring service are also tested [5].

Mayuri A. Bhabad, Sudhir T. Bagade (2015) The dissertation focus on the concept of IOT, architecture and security issues with suggested countermeasure and suggested further areas of research needed. Internet of things (IOT) is a widely distributed network of interconnected things/objects in which all the information is routed to the internet with the use of sensing devices and Radio Frequency Identification (RFID) tagging system. As IOT does not need any human to machine interaction, hence security is needed. But the rapid development of IOT has evolved with the challenges in terms of security of things [6].

Pankaj Oli et. al. (2014) the design of robust routing algorithms that adapt to the dynamically and erratically changing MANET network topology is the main challenging issue. MANET is a dynamic wireless self-organizing network that doesn't needs any existing infrastructure in which each node acts as a router. Each node in MANET is both a host and a router; a source node therefore can forward packets reach the destination node directly or by intermediate nodes. These nodes are free to move and organize themselves in the network and change their positions frequently. The routing protocols are categorized as Proactive, Reactive and Hybrid protocols. Reactive routing approach is widely used popular routing category for MANET. The design follows the idea that each node tries to reduce routing overhead by sending routing packets whenever a communication is needed. This paper compares AODV and AOMDV routing protocols for MANETs. The AODV is a single path routing protocol and AOMDV is a multipath version of AODV. AOMDV was designed primarily for highly dynamic ad hoc network where link failures and route breaks occurs frequently. AODV and AOMDV routing protocols are analyzed by broad simulations in ns-2 simulator and demonstrate that how pause time affect their performance. Performance of AODV and AOMDV is evaluated based on Packet Delivery Ratio, throughput, packets dropped, normalized routing overhead, end to end delay and optimal path length. [20]

K. Vanaja et al. (2013) Mobile Ad hoc Network (MANET) is a self-organizing, dynamically changing and infrastructure-less multi-hop network which contains several wireless mobile nodes, such as Personal Digital Assistants, laptops, etc. Forwarding packets through this dynamic network topology is a challenging issue. This paper is to investigate the environment based protocol under mobility induced link breaks. The Single path reactive routing protocol AODV and Multipath reactive routing protocol AOMDV considered analyzing the performance. The decision is made by taking the quantitative performance metrics packet delivery ratio, average end to end delay, throughput of AODV and AOMDV using Network Simulator NS-2. The performance analysis of AODV and AOMDV compares and results that out if AODV and AOMDV, AOMDV is the best suitable one in case there is a link break due to mobility with reduced packet drop ratio, improved throughput and end to end delay. [19]

J. Y. ZHOU et al. (2013) to improve the performance of AOMDV protocol, this paper proposed NS- AOMDV i.e. "AOMDV based on node state". In NS-AOMDV, the paper introduces node state to enhance AOMDV's performance for the selection of main path. In the process of route discovery, the rule of routing update calculates the node weight of each and every path and sorts the route list by descending value of path weight, and then chooses the path with largest weight for data transmission. NS-AOMDV also make use of energy threshold and route request (RREQ) packet delay forwarding for the ease of network congestion, limits the RREQ broadcast, and avoids low energy nodes to contribute in the establishment of the path. The results of simulation demonstrate that NS-AOMDV can effectively enhance network packets delivery rate, throughput and routing overhead in the situation of dynamically changing network topology and heavy load. [21]

Arjun P. Athreya et al. (2013) presented a review of correlated work in the area of self-organization and talk about the research opportunities and challenges for self-organization in the Internet of Things. The Internet of Things is a paradigm that permits the interaction of ubiquitous devices through a network to achieve common goals. So, network self-organization capabilities with these devices are required to allow for communication resilience. This paper considered the system perspective of the Internet of Things and then identifies and describes the key components of self-organization in the Internet of Things and confers enabling technologies. [25]

Vipul Maheshwari & Shrikant Jadhav (2012) The protocols are divided into three categories - Proactive, Reactive or Hybrid Mesh. One most popular protocol called ad-hoc On Demand Vector (AODV) is based on the approach of on-demand path selection in which the tree size is increasing in a proactive way. Also AOMDV routing protocol focuses on Ad-hoc on-demand Multi-Path Distance Vector routing and challenges AODV protocol in performance. In this paper, proposal to enhance the Ad-hoc On-demand Multipath Distance Vector (AOMDV) routing protocol to a delay-aware multi-path protocol for MANETs. The main focus is to improve the QoS in MANETs by creating a routing protocol, which considers the delay requests of real-time multimedia applications (voice and video) in making routing decisions. [17]

