Improvement of Adhoc ON Demand Distance Vector(AODV) Routing Algorithm inWireless Sensor Network (WSN)

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Improvement of Ad hoc ON Demand Distance Vector (AODV) Routing Algorithm in Wireless Sensor Network (WSN)

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1. Introduction

The telecommunication system is considered to be one of the important necessities of human life today. It is available on the several forms of technologies, one of them is wireless telecommunication that includes many techniques such as Mobile Ad hoc NETworks (MANETs). MANETs intercommunicate many combination mobile nodes using wireless channels shared among these mobile nodes. MANET categorized into multihop networks of nodes. MANET structure change consequently alterating mobility of these nodes suddenly. [Cheng, 2008]. The infrastructure of MANET connection and entrant nodes (hosts) makes the chain of transmission. The instability topology in any network comes from the mobility of its nodes which lead to searching new connection of new nodes. Thus, change of connection among nodes makes these nodes participate in the roles to becoming logical configuration [Cheng & Li, 2008].

Node in MANET is considered as the route, where it forwards packet to other nodes. The packet is delivered to a destination node by one or several nodes. Since the topology of MANET changes frequently due to some node left or another reason. This makes routing protocol of MANET play an important role in MANET. Thus, they have been investigated appropriate technique in several researches. They are available in various type such as AODV, Dynamic Source Routing (DSR), Zone Routing Protocol (ZRP), Location Aided Routing (LAR) and Destination Sequenced Distance Vector (DSDV) [Cheng & Li, 2008]. Every protocol has especial characteristics for sending packet. They have not use in real applications of WSN. This work chooses one of them that is AODV.

AODV is a distance vector type routing. It does not require nodes to maintain all destinations of all nodes as long as they are not active in the network as well as there are not available packet for sending to other nodes. When nodes want to send data, it uses different messages to discover and maintain link to destination. The messages are Route Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs). Also, when source node sends packet, it uses header processing applies which include sequence number (NS) for identifying all routes information requests and sent bytes packet thus NS preventing repeat routes information requests among nodes (Ambhaikar *et al*., 2012), as well as it can reconstructed sent bytes packet at destination. In the end, the shortest route with the same information from source to the destination is created by source nodes and one of its neighbors. Thus, the source node can use this route which has same sequence number of same information packet (Altman & Jirnenez, 2003). On other hand, several routes are available, valid and refresh themselves in wireless network. If source nodes detected other shorter route and than the current one, source node will use it instead of current between itself and destination node with same sequence number and same information packet.

New applications emerging from WSN which starts develop in many environments [Hac, 2003]. WSNs consist of a great number of sensor nodes. Their objective is collect information in their network [Cheng, 2008]. WSNs exclude the previous infrastructure like cellular and local wireless networks. Its topologies are similar in ad hoc network. It has several characteristics of sensor nodes such as the ability to wake up, join the network, go to sleep and leave the WSN dynamically [Cheng, 2008]. In contrast, a high density of the network of nodes will rise some issues, such as the intersection of sensing area, redundant data, communication interference and energy waste [Cheng, 2008].

The aim of the study is to present the study and evaluation of OADV protocol performance in WSN which is IEEE 802.15.4 or called Zigbee or Personal Area Network (PAN) in this study. The study concentrates on simulating and analyzing the performance of AODV routing protocol using NS2 2.35 simulator based on some metrics such as packet delivers ratio (PDR), packet loss and energy consumption as well as the number of nodes start from 10 to 100 with increment of 10.

The remaining paper is epitomized as follows. The routing protocol and WSN are illustrated and explained in section 2. In section 3 simulation tool and operation as well as used metrics are described. Section 4 included simulation results. Finally, conclusion of paper is showed in section 5. In the end bibliography are added.

2. Ad hoc on Demand Distance Vector Routing (AODV) for WSN

Routing Ad hoc mobile networks' protocols can be used by WSN. They are categorized to proactive, reactive and hybrid (combination of both proactive and reactive protocols). The example of proactive routing protocol is DSDV and the example of hybrid routing is ZRP. Whereas, AODV is an example of a reactive routing protocol which is chosen to be used in IEEE 802.15.4 network in this study. It builds routes between source and destination nodes on demand only.

