The Effect of Routing Protocols on End-to-End Delay and Energy consumption in event driven Wireless Sensor Networks

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Abstract
Wireless Sensor Networks (WSN) have become an very important technology for many applications such as the monitor and control of physical environment in Military, Industry and civilian areas, Home automation, Disaster monitoring and control, Target detection, Target tracking, Tactical systems and so on. Since power requirement of sensor nodes is depends on range of application and its availability is limited, so that energy efficient protocols has to be design in order to extend the lifetime of the networks. In most of the applications it is very difficult to replace the battery after its expiry and in some applications tiny sensor nodes typically operate with a small size of battery power so that energy efficient operations is very important issue. Energy conservation at MAC layer is found to be the most effective one because it controls the radio operations directly. In addition to this end-to-end delay is also one of the most critical issues for WSN application. Sensor networks deployed in industrial environment have very strict timing constraints on operation and its final end-to-end delay. However, the end-to-end delay is difficult to predict and measure for event- driven sensor networks, where nodes generate and propagate data only when an event of interest occur and thereby producing unpredictable traffic load. In this paper analyses is done for the end to end delay and energy consumption in event driven wireless sensor network by using two protocols i.e. Ad-hoc On-demand Distance Vector (AODV) and Destination Sequence Distance Vector (DSDV), under IEEE 802.11 as MAC layer protocol. The simulation results shows that end to end delays by using DSDV are lesser than AODV and it also shows slightly lower energy consumption than AODV in different traffic conditions.

Keywords:
AVDV, DSDV, End-to-end delay, Energy consumption, Wireless sensor networks

I. Introduction

Wireless Sensor Networks (WSNs) are a spatially distributed autonomous system which is a collection of power-conscious wireless sensors. The recent advances in MEMS (Micro Electro Mechanical Systems) [10], Digital Signal Processing and Wireless Communications have led to the production of new class of wireless, battery operated smart sensor nodes. So that, wireless sensor networks technology have attracted more and more related researchers for its advantages.

These networks will consist of large numbers of distributed nodes that organize themselves into a multi-hop wireless network. Each node has one or more sensors, embedded processors and low-power radios, and is normally battery operated. Typically, these nodes coordinate to perform a common task. WSN is useful in many applications like Industrial control, habitat monitoring, ubiquitous healthcare etc.

This paper concentrates on industrial application of WSN.

In industrial application quality of service of WSN is very important. The factor consider for maintaining good quality of service in industrial application are end to end delay, energy consumption, throughput, packet delivery ratio etc. These very strict timing requirements, if there is delay of fraction of second which leads to big hazard. It also has stringent energy requirement, if battery of any node will fail it leads failure of network. Here, the paper concentrates on this two major issues end-to-end delay and energy consumption. [1]

The delays and energy consumption will introduce in all layers of WSN. The paper considers the delays and energy consumption happen at medium access control (MAC) layer and routing layer. The MAC protocol used is IEEE 802.11 **application** which is widely used in low cost protocol for industrial application of WSN. Two routing protocol consider are AODV and DSDV, which are widely used protocol in ad-hoc wireless network.

The scope of this paper is to analyse the end-to-end delay and energy consumption of single sink environment of industrial by considering IEEE 802.11 as MAC protocol and AODV and DSDV as routing protocol under different traffic load conditions by using NS-2 (Network Simulator-2) [5].

The remainder of the paper is organized as follows: Section 2 gives short overview of IEEE 802.11, AODV and DSDV protocol. Section 3 describes the network model and simulation environment. Section 4 shows the simulation result and analysis of it.

II. Mac and Routing Protocol

This section gives the overview of MAC and routing layer protocol used in the experimentation. The MAC layer protocol used in IEEE 802.11 and two routing protocol

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i.e. Ad-hoc On-demand Distance Vector (AODV) and Destination Sequence Distance Vector (DSDV), are used for analysing the effect of routing protocol on end-to-end delay and energy consumption under different traffic load conditions. Traffic load is created in simulation environment and results are analysed.

A. IEEE 802.11 MAC PROTOCOL

It is a set of standards carrying out wireless local area network (WLAN) computer communication in the 2.4, 3.6 and 5 GHz frequency bands.

As compared to a wired LAN there are a number of characteristics that are unique to the wireless environment that the 802.11 standard have taken in to consideration. The physical characteristics of a wireless LAN introduce range limitations and unreliable media, dynamic topologies where nodes move about, interference from outside sources, and lack of the ability for every device to be in the coverage range of every other device within the WLAN.