Yicong TIAN, Rui HOU (2010) this dissertation designed a routing method that can take function as routing destination not just nodes. Compared with AOMDV, simulation results demonstrate that AOMDV-IOT achieves improved performance in average end-to-end delay, packet loss and discovery frequency. This proposed work improvement proves to be more suitable for the use in internet of things [1].

R.Balakrishna et al. (2010) This paper evaluates the performance of the two most popular reactive routing protocols - Ad-hoc On-demand Distance Vector (AODV) routing protocol, for single path and Ad-hoc On-demand Multi-path Distance Vector (AOMDV) routing protocol. On analyzing the performance of AODV and AOMDV, AOMDV incurs more routing overhead and packet delay than AODV but it had an enhanced efficiency if it is considered for performance metrics like number of packets dropped and packet delivery. [23]

Stephan Haller et al. (2010) studied the objects, devices, resources, things and services, as well as also studied identification, addressing, resolution and discovery in the Internet of Things. The Internet of Things is a hyped word and comes with a lot of related terminology that is not used regularly. This paper tries to bring clarity by describing the most significant terms like things, devices, and entities of interest, resources, addressing, and identity and, more importantly, the relationships between them. [24]

Mahesh K. Marina and Samir R. Das (2006) This paper proposed the novel approach of developing an AOMDV for mobile ad-hoc networks. Specifically, multipath is the extension to a well-studied single path routing protocol known as ad-hoc on-demand distance vector (AODV). The resulting AOMDV protocol guarantees loop freedom and disjointness of alternate paths. Performance analysis of AOMDV with AODV using ns-2 simulations demonstrates that AOMDV is capable to effectively handle the mobility-induced route failures. Also AOMDV reduces the packet loss by up to 40% and achieves a significant enhancement in the end-to-end delay (often more than a factor of two). AOMDV also reduces routing overhead by about 30% by reducing the frequency of route discovery operations. [22]

3. PROBLEM FORMULATION

Internet of Things (IOT) refers to the dynamic network interconnecting people and things. It is generally a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols. IOT is rather a new concept in IT field. However, the research of routing protocols with Internet of Things is still an issue in many factors, while route designing is an important part in the research of routing with Internet of Things.

3.1 Problem Statement

For improving the routing of AOMDV for Internet of Things we are working on the implementation of the algorithm by optimizing the protocol, such as routing table and internet connecting table will combine into one. It is AOMDV with IOT to adapt with the usage in internet of things. Our principal goal is to find and create the connection with lowest hop count between nodes and internet efficiently. The routing protocol will find node-disjoint paths and link-disjoint paths when discovering routes. Then it will take the discovered node as destination node to send message.

Comparing AOMDV-IOT with AOMDV, simulation results show that AOMDV-IOT has better performance in terms of packet delivery ratio, average end-to-end delay, and throughput of the network.

4. PROPOSED WORK

AOMDV protocol is an extension based on Ad-hoc On-demand Distance Vector (AODV) and AOMDV-IOT is based on AOMDV to improve the routing of AOMDV for Internet of things. Our principal objective is to find and create the connection between nodes and internet efficiently. It will find the most appropriate link automatically, and record other links as back up. If a node need to create a link to the internet, it ought to first check its internet connecting table, if the information there is valid, the node will choose the node which hops count is the lowest, or start the routing finding process. Then it will take the discovered node as destination node to send message.

This dissertation performs following tasks to work on the implementation to improve the algorithm through optimizing the protocol, such as routing table and internet connecting table will combine into one.