A. The glance of AODV

Reactive routing protocols identify routes to a destination just on demand. AODV can be considered to be one of several protocols of reactive routing protocols. As shown in Fig. 2.1, the AODV protocol has messages, like Hello messages, RREQ, RREP and RERR. Hello message is used for detecting the active node whether it is available in network or not. Also Hello message monitors and checks links among neighbour nodes in wireless network. AODV broadcasts a Hello message to all neighbors of source node periodically (Chakeres & Royer, 2004).

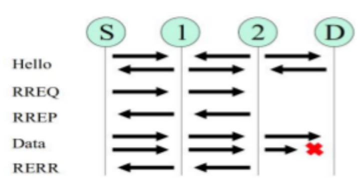
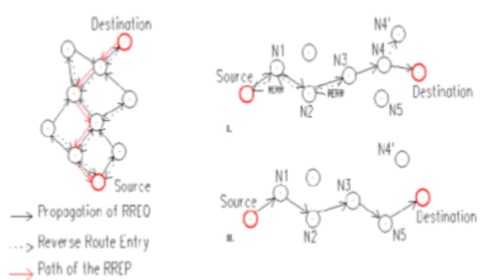


Fig. 1: AODV protocol messaging (Chakeres & Royer, 2004)

On the other hand, if the destination node is unknown to a source node, then, the source node will broadcast a RREQ to intermediate nodes. After that, when the destination receives a RREQ, it creates a route to the source by sending RREP as illustrated in Fig. 1. But sometimes destination node does not deliver RREQ from source node at the required time because it does not have current route to the required destination. Consequently, source node will rebroadcast the RREQ again (Chakeres &

Royer, 2004). Fig. 2.1 shows failed link for destination resulting from its invalid node thus, it will not receive any Hello messages from its neighbour. Then, the link becomes broken and it is detected by hello massage.

When the destination node is the same as the received node of RREQ at the first time or it know a current route to the required destination. It generates and uncasts RREP in hop by hop (node by node) method toward the source node. Where, the RREP spread among the whole intermediate nodes. Thus, the source node identifies route to destination by any intermediate nodes which produce several paths to the same destination. In contrast, multiple RREPs are available at node source. Consequently, it records them and selects one of them which include the best and shortest hops as illustrated in Fig. 2 (a). This Fig. shows the propagation of RREQ from the source and reverses route entry of the propagation of RREQ and path of RREP. Every node along route of flow data from source to destination nodes, they update the associated timers which include the routes to both source and destination as well as its neighbour nodes. Occurred invalid route because the node departs or another reason. The broken or invalid route will be observed and detected by Hello message. The data flowing through the invalid route is detected consequently. The one of neighbour nodes creates and delivers RERR to source node. Then, every intermediate node discards this invalid route. Fig. 2 (b) shows that node 4 moves to another place and this route become invalidated for destination node. If source node still needs and requests route, it will try to discover new route (Zurkinden, 2003). It selects node 5 which has route to destination node. Thus, node 5 replace node 4 from source node to its destination. Source node guarantee sending packet to its destination by node 5.



(a) **(b)**

Fig. 2: Propagation of RREQ & route maintenance (Zurkinden, 20030), (a) Propagation of RREQ and route determination (b) Route maintenance

B. Wireless Sensor Network (WSN)

WSNs are considered to be one of self-organizing Ad-hoc. WSN contains sensors distributed spatially and automatically to observe and monitor environmental or physical conditions. Wireless communication in WSN exhibits two states forms which include high energy cost and collision of packet when communicating with each other resulting from signal interference (Yu *et al.,* 2005). They are not interconnected networks of distinguished sensors and they face extreme energy constraints of resource. On the other hand, to make effective energy for WSN, an efficient algorithm should be assigned and designed. Thus WSN complex applications can overcome the challenge and crucial component in large-scale.

