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IQOS: A Cross Layer Design Approach for Improve Quality of Service in Wireless Sensor Networks

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Abstract

In Wireless Sensor Network, Sensors nodes have limited power and resources. Sensor nodes are used for monitoring particular area in wireless sensor network. Due to lack of limited resources, a sensor node does not work properly with traditional layered routing protocol. Traditional layered routing protocol allows interaction between wireless protocol stack layers adjacently but does not allow interaction between wireless protocol stack layers non-adjacently. Cross layer design approach can allow interaction between wireless protocol stack layers non-adjacently. Cross layer design approach allows sharing variables between layers. Developing cross layer design approach is most important for improve Quality of Service (QoS) parameters like Energy-efficiency, throughput and Average end to end delay in Wireless Sensor Networks. Thus our focus is to improve the Quality of Service (QoS) for Wireless Sensor Network. One of the ways to improve Quality of Service (QoS) is cross layer design approach. In this paper we propose a cross layer design approach (IQOS) which optimizes Quality of Service (QoS) factors of the sensor nodes at the Network Layer, Data Link Layer and Physical Layers of the wireless protocol stack because Quality of Service (QoS) factors exist in these three layers.

Keywords: *Cross-layer, WSN Protocol stack, Sensor nodes, quality of service (QoS) support, Wireless Sensor Network*

1. Introduction

Wireless sensor network is a network that is used to monitor the physical and environmental such as temperature, vibration, sound and so on. In traditional communication networks, the Open Systems Interconnection (OSI) layered architecture has been widely adopted and has served many communications systems well in the past; however, evolving wireless networks of today are seriously challenging this design philosophy. The layered architecture defines a stack of protocol layers in which each layer operate within its well-defined function and boundary, and thus allowing changes to the underlying technology at each layer without imposing the need to change the overall system architecture. Traditional layered approach has been successful in its ability to provide modularity, transparency and standardization in the wire line networks but might be unsuitable in the wireless sensor networks domain. In the recent years, many research works have been presented for wireless sensor networks which are based on the interaction between various non-adjacent layers of the wireless sensor network stack. Cross layer design is a co-operation between multiple layers that combine the resources and create a network that is highly adaptive. The cross layer design approach can increase energy efficiency of sensor nodes in wireless sensor network. The Cross-layered design approach in wireless sensor network is more useful, energy efficient, scalable and secure than with traditional approaches. Parameters which can be optimized by Cross layered design approach are throughput, network lifetime, quality-of-Service, resource constraint,

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scalability, functionality. The traditional layered approach follows strict layering principles and provides a platform for designing interoperable systems, but it suffers from more transfer overhead. So Cross-layered approach is used to minimize this overhead by having data and information shared among different layers. So there is requirement of a cross layer design approach that will improve quality-of-service for wireless sensors network. Cross layer design approach can allow interaction between layers. By using cross layer design approach, one layer can exchange data between different layers.

2. Cross Layer Design

Cross layer design is a approach that provides facility of exchanging information between layers. Cross. layer design allow interaction between different layers non-adjacently. Cross layer design approach is the best approach for improve Quality-of-Service(QoS) in WSN. In Traditional layered protocol architecture one layer can exchange data and communicate between each other one after other. A protocol encapsulates data arrived from its upper adjacent layer and forwards it down to its lower adjacent layer. Similarly, it can decapsulate data received from its lower adjacent layer and forward it up to its upper adjacent layer. There is no interaction between any non-adjacent layers as in such a layered architecture. Traditional layered protocol architecture is suitable only for wired networks but it is not suitable for wireless networks. To overcome the drawbacks of traditional layered protocol architecture design in wireless sensor networks, researchers have proposed the cross-layer design approach. Cross layer design may be defined as breaking of OSI layer in communication network, Cross layer design allows not only protocol interactions across the layers, but also the possibilities of merging and removal of layers, and the creation of new interfaces and entities for interactions between the layers [19]. The traditional layered approach provides a platform for designing interoperable systems, but it suffers from more transfer overhead. So, Cross layered approach is used to minimize this overhead by having data and information shared among different layers. In this paper we have proposed a cross layer design approach (IQOS). Proposed IQOS will be more energy-efficient as compare to existing approach.