Due to these limitations the 802.11 WLAN standards are used for short-range LANs made up of components that are within close proximity of each other. 802.11 addresses security, mobility, reliability, and the dynamic nature of wireless LANS while keeping compatibility with 802-type legacy networks.

The IEEE 802.11 is a well known contention based medium access control (MAC) protocol which uses carrier sensing and randomized back- offs to avoid collisions of the data packets. The Power Save Mode (PSM) of the IEEE 802.11 protocol reduces the idle listening by periodically entering into the sleep state [2].

This PSM mode is for the single hop network where the time synchronization is simple and may not be suitable for multi-hop networks because of the problems in clock synchronization, neighbour discovery and network partitioning.

B. DSDV ROUTING PROTOCOL

In Destination-Sequenced Distance Vector routing protocol (DSDV), routing messages are exchanged between neighbouring mobile nodes [3, 12]. Routing updates may be triggered or routine. Updates are triggered in case routing information from one of the neighbours forces a change in the routing table. A packet for which the route to its destination is not known is cached while routing queries are sent out.

The packets are cached until route-replies are received from the destination. There is a maximum buffer size for caching the packets waiting for routing information beyond which packets are dropped. DSDV was one of the early algorithms available. It is quite suitable for creating ad hoc networks with small number of nodes. Since no formal specification of this algorithm is present there is no commercial implementation of this algorithm

In DSDV, each route is tagged with a sequence number which is originated by the destination, indicating how old the route is. Each node manages its own sequence number by assigning it two greater than the old one every time.

When a route update with a higher sequence number is received, the old route is replaced. In case of different routes with the same sequence number, the route with better metric is used. Updates are transmitted periodically or immediately when any significant topology change is detected.

The performing routing are updated by two way , “full dump”, where a node transmits the complete routing table, and “incremental update”, where a node sends only those entries that have changed since last update. DSDV employs a "settling time" data, to avoid fluctuations in route updates, which is used to predict the time when route becomes stable. In DSDV, broken link may be detected by the layer-2 protocol [2], or it may instead be inferred if no broadcasts have been received for a while from a former neighbouring node.

The main contribution of the algorithm was to solve the Routing Loop problem. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present; else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number [13].

C. AODV ROUTING PROTOCOL

This Ad hoc On Demand Distance Vector (AODV) protocol [4] is capable of both uncast and multicast routing and it is designed for ad hoc mobile networks. It builds routes between nodes only as desired by source nodes and maintains as long as they are needed by the sources. AODV also forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes.

One distinguishing feature of AODV is its use of a destination sequence number for each route entry. The destination sequence number is created by the destination to be included along with any route information it sends to requesting nodes. Using destination sequence numbers ensures loop freedom and is simple to program. Given the choice between two routes to a destination, a requesting node is required to select the one with the greatest sequence number. [11]

AODV is a combination of both DSR (Dynamic Source Routing) and DSDV protocols. It has the basic route-discovery and route-maintenance of DSR and uses the hop-by-hop routing, sequence numbers and beacons of DSDV. The node that wants to know a route to a given destination generates a ROUTE REQUEST. The route request is forwarded by intermediate nodes that also create a reverse route for itself from the destination. When the request reaches a node with route to destination it generates a ROUTE REPLY containing the number of hops requires reaching destination. All nodes that participate in forwarding this reply to the source node create a forward route to destination.

The AODV routing protocol is designed for mobile ad hoc networks with populations of tens to thousands of mobile nodes. AODV can handle low, moderate, and relatively high mobility rates, as well as a variety of data traffic levels. AODV is designed for use in networks where the nodes can all trust each other, either by use of preconfigured keys, or because it is known that there are no malicious intruder nodes. AODV has been designed to reduce the dissemination of control traffic and eliminate overhead on data traffic, in order to improve scalability and performance.

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is intended for use by mobile nodes in an ad-hoc network. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the ad-hoc network.

III. Network Model and Simulation

The environment or network model consider for simulation purpose is as shown in figure 1. Here in this paper we have considered the industrial wireless sensor environment which consists of multiple source nodes and single sink node. The model is design for multi-hop and one hop situation.

In figure 1, node 0 is sink node and node1 to node 36 are source nodes. Every source is generating 100 packets each of size 100 bytes. Therefore total number of events sends from all sources are 3600. The simulation area is considered as 2500 meters by 1000 meters. The all other parameters which are considered for simulation are as shown in table 1 and 2.