- Study of AOMDV and IOT protocol
- Implementation of AOMDV and IOT protocol
- Compare the results of AOMDV and AOMDV IOT in NS2.34

5. RESULTS

Simulation results are evaluated with respect to the performance metrics such as number of packets received, delay introduced, packet drop in terms of throughput, number of packets, packet dropping ratio, packet delivery ratio which are described as

- **Total Packet Sent** The computation of the count value of the total number of data packets sent by cluster head node defines the total number of packets received.
- **Total Packet Received:** The computation of the count value of the total number of data packets sent by cluster head node and perceived by sink node defines the total number of packets received.
- **Total Packet Dropped** The given term is define as the difference between net data packets sent and received i.e. the total number of data packets sent and the total number of data packets received.
- **Packet Delivery Ratio** This term is stated as the number of packets successfully received with respect to the total number of packets transmitted.
- **Throughput of Network** The measure of a number of packets transmitted per second is called as Throughput.
- **Average End To End Delay** End-to-End delay indicates how long it took for a packet to travel from the source to the application layer of the destination i.e. the total time taken by each packet to reach the destination. Average End-to-End delay of data packets includes all possible delays caused by buffering during route discovery, queuing delay at the interface, retransmission delays at the MAC, propagation and transfer times.

In this dissertation AOMDV routing protocol is improved for routing with Internet of things**.** In order to improve the algorithm the routing protocol is optimized such that routing table and internet connecting table will combine into one. The results are shown below.

Here we compare the results of AOMDV and AOMDV-IOT. The comparison is done for 25, 50, 75 and 100 nodes.

Simulation results will show the performance evaluation of AOMDV and AOMDV-IOT based on the above listed performance metrics.

5.1 Simulation Results

In the simulation results we had considered four different scenarios of number of nodes in the network.

5.1.1 First Scenario:

For both AOMDV and AOMDV-IOT, the network has number of nodes 25. The outcome of AOMDV and AOMDV-IOT performance for 25 nodes is shown below.

Table 5.1 Performance evaluation for number of nodes 25 (nodes = 25)

	AOMDV	AOMDV-IOT
Total Packets Sent	53013	53013
Total Packets Received	50147	53013
Total Packets Dropped	7475	0
Packet Delivery Ratio	94.59	100.00
Throughput of network	25.0735	26.5065
Average end to end delay(ms)	0.047170916	0.001659730

