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Analysis of scalability for AODV routing protocol in wireless sensor networks

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ABSTRACT

This paper presents preliminary work to address scalability concern over AODV protocol in wireless sensor network. Firstly, we discussed the scalability design issues with related work in context of wireless sensor networks (WSN). Following, we designed and illustrated wireless sensor network model. Finally, significance of scalability on the behaviour of application, MAC, transport and physical layer performance is described.

1. Introduction

In the recent years, wireless sensor networks have become the one of the top area of research. Massachusetts Institute of Technology [1] reviewed the sensor networks as the top ten technologies that will change the world. A wireless sensor network consists of a group of sensors or nodes connected through a linked mechanism in order to perform distributed sensing work. Even though, wireless sensor networks can be deployed in the conditions, which are extremely critical from physical deployment. The application area of wireless sensor network ranges from military surveillance to the healthcare sector and many more areas are yet to be incorporated.

Such a tremendous growth in the wireless sensor networks has opened a new face of research in the field of distributed computing applications. Challenging [2] issues like scalability, coverage problem, localization, energy consumption and physical environment etc. must be addressed for the optimal performance of WSN system. For wireless and mobile environment, there is a great need of inexpensive and low power sensor node [3,5]. Analytical modelling of WSN and actual performance prediction are extremely difficult. Deploying test bed study in order to obtain the actual behaviour of WSN requires tremendous effort. In the future, we are expecting a lot of real time WSN application as one of the effort has already explored in the same field [4].

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The breakdown of the paper is as follows. Section 2 defines the scalability, their design challenges and AODV protocol within the context of wireless sensor networks. In Section 3, we introduce the proposed evaluation model for WSN simulation framework for our experiment. The primary results of performance investigation based on scalability of wireless sensor network are shown in Section 4. Finally, in Section 5, we conclude with a resultant about the scalability issue in wireless sensor networks

2. Scalability design criterions and related work

Scalability is the fundamental concern in the wireless sensor network because it can be considered as the major performance measurer for the same. In the general terms, scalability can be referred as the systems ability to perform useful work with the increase in system size i.e. network load. For example, does the performance of a network increases with the increase in the number of nodes, does the performance of a routing protocol increase with the increase in the network size etc. [5,6]. The answers of these problems show the actual significance of the scalability in the wireless sensor networks. Scalability act as a major design issue in the wireless sensor network because it specifies the system's capability to accommodate additional nodes up to certain threshold without restructuring the entire system [7]. Scalability plays a significant role specifically for the large scale WSN where the nodes work in synergy with each other in order to accomplish a common task. A wireless sensor network can be scalable in two ways namely: (i) geographic scalability (ii) network load scalability.

In case of geographical scalability, usability depends on the system's parameters like range, power etc. whereas in network load scalability, usability depends on the increase in number of nodes to the given network system. From hardware perspective, scalability involves the sensitivity and range of sensor, radio communication bandwidth and power consumption. Software perspective includes data management, transmission and algorithms used for network scalability [8]. Large volume of nodes increases programming model complexity and data management complexity. Therefore, one needs to carefully cope with the issues such as scalability to meet the performance requirement of the WSN application [9]. Some of the effort towards scalability issues given in the literature. Alazzawi et al. [10] evaluated three routing protocols namely – Flooding protocol, BVR protocol and PGR protocol for the scalability issue in wireless sensor networks. A performance comparison of RR protocol, SER protocol and SPIN protocol was given by Chalak et al. [11]. A novel approach for WSN was proposed and compared with GPSR protocol and flooding protocol was given in [12]. Lukachan et al. [13] evaluated SELAR protocol in contrast with LEACH and MTE protocol for scalability evaluation. A comparative study of the wireless sensor networks routing protocols scalability was illustrated by Hadjila et al. [14]. Here, we concerned about the network load scalability. Our major in this paper focuses on the scalability issue of the wireless sensor network over ad-hoc on demand distance vector (AODV) routing protocol. It is a reactive type of protocol, so the routes are created only when required. AODV routing protocol [15,16] fulfils the traditional approach of routing i.e. one entry per table and a sequence number. These parameters maintain up-to-date routing information and loop free routing in the different conditions. In AODV, routing information [17] can be determined by two cycles – query and reply. The AODV routing protocol uses four control type of messages: (i) routing request message (RREQ) for message broadcast to another node, (ii) routing reply message (RREP) for the message reception, (iii) routing error message (REPP) for link failure notification and (iv) HELLO message for the links evaluation and detection.