3. Existing Cross Layer Design Approach

A few cross-layer design approaches have been proposed for Wireless Sensor Network. There is a considerable amount of surveys in the literature that discuss WSN technologies in general [1]-[7].The complete literature survey have discuss in [8]-[16]. Irfan AI-Anbagi *et al.*, [8] have proposed a cross layer scheme for quality of service in wireless sensor network for obtaining delay and reliability. This cross layer scheme provide better reliability. Qingwen Liu *et al.*, [9] have proposed a scheduling mechanism for multiple connections for the increasing quality of service demand of different-different applications. This scheduling mechanism handles time diversity and frequency diversity. Alper K. Demir *et al.*, [10] have proposed cross-layer architecture for quality of service. This proposed architecture is very useful for achieving reliability and others quality of service parameters. Ghalib A. Shah *et al.*, [11] have describe a cross-layer approach for improvement quality of service by optimizing the functionalities of communication protocols. Rajeev Ranjan *et al.*, [12] have proposed a cross-layer design approach for Wireless Sensor Network. This cross-layer design approach improves energy-efficiency of sensor nodes in wireless sensor network. Veronica Sentongo *et al.*, [13] have proposed a cross-layer approach for improving end-user delay and per-user throughput of voice over internet protocol when packets size are increasing. Rafael Laufer *et al.*, [14] have proposed Cross-Layer backpressure architecture for handling multihop networks by using TDMA MAC Protocol. David Espes *et al.*, [15] have proposed a cross-layer routing protocol (PLOSA) to offer a high delivery rate, a low end-to-end delay & a low energy consumption. PLOSA optimize sleeping periods of devices because each node can receive

packets to be forwarded only in a specific part of the frame. Ramin Babaee *et al.*, [16] have proposed an efficient routing algorithm with the goal of minimization of the end-to-end outage probability from source to destination for Multihop Wireless Network.

4. Proposed Cross Layer Design Approach(IQOS)

Proposed cross-layer design approach (IQOS) allows interaction between layers. In IQOS, each layer interact with other layers and each layer has knowledge about others layers. We design IQOS as in Figure7 Firstly at Physical layer we calculate RSSI (Received Signal Strength indicator) Value of Sensor nodes from Base Station and send these RSSI values to Network layer. Secondly at Network Layer we check RSSI value of sensor nodes and if node has larger RSSI value then select this node as data forwarding node from sensor nodes to base station, Thirdly at MAC Layer we focused on avoiding collision and overhearing for this purpose a Scheduling algorithm is used here. Scheduling algorithm makes schedule of all sensor nodes that are coming from Network layer and provide error free transmission. Scheduling algorithm also increase flexibility. Scheduling algorithm provide high-quality data service, a multilevel of sensing coverage and network connectivity.

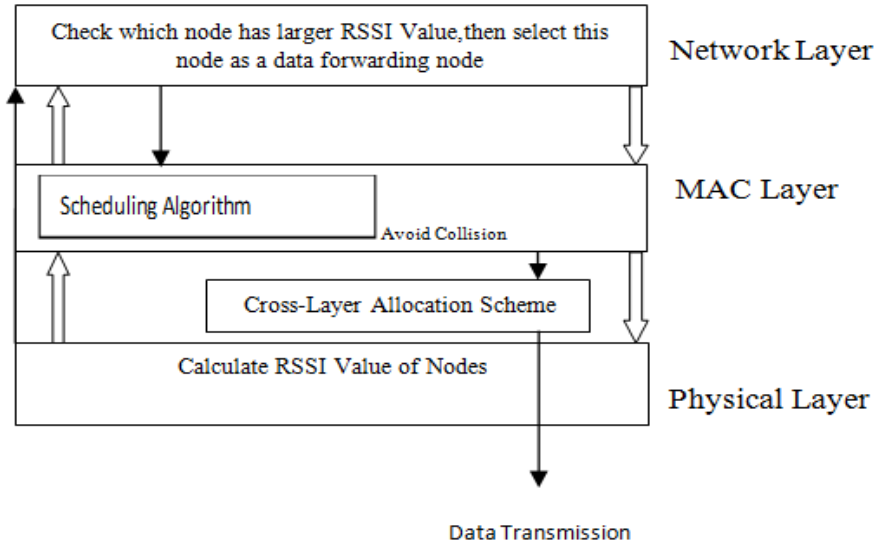

Figure 1. Proposed IQOS

Scheduling algorithm at MAC Layer is shown in algorithm 1. Scheduling algorithm make schedule of all sensor nodes that are coming from upper layer (Network layer).It check the channel whether it is free or not, if channel is free then give a time slot to sensor and dispatch packet to Cross layer allocation buffer (CLAB).CLAB check frequency, Channel and time slot of sensor nodes and if channel is free then dispatch packets from CLAB to Physical Layer.

