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# Comparison and Performance Evaluation of Wireless Sensor Network with different Routing Protocols

D.D.Chaudhary[1] (*Member IACSIT*), Pranav Pawar[2], Dr. L.M. Waghmare[3]

[1]Sinhgad Institute of Technology Lonavala, Dist. Pune, MS. India. 410401. Research Scholar at Aalborg University, Denmark. *dipra1987@gmail.com.*

[2] SKN College of Engineering Pune, MS. India. 411041.

*pranav21684@gmail.com.*

[3]Shri Guru Govind Singhji Institute of Technology Nanded MS India. 431601.

*lmwaghmare@yahoo.com.*

**Abstract.** In modern industrial automation scenario, Wireless Sensor Networks (WSN) becomes a very popular technology. It is highly demanding in industrial applications such as the monitor or control of temperature, humidity and pressure. A reliable transmission of packet data information, with low latency and high energy-efficiency, is truly essential for wireless sensor networks, employed in delay sensitive industrial control applications. The proper selection of the routing protocol to achieve maximum efficiency is a challenging task, since latency, reliability and energy consumption are inter-related with each other.

It is observed that, Quality of Service (QoS) of the network can improve by minimizing delay in packet delivery, and life time of the network, can be extend by using suitable energy efficient routing protocol. The three protocols namely Ad-hoc on-Demand Distance Vector (AODV), Destination Sequence Distance Vector (DSDV) and Ad-hoc on-Demand Multipath Distance vector (AOMDV) are compare and analyze. They also compared with IEEE802.11 and IEEE802.15.4 MAC protocol.

In this paper, overall performance of WSN is analyzed by comparing the End-to-End delay, Number of packet received, Packet drop ratio and Energy consumption of the Network. This was done with the help of simulation results, derived by using Network Simulator, NS-2 for proposed Network Model in different traffic conditions. These results may be particularly useful for deployment of sensor network for Industrial control.

**Keywords**: AODV, AOMDV, DSDV, End-to-End Delay, Energy Consumption, Wireless Sensor Networks.

## 1. Introduction

A Wireless Sensor Network is a network of many sensor nodes, having wireless channel to communicate with each other. Without any centralized control and predefined communication link, it can transfer signals to the exterior world. All nodes are capable to act as source or sink node at the same time. These nodes have a limited processing power because of their tiny physical size, which limits the capacity of processor and size of battery. When collectively works together, they have an ability to collect information of the physical environment. They have transceiver to communicate with the virtual world and the physical world. Routing topology to be used for the network depends on the transmission power available at its nodes. It also depends on the node's location, which may vary time to time. The main problem in ad-hoc networking is the efficient transmission of data packets to the mobile nodes. Hence, proper routing in ad-hoc networks is the challenge to the designers.

Efficient data packet transmission is the main goal in a wireless sensor networks. Sensor nodes collect the information, process it and send it to the base station. End-to-End delay is the most significant factor for assessing the Quality of Service. It is the time taken by a node, to sense, to process and to communicate with other nodes. It also depends on the scope of an application. Time delay in a network is calculated based on these activities as well as how much time a sensor takes to forward the data in heavy load traffic. When large numbers of nodes are uniformly deployed to transmit the data packets then, the network should be able to provide the guarantee of low-delay and low-error rate [1].

Low delay guarantee is the probability of delay in packet delivery from sources to destination, constrained within the time of '$T$'seconds on required probability, $P$ [E2E $\leq T$] $\geq$ 0.96. Low error rate guarantee is decided by the Packet Reception Rate (PRR). It is the probability, of that a data packet which is to be received at the proper destination. It is usually considered to better if it is more than Ω: $P$ [correct] ≥ Ω. It is observed that in the multi-hop scenario of MAC protocols, the delay introduced by periodic sleeping of sensor Node. When data packet moves through a multi-hop, it offers the various delays, such as, Carrier sense delay, Back-off delay, Transmission delay, Propagation delay, Processing delay and Queuing delay. These all delays depended on efficiency of a processing algorithm and the computing power of the node [2].

In multi-hop network using contention-based MAC protocols, these delays are inherent. These factors are the same for both S-MAC and 802.11-like protocols. In S-MAC, an additional delay may introduce because of the periodic sleeping of every node. Sender must wait until the receiver wakes up when he gets a packet to transmit. It is delay caused by the sleep of the receiver. It is observed that, in the latency calculation with MAC protocols, if we consider that only one packet is moving in the network then queuing delay and back off delay may be ignored. Delays related to propagation and processing are also negligible to eliminate. Carrier sense delay, Transmission delay and Sleep delay have to be considered [3].