3. Proposed Evaluation Model

To judge the influence of scalability issue on the WSN performance, we developed a basic model for WSN as shown in Fig. 1. The proposed WSN model constituted three stages namely: (i) input, (ii) process (iii) output stage. First stage consists of the specifications about the general scenario, wireless station and individual node properties. Second stage consists of deployment of all nodes and base station stage within the simulation environment. Final stage gives the output correspond to the input parameters. In the model, a wireless station is located in the centre of area to collect the information from all other nodes. The terrain condition we set as 1500 m × 1500 m as flat area. The entire area is further divided into 225 square shaped cells. Nodes can be either static or dynamic one. The type of wireless propagation model is two-ray

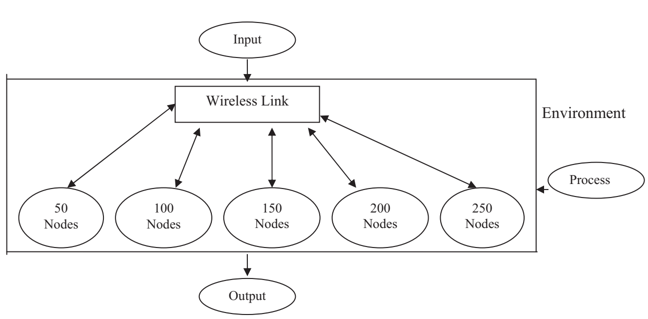

Fig. 1. Proposed WSN Model.

Table 1
General scenario properties.

No. of nodes	50, 100, 150, 200, 250
Simulation time	10 min
Terrain size	1500 m × 1500 m
Mobility interval	100 ms
No. of channels	1
Pathless model	Two ray

Table 2
Nodes properties.

No. of nodes	50, 100, 150, 200, 250
Network protocol	IPv4
Routing protocol	AODV
Battery model	Linear model
Battery charge monitoring interval	60 s
Full Battery capacity	1200 (mA.h)

ground propagation and node placement is random. There is one channel with 2.4 GHz frequency. Pause time, we have taken 30 s. The numbers of constant bit rate (CBR) connections are 10.

The mobility interval is set as 100 msec. The entire connection set up has been done randomly. The speed of the node varies from 0–20 mps. The pause time considered for this scenario is 30 s.

Simulations were carried out on the application layer, MAC Layer, Transport layer and physical layer. We have used IEEE 802.15.4 standard for physical layer protocol, IEEE 802.11 standard for MAC layer protocol, IPv4 for network layer protocol and AODV protocol for network routing. We divided the entire network scenario properties into three sets namely – General scenario, Node specific and wireless link specific properties as shown in Tables 1–3.

4. Performance analysis and results

This section enables us to analyze the assessment of AODV routing protocol in wireless sensor networks. We have implemented our proposed model with Qualnet 5.0 simulator [18] over windows platform; Simulations were run on P-IV 2.8 GHz processor with 2 GB of RAM memory. We evaluated the impact of scalability on the layers of the proposed simulation model. After simulation we found the variation in the following parameters specific to application layer, MAC Layer, Transport layer and physical layers. The parameters are (i) average jitter, (ii) end-to-end delay; (iii) broadcast packets sent and receive, (iv) packets from and to the application layer. Similar parameter like throughput maximization for ad-hoc wireless network was reported by Lin dai et al. [19]. Initially, we find the variation in the value to average jitter i.e. undesirable deviation from the actual periodic signal with the synchronization of the clock reference. Fig. 2 shows the graph for average jitter and end-to-end delay analysis with respect to the number of nodes. The metric value set for average jitter ranges from 0–0.011 s. Here the value of average jitter shows incremental behaviour from 50–100 nodes afterwards its value decrease up to 250 nodes. The value of jitter increases for AODV protocol up to certain threshold i.e. 100 nodes and further decreases up to 250 nodes. This is due to the fact that the nodes which are nearer to the wireless link station will send the packet at earlier stage instead for those which are farther away from the sink node.

Table 3
Wireless link properties.