a. Deployment

Many forms might be available for deploy of sensor nodes in physical environment.. One of them is deploy randomly by overthrowing them from an aircraft or installing them when choosing spots deliberately (Romer, & Mattern, 2004). There are some properties that have important influences on deploying. They are like the prediction of the density of node, locations of node, regular patterns in locations of node and prediction of network dynamics degree nodes (Romer, & Mattern, 200). The deploy might be to use a network of nodes accurately and separately. Consequently, a lot of nodes deploy during a period of time which use nodes. For instance, when the node becomes failed, its interesting location should be identified by deploy of nodes and period of time for replacing or improving coverage.

b. Infrastructure

Communication modalities have many ways of several communication networks to construct themselves realistically (Romer & Mattern, 2004). There are two popular forms that are usually used: infrastructure-based networks and Ad hoc networks. The infrastructure-based networks can directly communicate via devices of stations based on networks of nodes. Therefore, communication among these nodes is based on relaying of the base station. If several base stations are available, they will communicate with each other. Nodes support them via a range of communication and cover of the area whose base stations depend on them. For instance of his kind of networks is Smart Dust and Mobile node. The Ad hoc network, their nodes connect directly without control central. Consequently, they do not need the infrastructure. Therefore, nodes in the network are considered as routes. Where they forward messages in the form of number of hops to connect each other, available multiple applications which prefer used Ad hoc networks and sensor wireless network (Romer & Mattern, 2004). Finally, incorporation, both ad hoc networks and infrastructure, lead to established networks which are used in multiple applications also.

c. Network Topology

The simplest form of sensor network is a single hop which each node starts to communicate with other node directly. Multi hops in the network might form arbitrarily to cover all network (Romer & Mattern, 2004). The topology or the construction of connection is start, tree, mesh, bus or cluster. Several characteristics of network like robust, capacity and latency are affected by topology, Also, Every topology maintains different processing of both transmitted data and routing data.

d. Coverage

The performance of sensors network is identified by range of the sensor nodes. All nodes of sensor identify coverage of network area by their range and energies because sensor of nodes are connected each other. Thus, all sensors of the nodes connect each other in coverage network area. The same physical position is covered by multiple nodes of sensors. (Romer & Mattern, 2004). Deployment spectrum member nodes should be taken into account for avoiding weakness of network coverage.

e. Connectivity

Network connectivity can be defined as a set of individual nodes of sensor to create ranges of communication in physical locations. Connection of WSN (may be multiple of hops) will be available between every two nodes. This means the WSN become connected but sometimes communication among nodes become intermittent. Thus, the network connectivity becomes intermittent also. (Romer & Mattern, 2004). Consequently, probably it can be divided to evade this trouble. Mainly, the design by protocols and fashion of gathering data have effects on connectivity of communication. Both are necessary in any WSN and should be taken into account.

3. Simulation Tool and Operation

The software was performed in two steps as follows.

A. Improving AODV Routing Algorithm for IEEE 802.15.4 Network

AODV protocol has a role in routing packets from source to destination nodes. Every node in WSN discovers the new neighbour nodes during sending packets period. Routing tables of all nodes in WSN maintain address destination, sequences number and time to live (TTL) just when they start to send packets. Nodes creating their routing tables, then they start updating them periodically and interchanging information with other neighbors nodes during sending packets.

Table 1: The parameters of improved AODV routing protocol (Ambhaika *et al.,* 2012)

Parameter	Value
Protocol	Improved AODV
No of Node	10 to 100 with the increment of 10
No of Source	7 sources
No of Destination	3 and 7 destinations
Environment Size	300 x 300 m
Traffic Type	Transmission Control Protocol (TCP)
Simulation Time	100 second
Maximum Speed	1 m/s
Packet Size	Random
Packets Rate	Random (packet /s)
MAK Layer	IEEE 802.15.4
Frequency Band	2.4 GHz
Traffic Application	File Transfer Protocol (FTP)

B. Simulation Software

The simulation is performed in Ubuntu of Linux in the environment called a visual box under windows 7. The simulation model is executed on software called network simulator (NS2 2.35) which its instructions defines the structure topology of the IEEE 802.15.4 network and the nodes motion modes as well as it the evaluation performance IEEE 802.15.4 network. Fig. 3 shows example to the creation 10 nodes group randomly (mesh topology). Network AniMator (NAM) console stops at the end of the simulation.