There are so many routing protocols are available, but in this paper, three protocols DSDV, AODV and AOMDV are compared and analyzed. They also compared with 802.11 and 802.15.4 MAC protocol. Though main emphasis is given on End-to-End delay, but Energy consumption, Packet received and Packet drop ratio is also compared and analysed. In next sections of this paper, there is a brief discussion of these protocols followed by details of proposed network model and concluded by simulation results and conclusion.

## 2. Routing Protocols

Routing protocols in WSNs depends on network architecture and application. Sensors nodes have limited available power. So that energy efficient routing protocols is truly crucial for life of WSN. The major routing protocols are of two types i.e. Protocol operation type and Network structure type. Protocol operation type is sub-classified as Multipath based; Query based; Negotiation based; QoS based and Coherent based routing protocols. Other type is Network structure, which is categorized as Flat-based; Hierarchical-based routing (Cluster-based routing) and Location-based routing protocols [4]. Routing protocols are designed to satisfy task such as collision avoidance or prevention and faster data transmission. So that energy efficiency and low latency can be achieved. The three protocols considered here are DSDV, AODV and AOMDV and are discussed in following sections.

### 2.1. DSDV protocol

In Destination-Sequenced Distance Vector routing protocol (DSDV), routing messages are exchanged between neighbouring mobile nodes. Updated messages are got triggered in case routing information from one of the nearby node. This data get change in the routing table data. Packets for which route to its destination is unknown that packets are cached and, its routing queries are sent out in that duration.

The packets are allowed to receive till route-replies are received from the destination. The precise maximum buffer size of memory is available for collecting those packets, waiting for routing information. If the packets are received beyond that size then, that packets may be dropped. The sequence number to each entry is allotted. This numbers are generated by destination, and it is mostly even number if a link is present otherwise it is an odd number. Further, it is necessary for the transmitter to transmit the next update with this sequence number [5].

Routing protocol DSDV is explored by C. Perkins and P. Bhagwat in 1994. It is based on the Bellman-Ford algorithm and it is a table-driven protocol. This algorithm is suitable to solve the routing loop problems in the networks consist of a small number of nodes. Since DSDV has limitations to use for dynamic network, its improved versions are available.

## 2.2. AODV Protocol

Ad hoc On Demand Distance Vector (AODV) protocol is suitable for 'Unicast' and 'Multicast' routing. It is designed for ad hoc mobile networks. It is loop-free and self-starting protocol. It builds routing paths between the nodes only if demanded by the source nodes. This routing path will remain connected, till that particular node requires the same. It is suitable for large numbers of mobile nodes and it give new sequence numbers to newly generated routes. To assign a new destination sequence number, for every route entry is the unique feature of AODV protocol. Sequence number is use to keep track on updated information at that destination node. It consists of route information, which it has to send, to requesting nodes. When there is a choice between two routes then requesting node have to select that route with the greatest sequence number.

AODV is a combination of DSDV and DSR (Dynamic Source Routing) protocols. As similar to DSDV protocol, it also uses the routing sequence numbers per hop, and similar beacons of DSDV. It uses the basic route-discovery and route-maintenance technique as in DSR. The AODV routing protocol is suitable for large mobile nodes. It can handle different mobility rates with a variety of data traffic levels and quickly adapt to dynamic link conditions. Low processing times, small memory overhead, Low-network utilization, are some more advantages of AODV protocol [6].

## 2.3. AOMDV Protocol

An extension to AODV is Ad-hoc on-demand Multipath Distance Vector (AOMDV) routing protocol which is for computing multiple loop-free and link disjoint paths. For each destination, along with the respective hop counts it contains a list of the routing entries of the next-hops. Same sequence number is allocated to all next hops. This helps for keeping track of a route. A node maintains the assigned hop count, which is the maximum hop count for all the paths at each node. Loop freedom is assured for a node by accepting another path to destination if it has a less number of hop counts than the assigned for that destination. AOMDV allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. During route discovery, its message overhead is high, due to increased flooding. Since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overhead [7].

In this paper, all these three routing protocols are compared for proposed network model using NS-2 simulation software as shown in the next section.

# 3. Proposed Network Model and Parameters

The network model consider for simulation is as shown in figure 1. In this paper, the industrial wireless sensor network environment is proposed. It consists of single sink node and multiple source nodes. Model is design for the Multi-hop situation. The simulation parameter and node configuration is listed in Table 1.

