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Cross Layer Design for Energy Efficiency with Different Modes in Wireless Sensor Networks

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Abstract- **In wireless sensor networks a traditional layer network design is not efficient. Usually there is an underlying feature, for e.g. energy consumption, which spans across several layers. When the goal is optimized a certain value directly related to such a feature then separate design for each layer leads to a sub-optimal performance. In order to have a near optimal performance the different layers should be able to coordinate their behavior. Here the cross layer design of the use of forward error correction coding and the determination of the awake/sleep periods for narrow band wireless sensor network is presented. This design takes into account in a joint manner, the characteristics of physical and medium access layers. The author aims to illustrate and develop an approach that yields energy efficient design.**

Index Terms-**Cross-layer, Energy efficiency, Medium Access Control Protocols, Wireless Sensor Networks.**

I. INTRODUCTION

A Wireless Sensor Network can be described as a network of sensors which communicate with each other network wirelessly. These are built of nodes where, each node is connected to one or sometimes more than one sensors. In Wireless Sensor Networks, the only source of life for the nodes is the battery. Communicating with other nodes activities consumes a lot of energy in processing the data and transmitting the collected data to the destination. The cross layer approach is a flow from the waterfall-like concept of the OSI communications model with the virtual strict boundaries between the layers.

Although the Wireless Sensor Network is usually a wireless multi hop network, it has distinguished operational features over the traditional multi hop wireless networks. These features are related to the simplicity of deployment of sensor nodes, and the scarcity of resources (i.e. power and bandwidth) [2]. In a network, a large number of sensors increase the reliability of the system, as failure of the sensor nodes will not result in system failure. Like other electronic devices, sensor nodes have to be powered. To prolong network lifetime, energy spent should be minimum. Energy conservation can be done using efficient macro programming of Wireless Sensor Network. An approach is to design energy efficient approach (EOA) to MAC protocols.

II. WIRELESS SENSOR NETWORKS (WSN)

A. Protocol Stack

A simplified protocol stack for a Wireless Sensor Network is summarized in Figure 1.

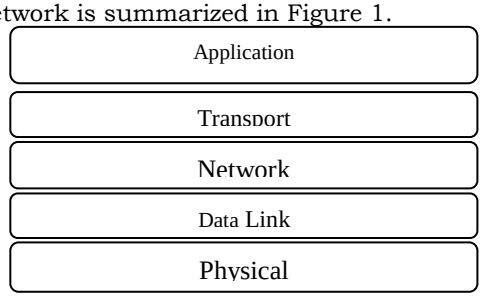

Figure 1. Architectural layers of WSN

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- *Application layer:* It defines a standard set of services and interface primitives available to a programmer independently on their implementation on every kind of platform.
- *Transport layer:* It helps to maintain a flow of the data if the sensor layer application requires it. This layer is mainly needed when the system to be accessed through the Internet or other external networks.
- *Network layer:* This layer takes care of routing the data, managing all the process of selecting paths along which the data has to be sent in the network.
- *Data Link layer:* This layer provides the multiplexing of data streams, detection of data frames and Medium Access Control MAC.
- *Physical layer:* It is responsible for power selection, modulation and data encryption.

III. LITERATURE SURVEY

One of the major issues of Wireless Sensor Network is Energy Consumption. This issue is considered separately at different layer of protocol stack. At Network Layer, inefficient routing of packets can lead to waste of energy. A protocol that needs many routing advertisements will make use of sensor energy to send them, reducing the network lifetime [4]. Thus protocols that are energy efficient can help to reduce energy consumption by avoiding retransmission and less control packets. At Data Link Layer, the error control methods are needed as wireless links are not reliable. In order to avoid collisions, Wireless Sensor Networks should use disputation less medium access and coordinated sleep schedules. But all these solutions are energy consuming, as the methods used to solve them require resources from one or more nodes. Therefore every proposed solution needs to be energy efficient. At Physical Layer, transmission power is to be optimized so as to have energy efficient routing protocol, since most of the energy efficient routing protocol assigns link cost because some function of transmission power which later depends upon several metrics like path loss, Signal to Interference plus Noise Ratio (SINR), Bit Error Rate (BER), etc. A comprehensive, cross layered scheme of energy efficiency solutions seems to be the best approach to manage the problem of energy efficiency as represented in Figure 2.

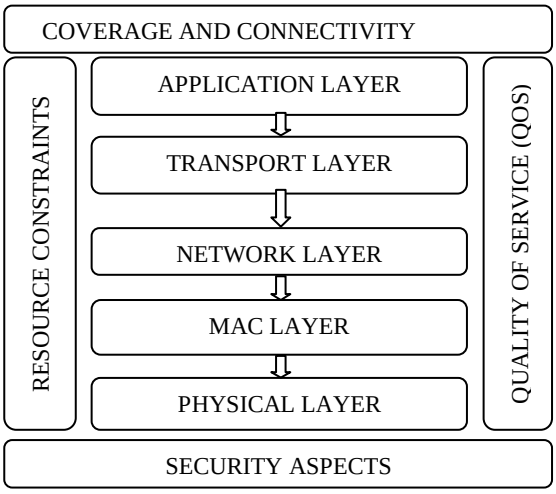

Figure 2. Cross layer issues in WSNs

Cross-layer design [9] states that parameters of two or more layers can be retrieved and/or changed in order to achieve an optimization objective. A few cross-layer protocols have been proposed for Wireless Sensor Networks. These cross-layer protocols optimize the different layers among Physical (PHY), Medium Access Control.