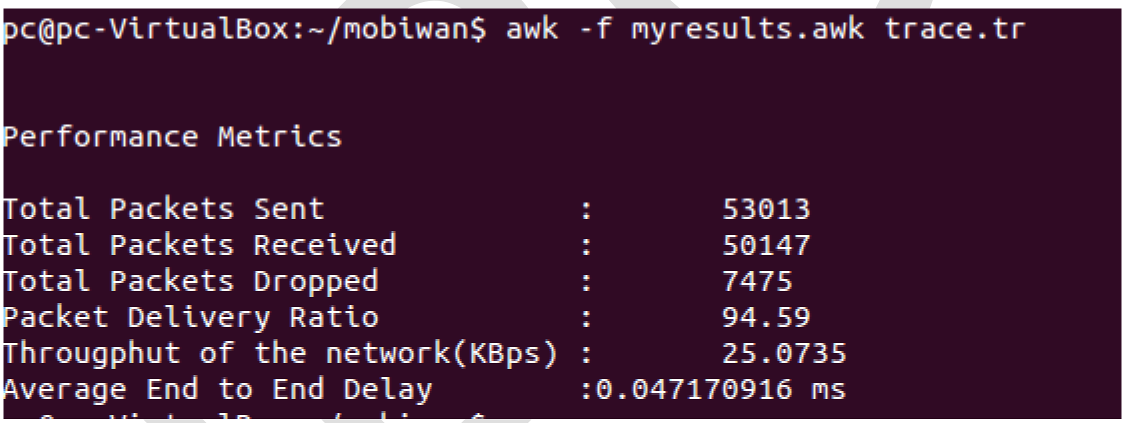

Figure 5.1 Performance evaluation of AOMDV with nodes = 25 on NS 2.35 Simulator

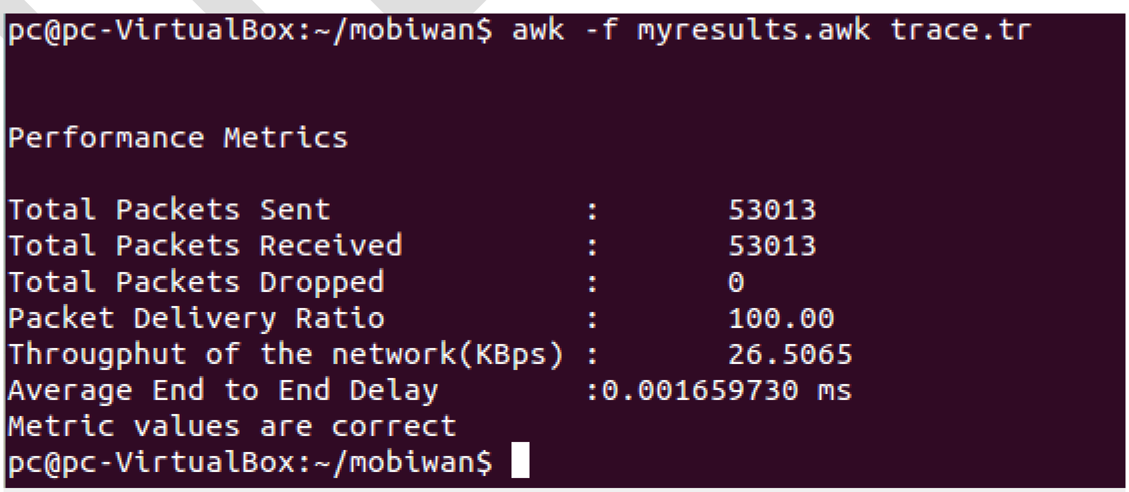

Figure 5.2 Performance evaluation of AOMDV-IOT with nodes = 25 on NS 2.35 Simulator

5.1.2 Second Scenario:

For both AOMDV and AOMDV-IOT, the network has number of nodes 50. The outcome of AOMDV and AOMDV-IOT performance for 50 nodes is shown below.

Table 5.2 Performance evaluation for number of nodes 50 (nodes = 50)

	AOMDV	AOMDV-IOT
Total Packets Sent	37571	37571
Total Packets Received	34190	37571
Total Packets Dropped	7485	0
Packet Delivery Ratio	91.00	100.00
Throughput of network	17.0950	18.7855
Average end to end delay(ms)	0.024838866	0.001686445