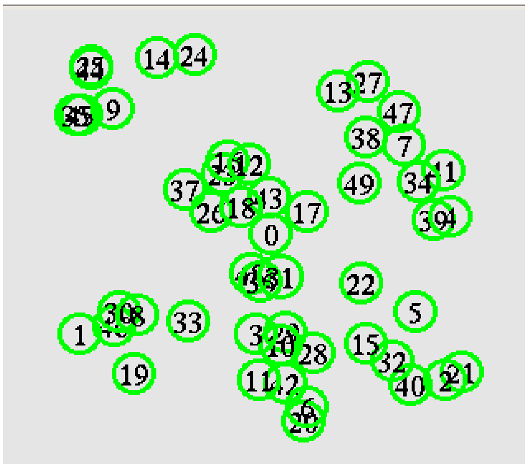

Fig.1: Proposed Network Model.

Table1: Simulation Parameters

| S.N. | Parameter | Details |
|---|---|---|
| 1 | Node Placement | Random |
| 2 | No. of Nodes | 50 |
| 3 | No. of sink (destination) | One (Node 0 ) |
| 4 | No. of sources | 49 (Node 1 to 49) |
| 5 | Area of simulation | 100 m*100 m, Short |
| 6 | Traffic Interval | Varying from 1to10 Sec. |
| 7 | Packets generated by each source | 100 |
| 8 | Total packets generated in N/W | 100*49 = 4900 |
| 9 | Size of each packet | 100 Bytes |
| 10 | Model | Energy Model |
| 11 | Initial energy | 1000J |
| 12 | Transmitting Power | 36.00mW |
| 13 | Receiving Power | 14.4mW |
| 14 | Transmission Range | 250m |

In figure 1, Node zero is sink node. All nodes from 1 to 49 are source nodes. Every source node will generate 100 packets, which may contain data of size 100 bytes in each packet. Therefore, total number of events send from all sources is 4900. The simulation area is considered as 100 meters by 100 meters. In this paper, the results are created by using Network Simulator [8]. It is a discrete-event simulator, and it has accurate implementation with TCP and fully compatible with other transport protocols. The radio power values used to compute energy consumption in various modes, such as idle, transmitting, receiving, and sleeping mode. These all values are available from the data sheet of 'RFM TR3000' radio transceiver.

The TR3000 hybrid transceiver is suitable when short-range wireless data is to be communicated. It supports robust operation with low power consumption and advantages of small size and low cost. The TR3000 consist of RFM's amplifier sequenced hybrid (ASH) architecture with excellent sensitivity and stability. Even in the presence of on-channel interference and noise condition its performance is robust. It has a wide dynamic range log detector with digital AGC and a compound data slicer. It has two stages of SAW filtering which helps to provide excellent out-of-band rejection. Its transmitter can work with on-off keyed or amplitude-shift keyed modulation techniques [9].

# 4. Simulation Results and Analysis

## 4.1. Measurement of Received Packets

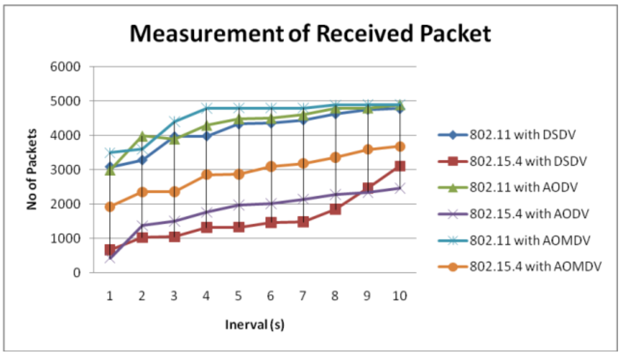


Fig. 2: Measurement of Received Packet

From the figure 2, it is observed AOMDV with IEEE 802.11 has the highest efficiency in receiving packets as compared with other protocols. Receiving packets rate of IEEE 802.15.4 with DSDV is lowest but may be increases after the interval of 8 and on word. Therefore, for high-throughput applications, AOMDV Protocol is most suitable.