In Babulal K, Tewari R, Cross Layer Design for the cooperative transmission in wireless sensor networks [5], the information of the Physical Layer and MAC sub layer is sent to the network layer and the information of the network is transmitted to below layers. Information about the physical channel condition is transmitted from physical layer to network layer. The data rate and power information are passed from network layer down to the physical interface. In Liu CH, Gkelias A, Hou Y, Leung K, the Cross-layer design for QoS in wireless networks [6], authors proposed a unified cross-layered framework that consists of the connection admission control together with QoS routing in the network layer and distributed

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scheduling in MAC layer. A function is defined which is exchanged between an efficient distributed fair scheduler and a multi-constrained QoS routing algorithm. In [7], authors performed the routing decision which results in the successive competitions at the medium access level. The next hop which is to be selected based on the progress and the transmit power is successively increased until the most efficient mode is found. These above works provides the simulation results without any communication protocol design and performs a cross-layer design within limited scope, which do not consider all the layers of the protocol stack that involves in the communication in Wireless Sensor Network. Thus there is a need of cross layer energy efficient protocol design. Cross-layer approach from above considers the interactions between corresponding protocol layers.

IV. COMPARITIVE STUDY

In this paper, we discuss the comparison of the MAC-layer protocols in Table 1.

Table 1: Comparison of MAC-layer protocols

Layer	Issue	Techniques to handle issue
Physical	Signal fading, shadowing and path loss effect.	Low power modulation techniques are used.
Data Link	Requirement of protocol for mobile sensor network, determination of lower bounds on energy.	Provides data streams, data frames and MAC
Network	Routing data in network.	Adjust the routing protocols according to availability of memory, energy.
Transport	Packet loss and congestion.	Hop by hop transmission is used.
Application	Large amount of data transfer, require more memory.	Different protocols are used.

V. PROPOSED WORK

By the above cross-layer principle, we design the cross-layer energy efficient protocols as in Figure 5.1 [9].

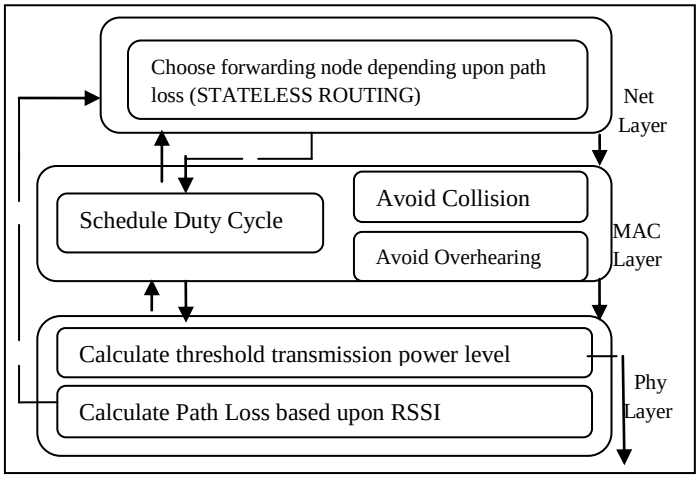

Figure 5.1. Cross layer design of the proposed protocol

Firstly at physical layer, the protocol calculates the path loss on the basis of the RSSI by means of beacon packet transmission from the sink node. Using path loss, a node decides whether to participate in contention or not to be a relay node. Secondly at network layer, a node with larger RSSI value (or with a shorter path loss as compared to the sender) is selected for the data forwarding task as next-hop node. Thirdly at MAC layer we form the awake/sleep period scheme for each sensor node. By this scheme, a node must be awake if it actually takes part in the transmission activity; otherwise it continues to keep asleep in the rest of time. Finally again at physical layer, this algorithm obtains the threshold transmission power level between the transmitting node and the selected next hop node and data transmission takes place with minimum transmission power level just above the threshold transmission power level.

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CONCLUSIONS

Now a day, Wireless Sensor Networks (WSNs) have received a growing attention due to their potential in many real-life applications. In this paper, we discussed the characteristics of the Wireless Sensor Networks, various types of energy efficient MAC protocols of Wireless Sensor Network and also the cross-layer design in Wireless Sensor Networks. Traditionally, the energy consumption optimization problem is considered separately at different layers of protocol stack, this paper proposes a cross layer energy efficient protocol which optimizes energy consumption of the sensor nodes at the Network, MAC, and the Physical layer of the protocol stack simultaneously. Choosing a communication path having large number of short hop nodes over a path and less number of long hop nodes leads to a significant reduction in the total energy consumption and thus a cross layered scheme of energy optimization is better approach to manage the problems of energy consumptions.

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