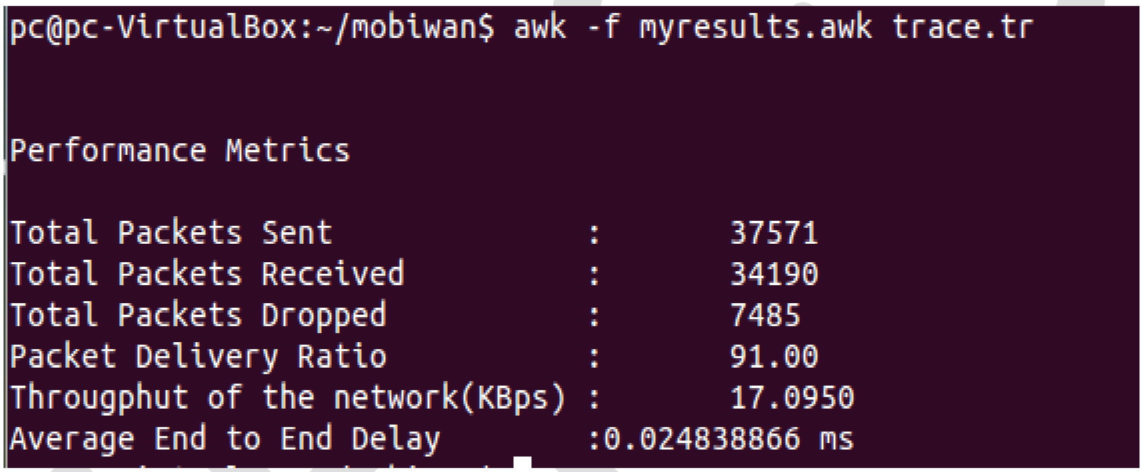

Figure 5.3 Performance evaluation of AOMDV with nodes = 50 on NS 2.35 Simulator

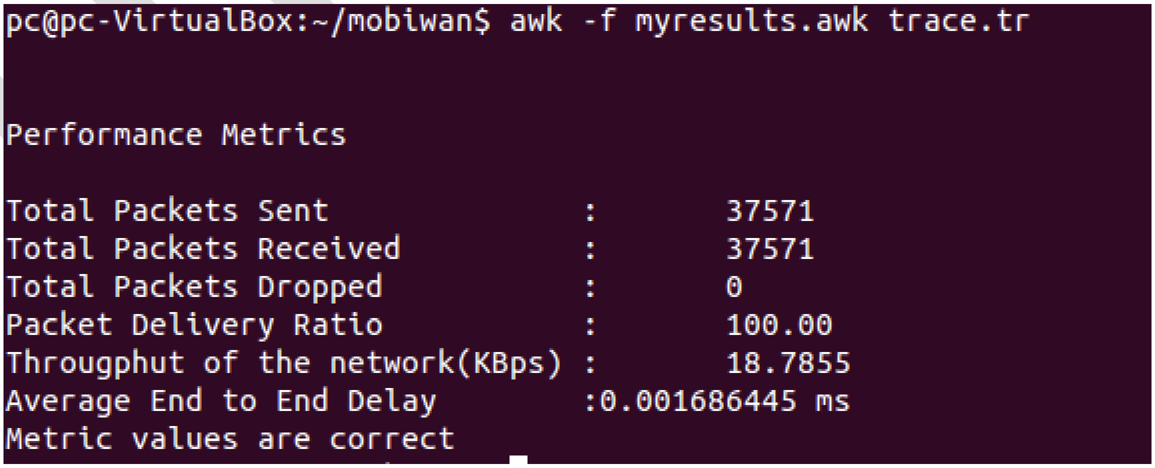

Figure 5.4 Performance evaluation of AOMDV-IOT with nodes = 50 on NS 2.35 Simulator

5.1.3 Third Scenario:

For both AOMDV and AOMDV-IOT, the network has number of nodes 75. The outcome of AOMDV and AOMDV-IOT performance for 75 nodes is shown below.

Table 5.3 Performance evaluation for number of nodes 75 (nodes = 75)

	AOMDV	AOMDV-IOT
Total Packets Sent	30397	30397
Total Packets Received	26385	30397
Total Packets Dropped	9159	0
Packet Delivery Ratio	86.80	100.00
Throughput of network	13.1925	15.1985
Average end to end delay(ms)	0.040563530	0.001498503

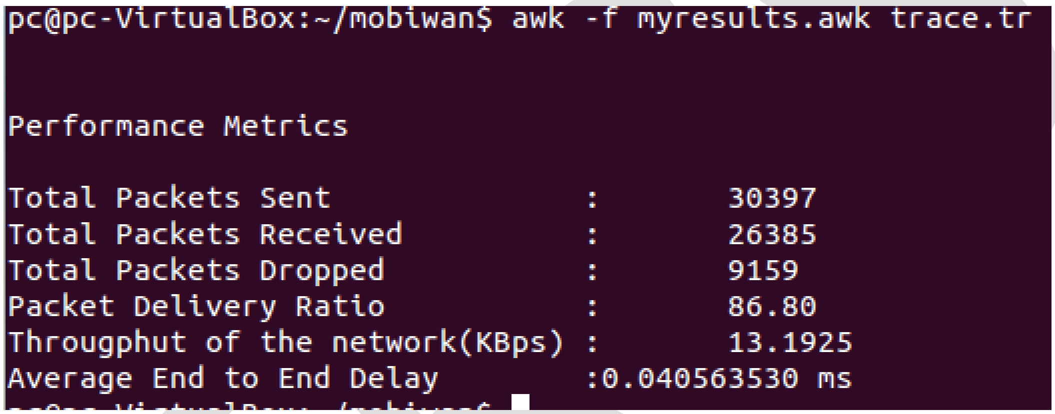

Figure 5.5 Performance evaluation and of AOMDV with nodes = 75 on NS 2.35 Simulator