In this paper, the graphical results created by using Network Simulator .It is discrete event simulator and more common among researcher's community since it is an open- source simulator. It has accurate implementation and substantial support for TCP as well as other other transport protocols over conventional wired network. The NS -2.34 version is used here for the simulation.

The radio power values used to compute energy consumption in idle, transmitting, receiving, and sleeping state are in accordance with the data sheet of RFM TR3000 radio transceiver on Mica Motes [6]. The list of Simulation parameter and node configuration parameter sets are considered as per Table 1 and Table 2 respectively.

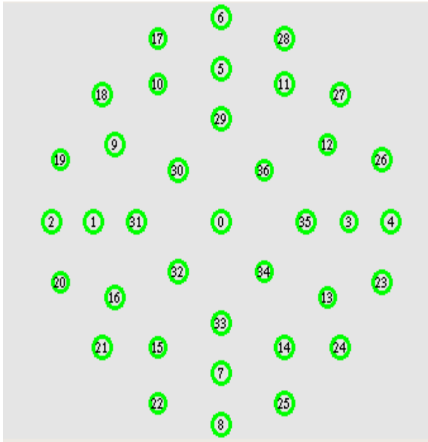

Figure 1. Proposed Network Model

Table 1.Simulation Parameters

Simulation Area	2500m * 1000m
Model	Energy Model
Initial energy	1000J
Transmitting Power	36.00mW
Receiving Power	14.4mW
Transmission Range	250m

Table 2: Node Configuration Parameters

Channel Type	Wireless Channel
Radio Propagation Model	Two Ray Ground
Antenna Model	Omni Antenna
Network interface type	Wireless Physical
MAC Type	802.11
Routing Type	AODV and DSDV
Interface Queue Type	PriQueue/CMUPriQueue
Buffer size of IFq	50

IV. Simulation Results and Analysis

With the help of network simulator and considering above parameters following results are obtained.

The above figure 2 and 3 shows the measurement and comparison of End-to-End delays. The graph shows that the end-to-end delays in 802.11 with DSDV are lesser than 802.11 with AODV. Both the figures show that when interval is small then the routing protocol AODV performs better than the DSDV. In graph, for interval one and two the end-to-end delays in case of AODV are better than DSDV but as the interval increase DSDV performs better than the AODV. The reason for this kind of behaviour is, DSDV exchanges routing messages with the neighbouring nodes to decide the route and then it will start actual data transfer but in AODV the routing is hop by hop routing. Therefore when interval is small DSDV require time to transfer routing messages to neighbouring nodes and then data transmission. [3, 4] .This shows that for particular wireless sensor node applications where number of nodes are less then AODV is suitable option, otherwise for large node application one must use DSDV routing protocol.

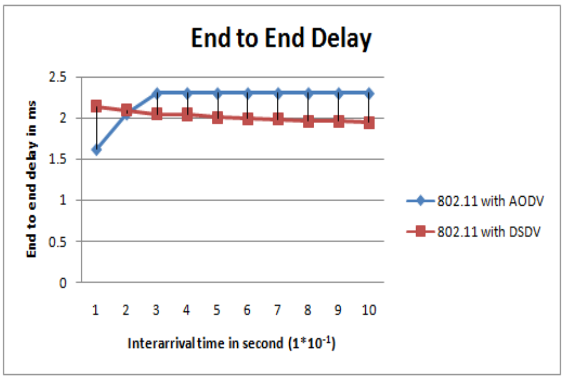

Figure 2: Measurement of End-to-end Delay

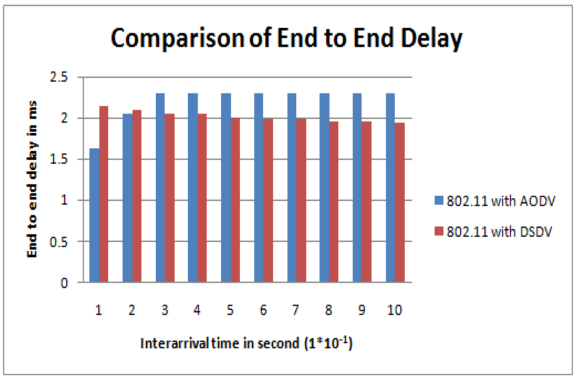

Figure 3: Comparison of End-to-end Delay

The energy consumption is analysed with same parameters for same network model and its graphical comparative results are as shown in figure 4 and figure 5.

