Performance Evaluation of IEEE 802.15.4 under Different Traffic Conditions

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Abstract— In any network the enhancement of QoS are major issue so as in wireless sensor network. The performance of wireless sensor network is severely affected by various factors and network traffic is one of them. For any network designer choosing appropriate parameters to achieve optimum value of QoS is a challenging issue. In our analysis, we are considering the effects of various traffic conditions on performance of Wireless sensor network with beacon enabled mode and non beacon enabled mode. We have evaluated the performance of wireless sensor network on the basis of various QoS parameters. The whole analysis is done using network simulator tool.

Index Terms— wireless sensor network; CBR traffic model; FTP traffic models; Poisson traffic models; network simulator; beacon enabled mode; non beacon enabled mode; throughput; packet delivery ratio; normalized routing load; average end-to-end delay.

1 Introduction

Data source of any network can be modeled as stochastic model which is known as traffic model. In WSN, the distribution of data traffic load is not even. The performance of WSN degrades due to imbalanced distribution of data traffic load as it reduces network lifetime and affects its functionality [1].To understand the behavior of network traffic, network congestion and other network parameter we require correct modeling of data sources [2]. Traffic model should be such that it resembles real world network traffic. It should satisfy specific applications of a network and enhance capacity of a network. As there is no such single traffic model which can satisfy all the network traffic characteristics under different possible conditions [3].

The knowledge of communication pattern and traffic characteristics is essential for designing of wireless sensor network and optimizing its performance [1]. The uneven distribution of traffic become a challenge for QoS support in WSN because in uneven distribution of traffic the flow of data is from large number of source node to small number of sink node and each node follows unpredictable traffic pattern, which make traffic heterogeneous in nature and it will affects the QoS of WSN [4].

To choose the appropriate parameter in accordance with the traffic conditions to enhance the QoS of network is a challenge for a network designer. Hence investigating effect of different traffic models on wireless sensor network under beacon enabled modes and non beacon enabled mode is the focus of our work. There are various types of traffic exists in wireless sensor network like data traffic, hello message and feedback in link layer and rout discovery traffic etc [1]. In this work we are analyzing different data traffic model. The rest of the paper is outlined as follows section II describes about various traffic models and beacon enabled mode and non beacon enabled mode, in section III simulation environment is discussed, in section IV simulation result is discussed and finally section V gives conclusion of the paper.

2 Traffic models and Operating modes of WSN

Traffic models are mainly used for prediction of performance of network and congestion of network. Traffic models which are not able to adopt actual network traffic characteristics may lead to bad network performance as such type traffic model may underestimate or overestimate the network performance [5]. The development of universal traffic model is not possible because it may appropriate for one application but not suitable for another application for example in agriculture low energy consumption is required while in military applications fast time response is required at the cost of energy consumption. Hence one traffic model is suitable one application may not perform well for another application [6]. The various traffic models which we have considered in our analysis are discussed below:

2.1 FTP traffic model

File transfer protocol is the application protocol used to transfer file between computers on internet. It uses TCP/IP protocol for data transfer. FTP protocol is based on client server model and is used for transfer of web pages, to download programs and other file from one computer to another computer [7]. In FTP traffic model data is transferred using TCP transport agent and is used for bulk data transfer. This traffic model work by advancing the count of packets available to be sent by a TCP transport agent. The actual transmission of available packets is still controlled by TCP's flow and congestion control algorithm [8].

2.2 CBR traffic model

It generates traffic according to deterministic rate packet size is constant. Optionally, some randomizing dither can be enabled on the interpacket departure intervals. CBR traffic model provides the best guarantee of delivery of traffic [8]. It uses UDP as its transport agent. As in private line interface time division multiplexing is used and it does not allow oversubscription, the same characteristics are used in CBR traffic model. There is no requirement of silence suppression and CBR traffic model supports transparent bit stream such that no eight bit byte boundary

is required [7].

2.3 Poisson traffic model

It generates traffic when bit rate is variable and this traffic model is suitable when data traffic is not bursty [1]. It generates traffic according to Poisson distribution. Packets are sent at very high rate during on period and no packets are sent during off period. Packets are constant size (Kevin, [8].

There are two operating modes of wireless sensor network which are discussed below:

2.4 Non beacon enabled mode

Whenever there is light traffic in between nodes non beacon enabled mode is useful. The unslotted CSMA-CA mechanism is used for contention and channel access. It implements random backoff scheme to prevent transmission by two nodes at same time. It require channel to be idle before transmission starts. In non beacon enabled mode various nodes compete to access the channel. For each packet to send, a limited number of attempts are given for retransmission of packets. If the medium is found busy in limited number of attempt the packet may be dropped. The power consumption is more in this mode as compared to beacon enabled mode as the node keeps on listening channel until it is found idle.