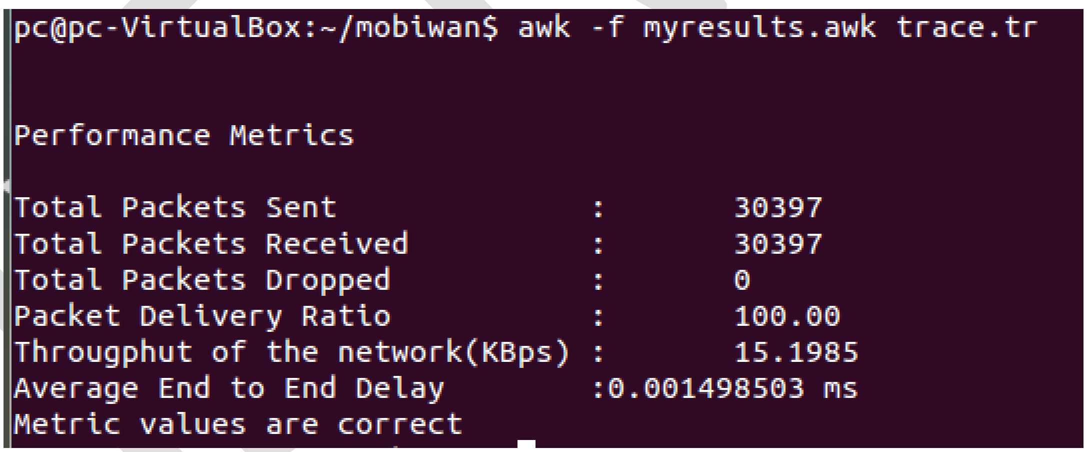

Figure 5.6 Performance evaluation of AOMDV-IOT with nodes = 75 on NS 2.35 Simulator

5.1.4 Fourth Scenario:

For both AOMDV and AOMDV-IOT, the network has number of nodes 100. The outcome of AOMDV and AOMDV-IOT performance for 100 nodes is shown below.

Table 5.4 Performance evaluation for number of nodes 100 (nodes = 100)

	AOMDV	AOMDV-IOT
Total Packets Sent	26395	26395

Total Packets Received	21793	26395
Total Packets Dropped	8713	0
Packet Delivery Ratio	82.56	100.00
Throughput of network	10.8965	13.1975
Average end to end delay(ms)	0.047285584	0.001546135