Notations used:

B_D - Buffer data
P_N - Packets
CLAB - Cross layer allocation buffer
T_s -Time Slot
Ch - Channel

Algorithm 1: Scheduling Algorithm at MAC Layer

1. If buffer data $B_D = P_N$ Then
2. Check Channel Ch whether it is free or not
3. If Ch=0 then set $Ch=P_N$
4. Set $P_N = T_s$
5. P_N dispatch to CLAB buffer
6. CLAB Check Ch is free or not
7. If Ch=0 then
8. Dispatch P_N from CLAB
9. Repeat Step 1 to 8

5. Performance Evaluation

We develop a simulation environment to evaluate the efficiency of IQOS. For this purpose we are using QualNet 5.0.2 simulation modeling tool. We are using some QoS parameters like Average jitter, Throughput, Average end-to-end delay.

1. Average Jitter

Data from source to destination will reach the destination with different delays. A packet's delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably. This variation in delay is known as Jitter.

2. Throughput

Throughput means total number of packets received by the Base Station. Throughput is the average rate of successful message delivery over communication channel.

3. Average End-to-End Delay

Average end-to-end delay is time in which data send from sensor node to the base station. Due to queuing and different routing paths, a data packet may take a longer time to reach its destination. The end-to-end delay experienced by the packets for each flow the individual packet delay is summed and the average is computed.

Table 1. Simulation Parameters

Parameter	Value
Sensor nodes	1,2,3,4,5,6,7,8,9,10
Destination node	11
Buffer Size	1024
Terrain Range	100m x 100m
No. of nodes	10
Frequencies	2.4GHz
Traffic Type	CBR
Channel Type	Wireless channel
Protocols	AODV

The performance of proposed IQOS is verified in the experiment, the sensor nodes in Wireless Sensor Network are distributed randomly in the 100m * 100m area. In this simulation environment (Figure 2) sensor nodes 1,2,3,4,5,6,7,8,9,10 are co-operately pass their data to the destination node (Base Station) running simulation is shown in Figure 3. In Running simulation sensor nodes are sending packets to destination node 11(Base Station).