## 4.2. Measurement of Packet Drop

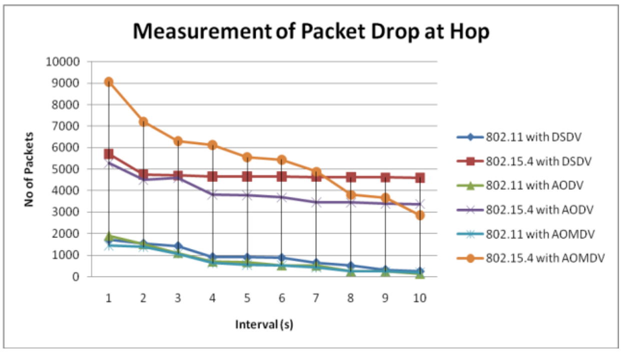


Fig. 3:Measurement of Packet Drop

From figure 3, This analysis shows that, the packet drop ratio in IEEE802.11 with all three protocols is less as compared to IEEE 802.15.4. It is because 802.11 has a transmission range of more than 120 meters as compared only 75 meters for 802.15.4. As compared to other two, AOMDV with 802.15.4 may have worst performance for lower interval, It but may improve, if the number of the interval is higher.

## 4.3. Measurement of Energy Consumption

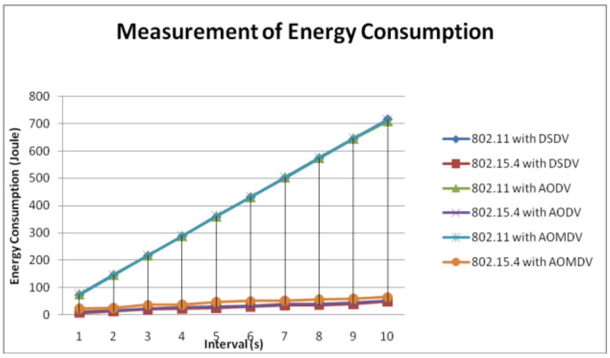


Fig. 4: Measurement of Energy Consumption

This graphical results from figure 4, are highly significant, because it may decide the life span of WSN. Graph shows that energy consumption is higher in all routing protocol for IEEE 802.11 standards, since it is a high-power transmission method. On the other hand, IEEE 802.15.4 standard is the low-rate transmission so that energy consumption is less in all three protocols. So that for the long-life applications IEEE 802.15.4 may be the right option.

### 4.4. Measurement of Delay

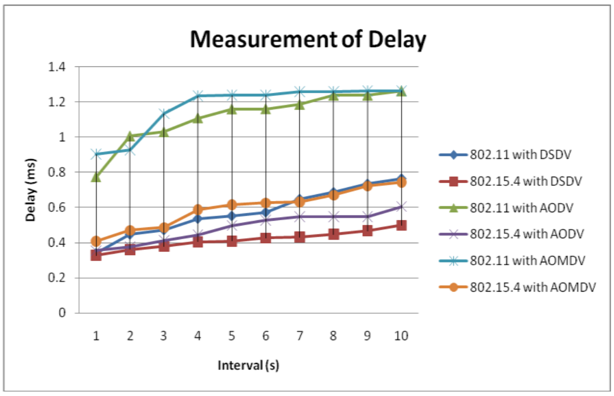


Fig. 5: Measurement of Delay

This graphical results from figure 5 are extremely powerful. It shows that End-to-End delay in IEEE 802.15.4 with DSDV is lowest as compared with AODV and AOMDV. It has significantly higher delay with an AOMDV as compared with AODV.

This shows that for delay-sensitive applications, DSDV protocol with IEEE 802.15.4 standards is remarkably well suitable.

## 5. Conclusions

Wireless sensor network is highly emerging area for industrial control and monitoring applications. In some typical application like, disaster management or environmental control, the delay in data transmission is not acceptable. In these applications, the selection of appropriate routing protocol is extremely crucial. In this article, three protocols i.e. DSDV, AODV and AOMDV are compared with 802.11 and 802.15.4 IEEE standards. From the all the graphical results, which are explored using NS2 simulator, it is observed that, for delay-sensitive applications, it obligatory to adopt the 802.15.4 IEEE standard with DSDV routing protocol. The energy consumption is also low in this combination. The limitation of this protocol is that its throughput is limited because its packet drop ratio is large. The applications where throughput is vital and, delay can be tolerated, then the 802.11 with AOMDV, can be the best solution.

It is observed that overall Quality-Of-Service depends on proper selection of the routing protocol, for a particular application of wireless sensor network. These results may be immensely useful to the designers and engineers for deployment of actual wireless sensor network in Industrial automation and control.

## 6. Acknowledgement


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