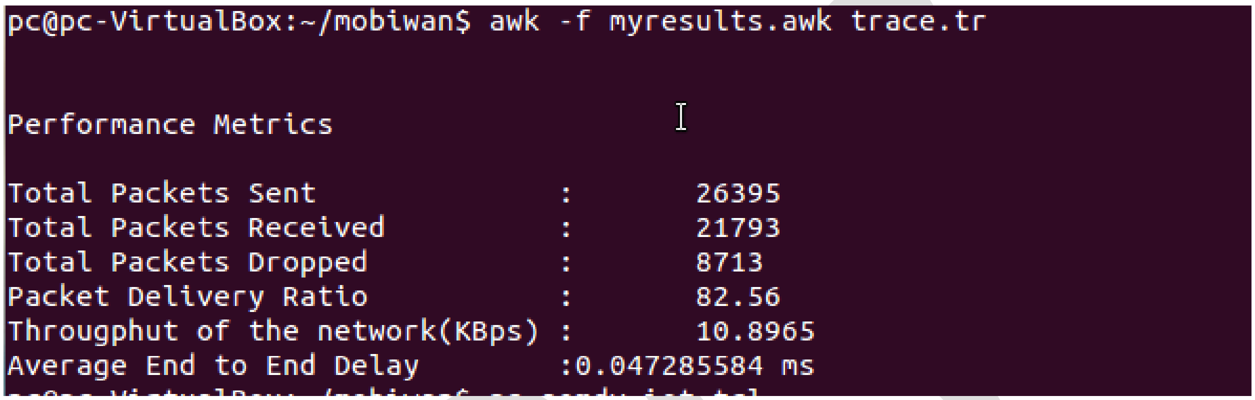

Figure 5.7 Performance evaluation of AOMDV with nodes = 100 on NS 2.35 Simulator

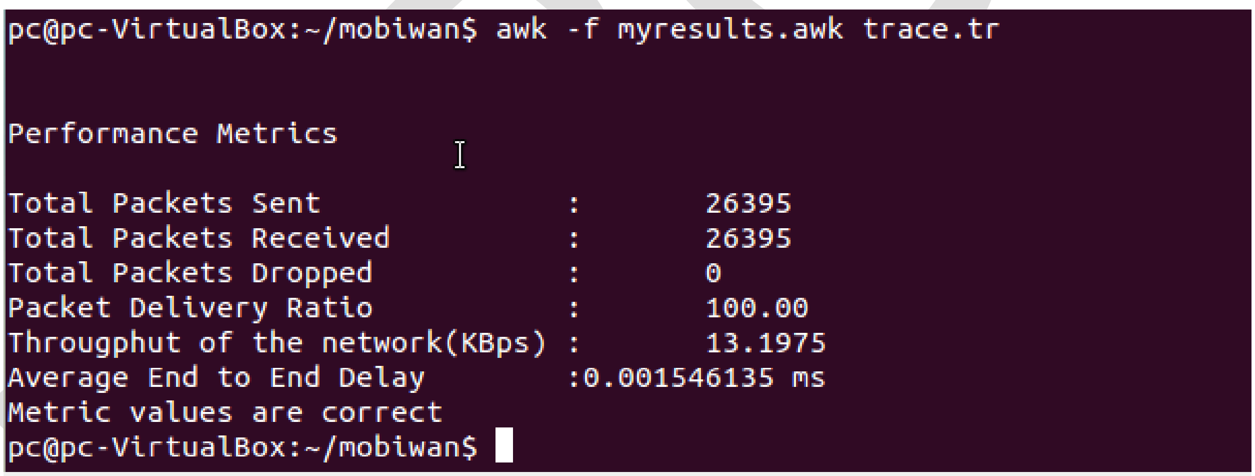

Figure 5.8 Performance evaluation of AOMDV-IOT with nodes = 100 on NS 2.35 Simulator

5.2 Summarize Results

Summarizing the simulation results of all the four scenarios we conclude our analysis of AOMDV and AOMDV-IOT with Packet Delivery Ratio, Throughput of Network and Average End-To-End Delay.

Table 5.5 Representing the Packet Delivery Ratio Summary for the four scenarios.

	AOMDV	**AOMDV-IOT**
Nodes = 25	94.59	100.00
Nodes = 50	91	100.00
Nodes = 75	86.80	100.00
Nodes = 100	82.56	100.00

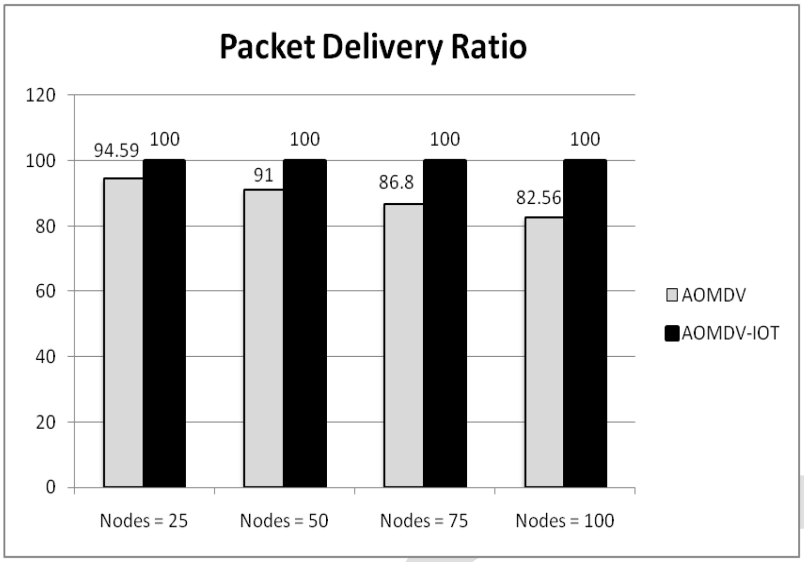

Figure 5.9 Graph representing the Packet Delivery Ratio Summary by AOMDV and AOMDV-IOT.

Figure 5.9 shows the Packet Delivery Ratio Summary by AOMDV and AOMDV-IOT.

Table 5.6 Representing the Throughput of the Network Summary for the four scenarios.