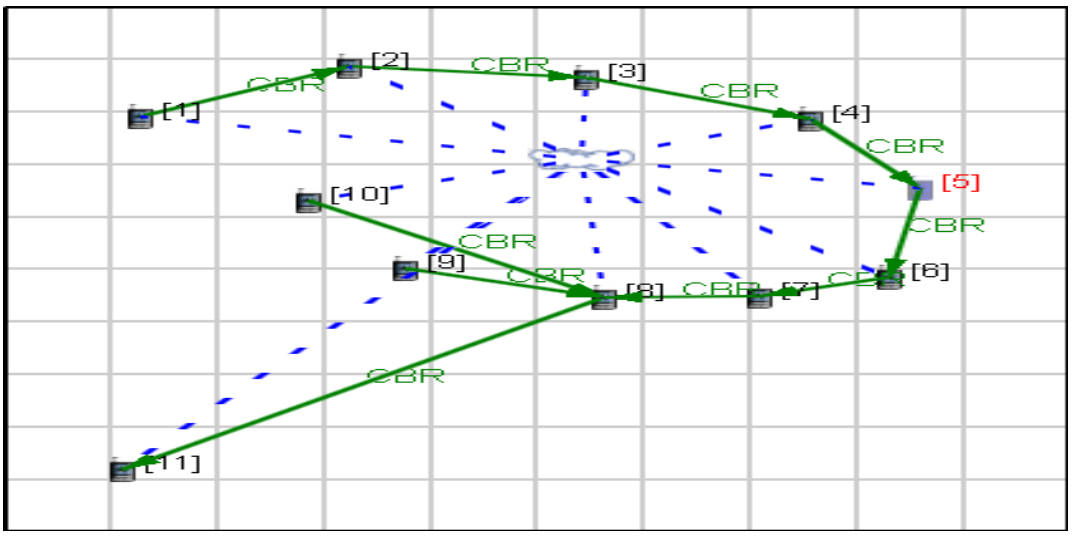

Figure 2. Simulation Environment

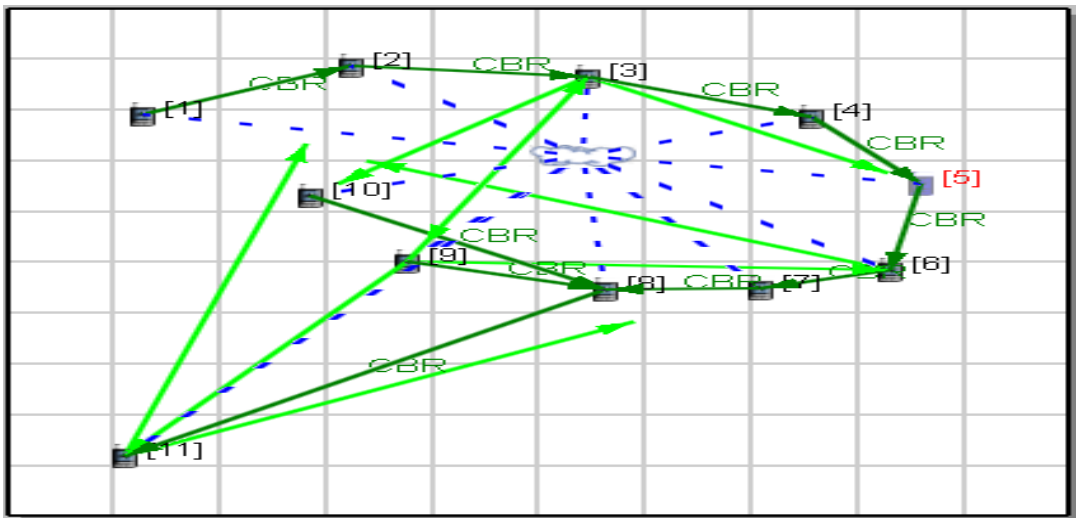

Figure 3. Running Simulation

6. Simulation Results

QualNet 5.0.2 simulator is used to implement the Proposed cross layer design approach. The Performance of Proposed cross layer design approach is evaluated. Table 1 lists the parameters used in the simulation. The key performance measures are Average jitter, Throughput and Average end-to-end delay. In Figure 4 show result Average jitter. Sensing data that are coming from sensor nodes to base station, Average jitter show the delay of sensing data from sensor nodes to base station.