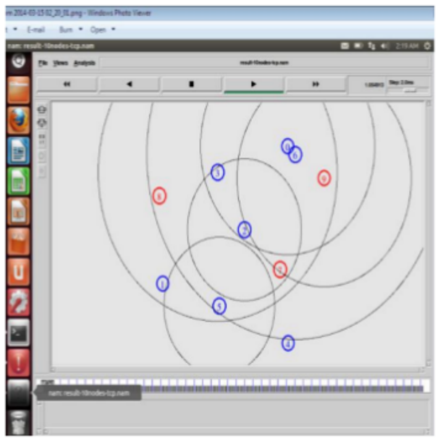


Fig. 3: Creation 10 nodes group in NS2

The simulation uses the behavior to evaluation the performance improved AODV protocol in NS2. The behavior is based on the evaluation of some metrics in IEEE 802.15.4 network (Ambhaika, 2012). The simulation considers the three significant metrics as follows.

a. Packet Delivery Ratio (PDR)

To know the reliability of the AODV protocol in IEEE 802.15.4 network (Ambhaika, 2012), simulation should utilize PDR to illustrate a portion of delivered packets. Source and destination nodes sent and received packet respectively, thus the simulation takes all source and destination nodes into account of obtain the IEEE 802.15.4 network PDR. Then, the simulation identifies reliably of the AODV routing protocol in IEEE 802.15.4 network. PDR can be calculate by the following equation (1).

$$\text{PDR} = \frac{\sum \text{delivered packet}}{\sum \text{Sent packet}} \text{x} 100\ \% \qquad (1)$$

b. Packet Loss

Packet loss in IEEE 802.15.4 network is caused by some factors such as intervention, multiple of hop and channel circumstances (Zurkinden, 2003). Therefore, when source nodes send packet„ some packet do not deliver to their destinations. Thus number of packet generated from source nodes should be determined previously, Yet, percentage of packets success and failure can be determine (Cuomo,2007). Failed Packet should take into account of all nodes which generated sent packet. In contrast, ratio between both sent and failed packet of all nodes can identify packet loss by the equation (2) as follows.

$$\text{Packet Loss} = \frac{\sum \text{Lost packet}}{\sum \text{Sent packet}} \text{x} 100\ \% \qquad (3)$$

c. Energy Consumption

The energy consumption is major factor, whereas limited battery energy is critical factor in IEEE 802.15.4. To evaluate the performance any protocol should used the average energy consumption ratio (Al-jarrah & Megdadi, 2008). Node has routing process and energy consumption in IEEE 802.15.4 network which needs energy as well as to know correct node transmission a packet. Because some nodes departure IEEE 802.15.4 network resulting their batteries depletion or another raeson. Thus these paths become failure. In this case source node should reset another route. Consequently, it broadcast control and discovery message again [Heni & Bouallegue, 2012]. On another hand, the dynamic nodes have energy consumption more than the static nodes, therefore, the lifetimes of static nodes more than lifetimes of dynamic nodes (Nagabhushan, 2011). Energy consumption of any node depends on its position and different scenarios of network. Energy efficiency is equal to all transmitted bits divided all energy consumption. All transmitted bits include just data packet by application layer. Whereas, all energy consumptions are calculated by every node as follows sum them during time of simulation (Kulkarni & Roa, 2006).

Moreover, in this simulation evaluation the performance OADV routing protocol in IEEE 802.15.4 network through different scenarios [Cuomo *et al.,* 2007]. It uses the number of nodes of groups 10 to 100 nodes of IEEE 802.15.4 with the increment of 10. The simulation scenarios run ten times, and then the simulation determines the metrics magnitudes average of every scenario.