Antenna model	Omni-directional
MAC protocol	IEEE 802.11
Network protocol	IPv4
Routing protocol	AODV
Temperature (K)	290

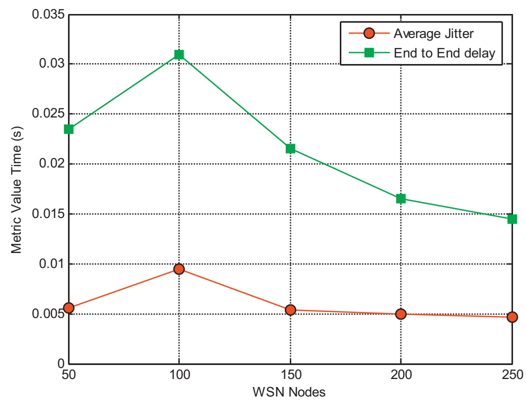

Fig. 2. Graph for average jitter and end-to-end delay analysis.

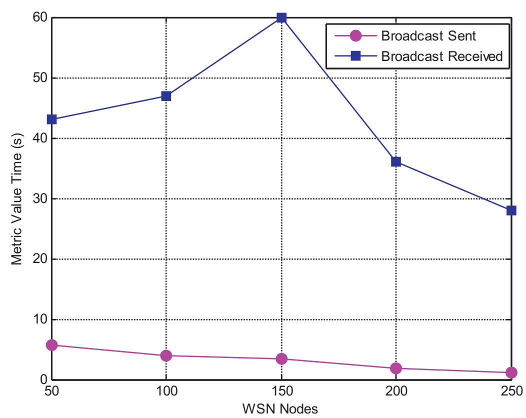

Fig. 3. Graph for broadcast sent and received analysis.

End-to-end delay referred to the total time a packet takes from the source to destination across a given network. This total time includes transmission delay, propagation delay and processing delay. In our scenario, the metric value ranges from 0–0.036. End-to-end delay increases up to 100 nodes afterwards it decline up to 250 nodes. Broadcasting refers to the packet transmission to all the nodes available in the network. The metric value for the broadcast sent and receive ranges from 0–6.5 and 0–70. The behaviour shows that the value of the broadcast sent decreases as we increase the network load i.e. nodes as shown in Fig. 3. The broadcast value increases from 50–150 node networks, afterwards it declines up to 250 nodes network.

The behaviour of the network from application layer point of view is shown in the Fig. 4.The metric value ranges form 0–5.5 for the packets being transmitted from application layer and 0–3.2 for the packets being transmitted to the application layer. Both of theses analysis shows decrement in their behaviour from 50–250 nodes networks.

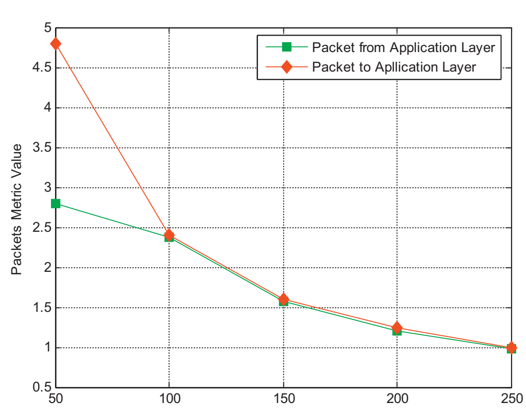

Fig. 4. Graph for packet from and to application layer analysis.

5. Conclusion

In this paper, we concluded with the behavioural analysis of the AODV protocol for scalability issue in wireless sensor network. We evaluated the proposed WSN model for QoS parameters like average jitter, end-to-end delay, broadcast send and receive and packets from and to application layer. Simulation results show that value of average jitter and end-to-end delay increases from 50–100 nodes WSN i.e. maximum and afterwards it decreases up to 250 nodes WSN. For the 200 and 250 nodes WSN, the value first packet reception is less as compared to other because of the fact that the nodes which are nearer to the sink will send the packet at the earlier time spam. Broadcast sent and receive shows the declined behaviour from 50 nodes WSN to 250 nodes WSN. Further packets from and to application layer declined in its value for 50 nodes WSN to 250 nodes. Further enhancement can be done by increasing network load and using other protocols into the network scenario.

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