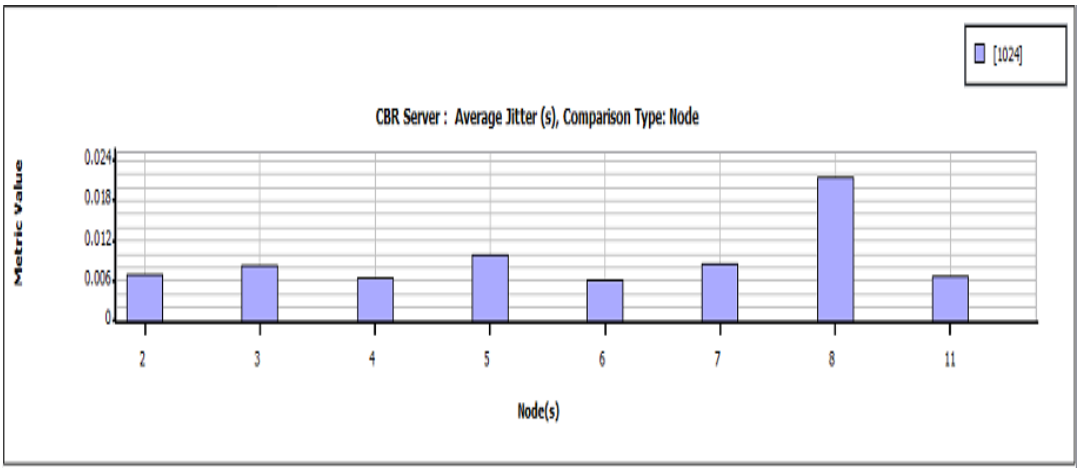

Figure 4. Average Jitter

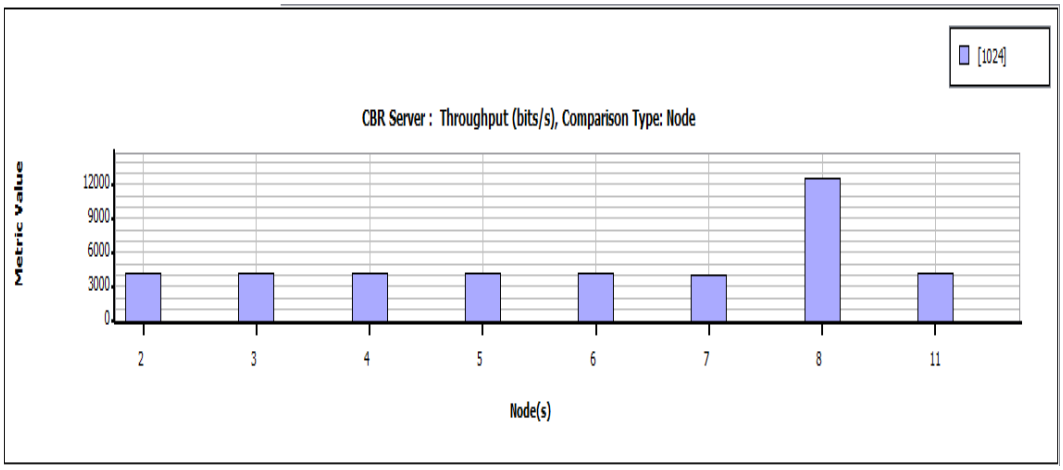

Figure 5. Throughput (bits/s)

In Figure 5 shown total number of packets received by base station. Sensor nodes 1, 2,3,4,5,6,7,8,9,10 are sending packets to base station, there are base station received different-different packets from sensor nodes.

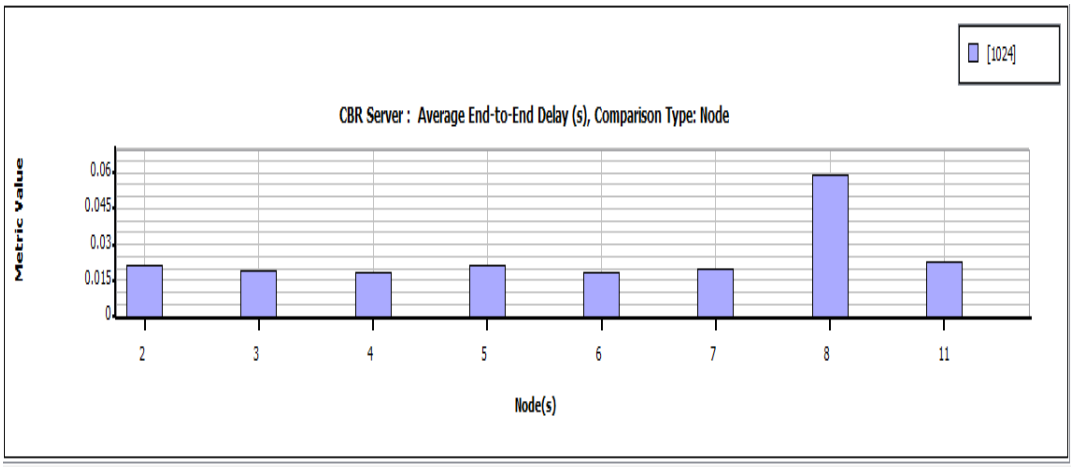

Figure 6. Average End-to-End Delay

In Figure 6, all sensor nodes are sending packets to base station without delay. Figure 6 show average End-to-End Delay. Average end-to-end delay is time in which data send from sensor node to the base station.

7. Conclusion

In this paper, we have proposed a cross layer design approach (IQOS) for improve energy-efficiency and system throughput in wireless sensor network. Proposed IQOS will optimize energy consumption at Physical layer, Data link layer and Network layers of the Wireless sensor network protocol stack (Simplified Protocol Stack of OSI Model). Proposed IQOS allow Communication between layers non-adjacently and each layer has knowledge about other layer like Application layer has knowledge about MAC Layer and MAC Layer has knowledge about Network layer and Network layer has knowledge about Physical and Data link layer. In Proposed cross layer design approach, Scheduling algorithm make schedule to all sensor nodes that are coming from network layer and cross layer allocation scheme allow multiuser transmission in a single communication channel. Proposed IQOS is more energy-efficient approach as compare to existing approach. Proposed IQOS will improve quality of service for wireless sensor network.

Ethics

This Research paper is original and not published in any conferences or in any journal.

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