4. Simulation Result

A. Simulation Set-up

The simulation was designed for 10 nodes then the number of nodes was increased to 100 by using the increment number of 10. The average values of metrics such as packet deliver ratio (PDR), packet loss and energy consumption of each group are identified in the simulation.

B. The results of Used Metrics

The simulation was used three metrics which their results as follows.

a. Packet Delivery Ratio (PDR)

Fig. 4 illustrates PDR average values which are presented by AODV protocol of all groups from 10 to 100 nodes with the increment of 10. The highest PDR average is

71.00 % at 10 and 20 nodes groups, its lowest value is 28.32 % at 100 nodes group. According to these PDR averages, the higher number of nodes result to lower PDR average. PDR average of the rest groups is between 31.41 % and 54.70 %. The reason is some packet dropped at MAK layer due to congestion at some points especially in the group of 80 and100 nodes because HELLO messages were broadcasted by AODV routing protocol periodically.

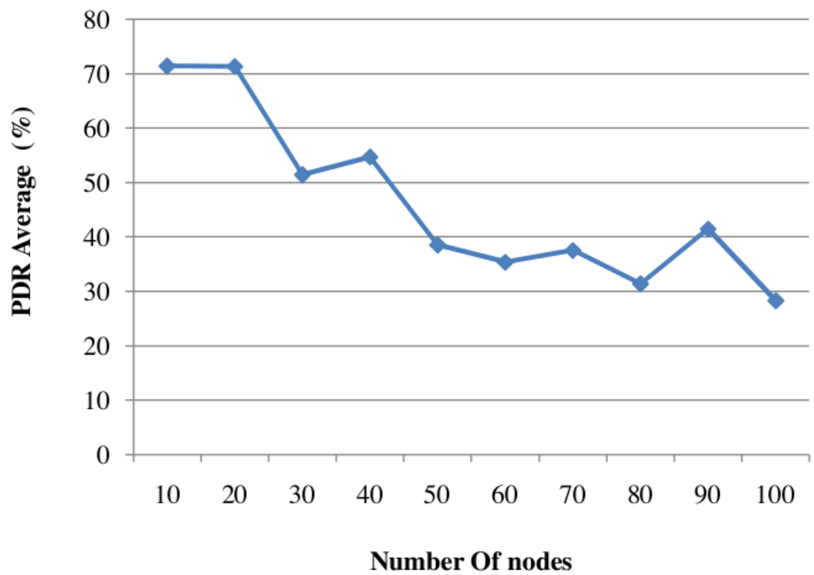


Fig. 4: PDR average values of nodes groups

b. Packet Loss

Fig. 5 illustrates the packet loss average values of groups of 10 to 100 nodes with the increment of 10. More of the sources of nodes groups delivered packet to their destinations including small errors rate.

AODV routing protocol gives high quality of source of nodes for sending a packet successfully. This Fig. shows lower packet loss at 10 and 20 nodes groups with 16.26 % and 14.79% respectively resulting to low number of nodes. On the other hand, AODV routing protocol uses number of control messages such as RREQ, RREP and RERR at the MAC layer. These messages establish connection between both source and destination to satisfy their network. Sometimes the source node does not find the route to destination in the first transmits. Thus, it needs more than one of control messages and nodes which consequently causing high packet loss such as 59.68 % at 100 nodes group.