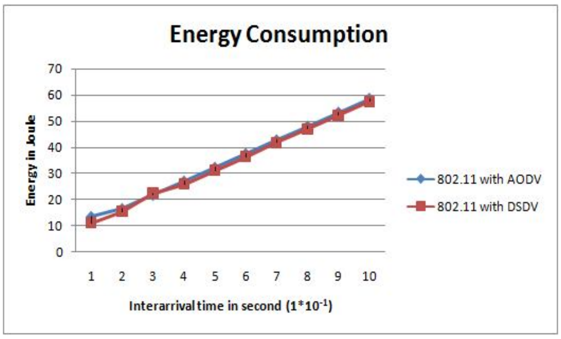

Figure 4: Measurement of Total Energy Consumption

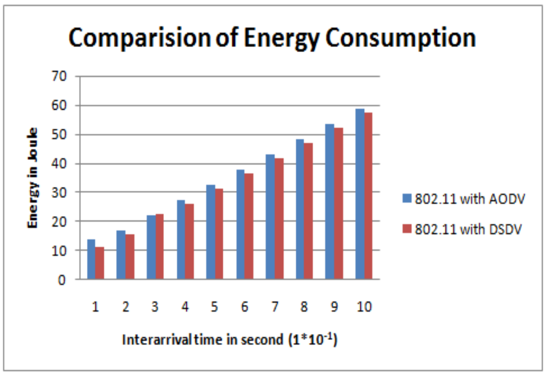

Figure 5: Comparison of Total Energy Consumption

The above figure 4 and 5 shows the measurement and comparison of total energy consumption. The graph shows that the total energy consumption in 802.11 with DSDV are slightly lesser than 802.11 with AODV. The energy consumption in both cases increasing linearly. In AODV hello packets are flooded regularly throughout the network. This leads to higher power consumption in AODV than DSDV. [3, 4]. This shows that DSDV routing protocol is superior to AODV routing protocol where limited energy is critical issue in some industrial wireless sensor network applications.

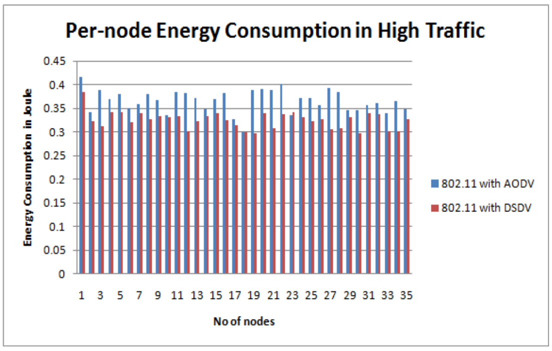

Figure 6: Measurement of Per-node Energy Consumption

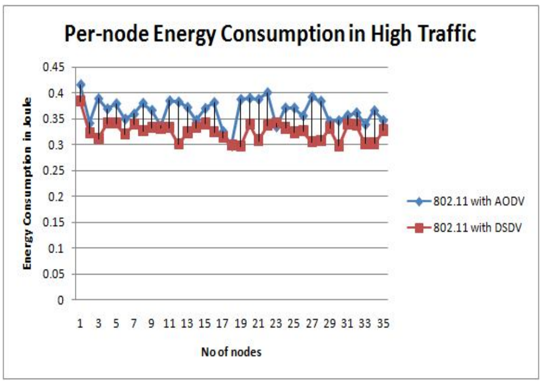

Figure 7: Comparison of Per-node Energy Consumption

The above figure 6 and 7 shows the per-node energy consumption in High traffic. Here, too the energy consumption of AODV is higher than DSDV at every node. The reason for this every node will flood routing packets in network and leads to more energy consumption.

V. Conclusion and Future Work

The performance of both the routing protocols DSDV and AODV are measured with respect to End to End Delay and Energy consumption per node and total energy consumption. Simulation results in the explained network model of industrial environment shows that IEEE 802.11 with DSDV is better option as compared to the IEEE 802.11 with AODV. The end-to-end delays in case of DSDV are lesser than AODV in above mentioned scenario when there is moderate traffic in the network and it also show lesser energy consumption as compared to AODV.

It is also observed that the performance is better especially when the number of nodes in the network is higher. This is because the performance of network get drop at 20 to 30 nodes due to placement barrier in network topology and also due to varying source and destination nodes.

From results this paper concludes that IEEE 802.11 with DSDV is useful in industrial environment where end-to-end delays and energy consumption is not a critical parameter.

In future work the improved DSDV protocol (I-DSDV) can analyse in order to achieve improved results. The performance comparison with other routing protocols can be done in different classes of parameters and operating conditions, which will be useful for actual deployment of sensor network in particular application of industrial control.

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