2.5 Beacon enabled mode

There are two operating modes of wireless sensor network and they are beacons enabled mode and non-beacon enabled mode. We are considering beacon enabled mode of WSN for our analysis which is discussed below:

Beacons sent periodically in beacon enabled mode, which contain information about synchronization between nodes for effective communication and it also contain information about data pending for different network nodes [9]. In beacon enabled mode superframe structure is used for communication over network. Each superframe structure consists of active and inactive period. In active period, nodes send packets using slotted CSMA-CA mechanism and in inactive period node is tuned off to save battery power. Active period consist of a beacon, a contention access period CAP and a contention free period CFP. The structure of superframe is characterized by two parameters and they are Superframe Order SO and Beacon Order BO. Superframe Order establishes the Superframe Duration SD which is an active period. Beacon Order establishes the Beacon Interval BI which is the length of superframe [10]. The relation between SO and BO that must be satisfied: $0 \leq SO \leq BO \leq 14$. The BI and SD can be defined as follows:

$$BI = B \times 2^{BO}$$

$$SD = B \times 2^{SO}$$

The constant B can be defined as a base superframe duration which is a minimum duration of superframe when the value of BO is equal to 0. Real time applications require QoS support for which GTS allocation is done in CFP.

3 Simulation Environment

In order to analyse the effect of various traffic models on beacon enabled mode of wireless sensor network, we are using network simulator tool for our analysis. It is a software tool that simulates the behavior of network without an actual network is being present. The model of real world network can be analyzed in network simulator. A wide variety of scenarios can be analyzed at low cost relative to making changes to real network.

In particular, we are considering the effect of FTP, CBR and Poisson traffic model on performance of wireless sensor network with beacon enabled mode. The various QoS parameters which we have used to evaluate the network performance are average end-to-end delay, normalized routing load, packet delivery ratio and throughput. The value of Beacon Order BO and Superframe Order is taken as 3 and rest of the parameters which we have used in our analysis are given in table 1[11].

TABLE 1
SIMULATION PARAMETERS

Topology	50×50
Routing protocol	AODV
MAC	802.15.4
Simulation time	100 s
Traffic models	CBR, FTP, Poisson
Radio propagation model	Two ray ground

4 Simulation Result

The various results obtained from simulation are discussed below:

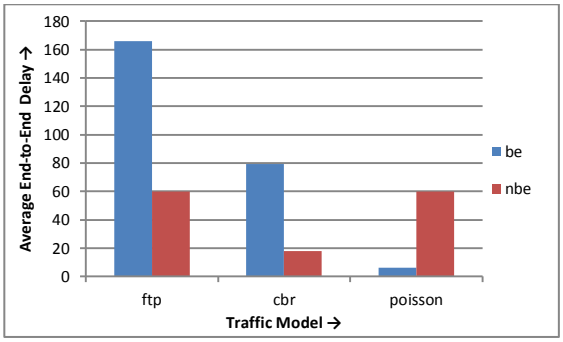

Figure 1 Effect of traffic models on average end-to-end delay

As shown in fig 1, when FTP or CBR traffic model is used and average end-to-end delay is considered as performance parameter then the performance of non beacon enabled mode of wireless sensor network is better than beacon enabled mode. If Poisson traffic model is used, beacon enabled mode performs better than non beacon enabled mode of WSN in terms of average end-to-end delay.

Figure 2 Effect of traffic models on throughput

In fig.2 throughput of beacon enabled mode wireless sensor network is better with FTP and CBR traffic model but Poisson traffic model in case of non beacon enabled mode of WSN with perform better than beacon enabled mode.

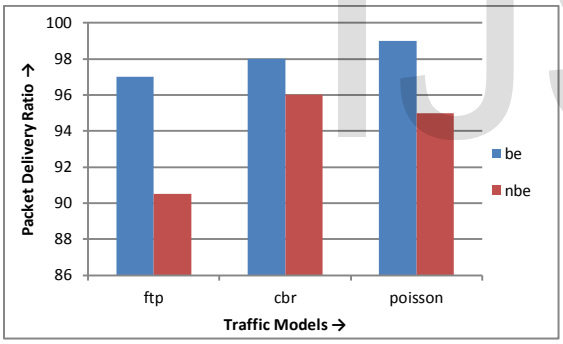

Figure 3 Effect of traffic models on packet delivery ratio

In fig.3 the performance of beacon enabled mode of WSN is better than non beacon enabled mode in terms packet delivery ratio with all the three traffic models but highest value of packet delivery ratio is achieved with Poisson traffic model.

Figure 4 Effect of traffic models on normalized routing load

In fig.4 the performance of beacon enabled mode of WSN is better non beacon enabled mode in terms of normalized load with all the three traffic models but minimum value of normalized routing load is obtained with FTP traffic model with beacon enabled mode.

5 Conclusion

When FTP traffic model is used, the performance of non beacon enabled mode of WSN is better than beacon enabled mode in terms of average end-to-end delay but beacon enabled mode performs better than non beacon enabled mode of WSN in terms of throughput and packet delivery ratio and normalized routing load.

When CBR traffic model is used, the optimum value of average end-to-end delay is achieved with non beacon enabled mode of WSN but the optimum value of throughput, packet delivery ratio and normalized routing load is achieved with beacon enabled mode of WSN.

When Poisson traffic model is used, beacon enabled mode of WSN performs better than non beacon enabled mode with all the performance parameters like average end-to-end delay, throughput, packet delivery ratio and normalized routing load.

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