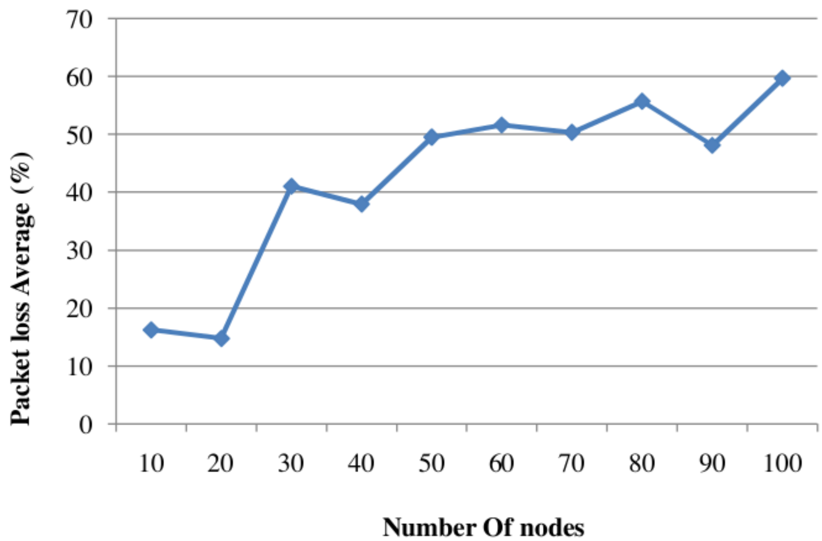


Fig. 5: Packet loss average values of nodes groups

c. Energy Consumption

Fig. 6 illustrates the energy consumption average values of group of 10 to 100 nodes with the increment of 10. The energy consumption average values of all nodes groups is between 72.244 W.s for 10 nodes group and 22.899 W.s for 80 nodes group.

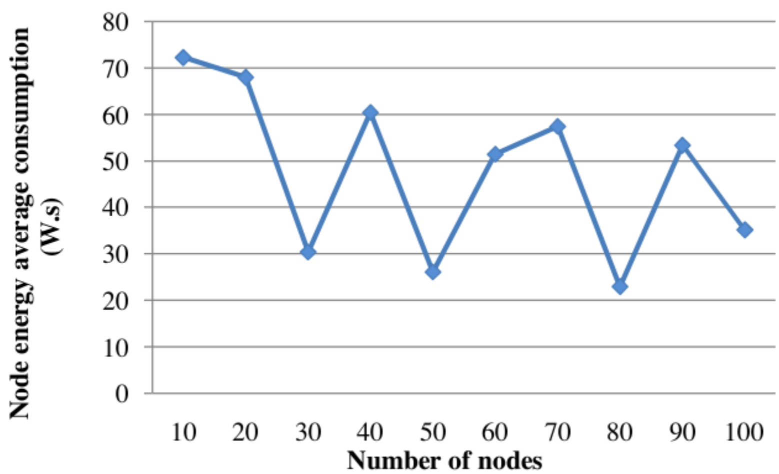


Fig. 6: Energy consumption average values of Nodes groups.

These values are fairly good compared to the input energies. The interpretation is that, AODV is reactive routing protocol and discovers route on demand. Consequently node consumes energy only on demand for sending or delivering a packet. On other hand, the static nodes consume lower energy than the dynamic Nodes. The dynamic nodes consume higher energy to move and change their positions. AODV routing protocol chooses the best and shortest route and also uses DSN to prevent routing loops. Therefore, AODV is loop free and reliable as well as quick to respond to link broken link. Thus, it repairs routes with minor errors. The low energy consumption is shown in Fig. 6.

5. Conclusion

The study has interpreted and evaluated the performed AODV routing protocol via IEEE 802.15.4 network.. AODV was evaluated and analysed based on many scenarios of number of nodes by NS2 simulation. This simulation set the first scenario of 10 nodes of IEEE 802.15.4 at the initial then start to increase number of nodes as follows 20 to 100 with the increment of 10. The study identified the average values of some metrics of all nodes groups in simulation such as PDR, packet loss and energy consumption as well as one kind of traffic which is TCP over FTP.

Results of simulation demonstrated average PDR values presented by simulation of all groups of nodes are decreased when number of nodes group increasing. High number of nodes has bad impact in PDR of nodes groups resulting increased the congestion in network especially in the group of 80 and100 nodes. Consequently, packet loss values are increased as increasing number of nodes of the groups. Also, the results of simulation exhibited the energy consumption average values of all nodes groups. Approximately all average energy consumption values are low and fairly good compare than initial input energies.

From this result and evaluate the performance of AODV protocol via IEEE 802.15.4 network. AODV routing protocol might help in future for further development of IEEE 802.15.4 networks with regard of the number of nodes, because, it is not a appropriate candidate routing protocol for high number of nodes in IEEE 802.15.4 networks.

6. Acknowledgements

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