	AOMDV	AOMDV-IOT
Nodes = 25	25.0735	26.5065
Nodes = 50	17.095	18.7855
Nodes = 75	13.1925	15.1985
Nodes = 100	10.8965	13.1975

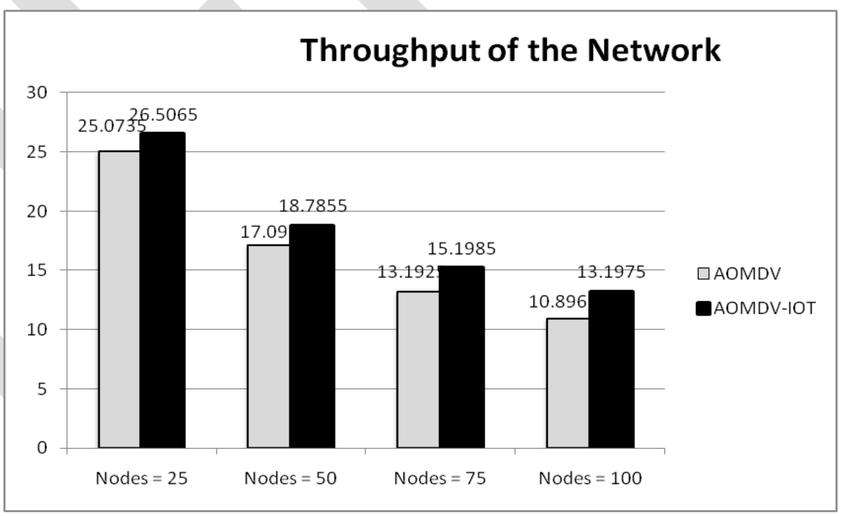

Figure 5.10 Graph representing the Throughput of the AOMDV and AOMDV-IOT Network.

Figure 5.10 shows the throughput of the AOMDV and AOMDV-IOT network.

Table 5.7 Representing the Average End-To-End Delay Summary for the four scenarios.

	AOMDV	AOMDV-IOT
Nodes = 25	0.047170916	0.00165973

Nodes = 50	0.024838866	0.001686445
Nodes = 75	0.04056353	0.001498503
Nodes = 100	0.047285584	0.001546135

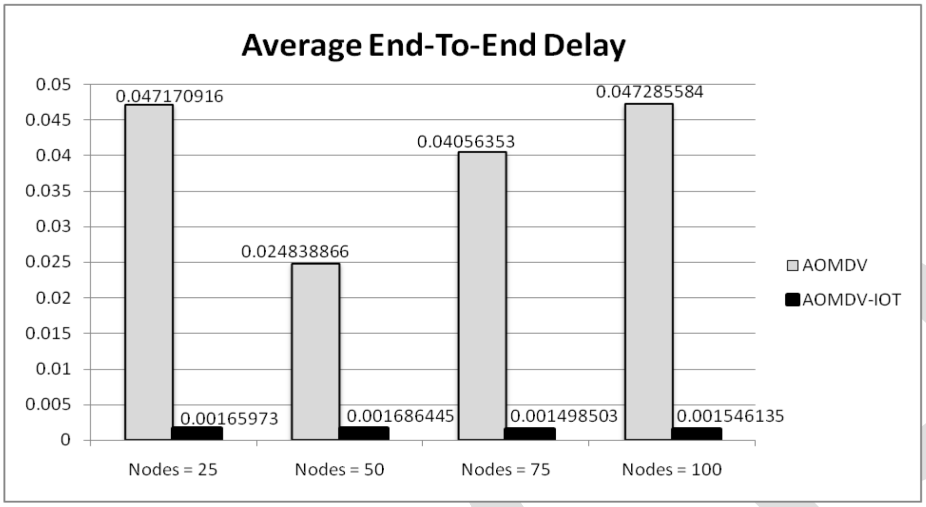

Figure 5.11 Graph representing the Average End-To-End Delay by AOMDV and AOMDV-IOT.

Figure 5.11 shows the average end-to-end delay by AOMDV and AOMDV-IOT.

CONCLUSION

Internet of Things has the widespread future by providing applications with many aids to users. Internet of Things has prominent benefits over the worldwide. As IOT is the new technology, it has some challenges. The presented dissertation discussed AOMDV routing protocol for Internet of Things to improve the algorithm by optimizing the protocol, such as routing table and internet connecting table are combined into one. Proposed AOMDV-IOT gives better performance in terms of Packet Delivery Ratio, Throughput of network, and Average End-to-End Delay.

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