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A survey on optimizing cross layer design for wireless sensor networks

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Abstract- Recent researches has shown the enormous growth of Wireless Sensor Network in many areas like medical and health care, disaster relief operations, biodiversity mapping, agriculture etc. This paper deals with the basics of WSNs and about how it is been developed with the cross layer design replacing the traditional layered protocols that have been used so long for WSNs. The main objective for optimizing the cross layer design is to provide high reliable communication with minimal energy consumption.

Index Terms- Cross-Layer Protocol, Optimization, Wireless Sensor Networks, energy consumption.

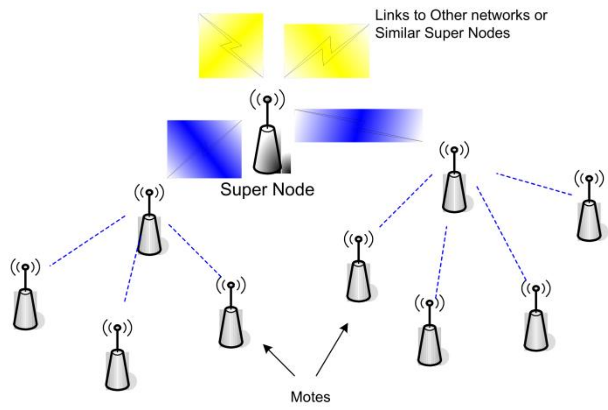
1. Introduction

Wireless Sensor Networks are formed by hundreds or thousands of motes (small, low-power, low-cost computer) that communicate with each other and pass data along from one to another. Many researches done in this area focus mostly on energy aware computing and distributed computing.

Cross layer design may be defined as, “developing or designing a new protocol from the existing OSI layers by violating the referenced architecture or by breaking or merging the seven layers defined on the ISO-OSI reference model s”. The breaking of OSI hierarchical layers or the violation of reference architecture includes layers are being merged, new interfaces are created, or providing additional interdependencies between any two layers.

Issues in the existing system:

- The energy available in the operation of sensor nodes is an important bottleneck.
- The design of hardware for sensor nodes should also consider energy efficiency as primary requirement criteria.
- Sensor nodes are randomly deployed, Hence do not fit into regular topology.
- Sensor networks are infra –structureless. Routing & Maintenance algorithm need to be distributed.
- Direct Communication is difficult with heterogeneous network.
- Load Balancing is not very efficient.



2. Related Work

In recent years, there are researches using cross-layer design for high efficiency and low cost multi-hop wireless communication systems. These efforts can be classified into four categories according to their optimization goals. First, relaxing power constrains. Second, improving system throughput. Third , fulfilling QoS requirements. Fourth, achieving better resource efficiency.

In our proposed work ,we are working forward to design a cross layer based scheme to enhance Power Conservation, Routing and Scheduling. Designing deterministic, schedule based schemes to conserve battery energy of a sensor node. We focus on secured Routing, Load balancing and Interoperability.

3. Goals

The overall goal of this study is to provide a feasible and flexible means to solve the conflicts between the requirements and the constraints of current wireless sensor networks. It will be a key step to make actual WSN applications into reality.

Our research will target three major optimization problems that have been proposed to solve the conflicts for years but still exist as major obstacles.The first problem or optimization goal is how to support a large scale network [2] while keeping throughput feasible per-node from each node to designate data sinks. Gupta and Kumar [1] have shown that in a general wireless network, the available per-node throughput can be estimated by $O(W/N)$, where W stands for the bandwidth between direct neighbors and N represents the address individual nodes and how to provide QoS services are also related with the problem. Thus our first optimization goal is to find a systematic way to study the relationship among those factors.The second problem or optimization goal is to fill the gap between the power consumption and the limited power supply.Requirements to solve this problem include: (*i*) improving the power efficiency in the system; and (*ii*) preventing the system deconstruction due to unfair power usage. Approaches to deal with the power problem include: (*i*) using power-aware protocols and working mode decisions to improve the power efficiency; (*ii*) optimizing the transmission range according to the system topologies; and (*iii*) taking the low power hardware design or using more powerful batteries.

The third problem or optimization goal is to improve the versatility with the strictly limited node resources, such as computing power, storage capacity, and interruption availability. There are two aspects by versatility. One is that each node may take the responsibilities of collecting, processing, storing, and sending the real-time sensing data as well as fusing, buffering, analyzing and relaying the passing-by data simultaneously. The other is that a practical application may need to support multiple functional modules that may require various working protocols in a single node during the same time period.

4. Motivations

Multiple reasons have motivated the cross-layer research for the wireless sensor networks.

1) *Optimization can be achieved in multiple layers.*As shown in Table I, all three optimization goals we are targeting at can be achieved in all five layers of the system.

This provides a rationale for optimizing the cross-layer to achieve our research goal.

2) *Optimization in one layer may need co-operations of other layers to show its effects.*

Cross-layer optimization is necessary because it is possible that different approaches for the same optimization target may counteract each other. For example, if we want to optimize the power usage in a WSN system and we design a power-saving routing protocol. Let's assume the routing protocol will always select among the shortest routes so that they will pass the most densely deployed area. This kind of routes may take advantage of the fact that for the same transmission distance taking more number of smaller-distance hops will save transmission powers compared with a single larger-distance hop. However, data transmission with more hops may have larger contention possibilities. If the MAC layer is not optimized accordingly,the advantages of the routing design may be counter acted by the increasing power consumption due to the increase of contention possibility.

3) *There exist conflicts between optimization goals.*Table I shows that some solutions for those three optimization goals are either conflict with each other or orthogonal to each other. This makes all-in-one consolidate design the most promising solution for actual applications. The core idea of such design is to fit every optimization into a complete application context and achieve all possible optimization goals in an integrated way.

4) *Some situations do not need supports by all layers.*In those situations, the most efficient way of optimizing the system is to remove those unnecessary layers. An example for such applications is a multi-hop Local Positioning System (LPS), which is based on hop-by-hop distance measurements and redundant information to estimate the relative distance between any nodes and anchor nodes. The network layer and transport layer that handle the end to end data transmissions will be of no use in this application. It suggests that the composition of the protocol stack to support certain applications can also be optimized by the cross-layer approach.

5. Conclusion

In this paper, we study about the optimization of the application oriented cross-layer protocol optimization. The main aim is to provide long life time to the Wireless Sensor Networks (WSNs) by improving the battery energy by using cross layer design approach.

We can justify that optimizing the cross-layer will be a solution to provide high reliable communication with minimal energy consumption.

Table I. Optimizing approaches at each layer

Layer	Network Scale	System Life-time	Node Versatility
Application	Data fusion, Compression	Power-aware mode control	Load detection, Automatic mode decision
Transport	Bounded Delay	QoS-power trade off	Load-aware transport control
Network	Node naming, Efficient routing, Efficient Node discovery	Power-aware routing, Reduced overhead	Load-aware routing, Simplified node discovery, Distributed Storage
MAC	Contention control, Channel reuse	Synchronized sleep, Transmission range control	Load-aware channel allocation
Physical	Ultra-wide Band	Low-power design, Powerful battery	Attach specific accessories (GPS)

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