Quality of Service in Heterogeneous Wireless Sensor Networks

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I. Introduction

Wireless sensor networks are networks consisting of many tiny and often resource-impoverished sensor nodes communicating through a low-power and short-range radio interface. As can be seen in Fig. 1, they are used for monitoring, building automation, tracking and multimedia services such as voice and video. For many years, the main research focus was on energy efficiency, while Quality of Service (QoS) parameters such as delay, reliability and throughput were often ignored. However, in the next-generation heterogeneous wireless sensor networks, making a trade-off between energy efficiency and delivering the right QoS guarantees becomes a very challenging task.

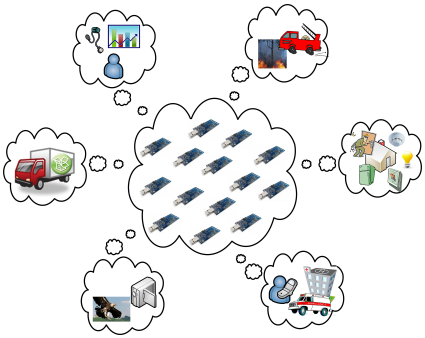

Figure 1. Wireless Sensor Networks

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II. Quality of Service in Heterogeneous Networks

The next-generation wireless sensor networks are characterized by a growing heterogeneity [1].

First, sensor nodes may have different time-varying node capabilities such as power, memory and storage. Exploiting and optimizing these parameters in routing and MAC protocols can extend the network's lifetime and even increase the QoS delivered to the network.

Second, sensor networks are used for many diverse applications, each having their own specific QoS requirements. A sensor network will have to cope with dynamic and time-varying QoS requirements.

Finally, sensor networks are only a part of the big picture. When they are used within or beside other networks such as wireless mesh and bluetooth networks, QoS has to be delivered over the networks' boundaries.

III. Modular Cross-Layer Architecture

A. Architectural Design

Quality of Service is one of the few functionalities that is involved in all the layers of the OSI Reference Model [2]. This traditional layered structure is show in Fig. 2a. The advantage of this layered structure is its clear and hierarchical modular design, but for wireless networks, the layered approach is not always the best. It can be very useful to exchange information between two or more not adjacent layers, and therefore, the cross-layer approach

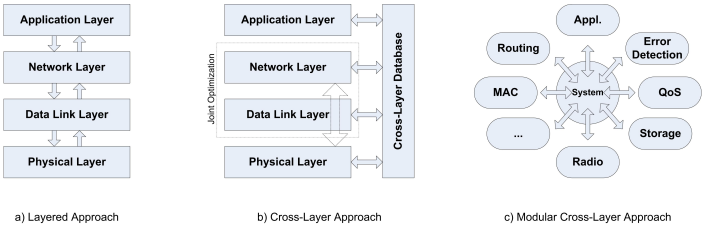

Figure 2. From Layered to Modular Cross-Layer Architectures

from Fig. 2b is very promising. It allows the information to be exchanged between layers directly or through a separate database. Also joint optimization between two adjacent layers is a successfully approach. However, the disadvantage is its unclear structure and it is very difficult to deal with new layers in a plug and play manner [3].

Therefore, there is a great interest in new design structures that allow cross-layer design, while maintaining the modular aspect of the traditional layered structure [4]. In Fig. 2c, such a new architecture is proposed. This architectural design easily allows to extract the QoS functionalities from each *layer* and plug them in as a separate module that can control and influence the other *layers*.

Replacing the QoS module by another QoS module meets the heterogeneous nature of the next-generation wireless sensor networks. Nodes with more capabilities can easily replace a basic QoS module by an advanced module with more QoS functionalities or vice versa.

B. Supporting Quality of Service

In the proposed modular cross-layer architecture, a combination of a flow-based (IntServ) and a class-based (DiffServ) QoS approach is used. Similar to the class-based approach, some basic classes are defined in which each traffic flow fits. In our approach, to make a distinction between the different flows in the same class, some extra attributes are added on each flow. These attributes are parameters with additional information on reliability and delay, so that each intermediate sensor node can treat each flow differently inside the borders of its appropriate class. This way, it is possible to upgrade the priority of a packet when its delay is almost reached and the other packets within the same class have still enough time left.

IV. Conclusions and Future Work

The architectural design is only one step in the way towards guaranteeing QoS in wireless sensor networks. It forms the fundamentals on which we can build a whole QoS supporting infrastructure. Future work will include the optimization of existing and developing of new QoS aware network protocols.

Acknowledgments

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