Aggregator-Centric QoS for Body Sensor Networks

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By integrating sensing, wireless communication and computation into tiny sensor devices, wireless sensor networks are receiving significant research attention from both academia and industry. Among the wide range of sensor network applications, assisted living [1] [2] has demonstrated great market potential as well as research challenges, and has been considered as one of the "killer" applications for wireless sensor networks. As shown in Figure 1, a body sensor network is usually the first and also the most basic step in a larger assisted living system where doctors and other healthcare givers are involved. A body sensor network usually consists of an aggregator, the cell phone in Figure 1, as well as multiple sensor nodes. Sensor nodes sample patients' physiological conditions and report the sampled readings to doctors through the aggregator. During a remote diagnosis, doctors may need to control specific sensors to increase or decrease sampling intervals. Also, different data streams may have different importance levels. For example, an EKG heart activity data stream is usually more important than a temperature data stream. To make efficient use of the limited wireless resource, quality of service is needed for the prioritized data streams. Our BodyQoS system is developed for these purposes.

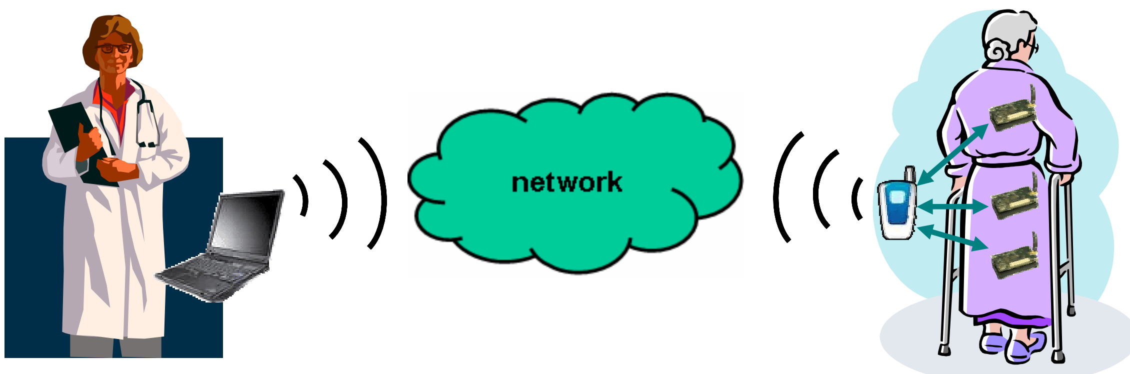

Figure 1: Body Sensor Network in a Bigger Assisted Living System

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Features Provided: (1) BodyQoS keeps track of the total available wireless resource as well as the current resource usage in real-time. This is very challenging because the low power wireless communication is notoriously irregular [3] [4] [5], and it may also suffer from interference generated by co-existing wireless networks or electrical devices like microwaves [6]. (2) Users assign different priorities to different data streams depending on their importance levels. BodyQoS conducts admission control decisions based on the priorities and other QoS specifications like bandwidth and delay. When the available wireless resource can not meet all QoS requests, those with higher priorities are served first. (3) Providing effective bandwidth is essential for body sensor networks, because failure to deliver the requested bandwidth may lead to accumulation and even overflow of sensor buffers. When the network is not suffering interference, BodyQoS just needs to allocate the requested bandwidth in order to provide effective bandwidth. However, when the network suffers interference and the effective bandwidth decreases, BodyQoS allocates more resources than requested to high priority streams, so that statistically the actually delivered bandwidth still meets the QoS requirements. Doing so may require moving resources from lower priority streams and assigning them to higher priority ones. Some low priority streams may even be terminated.

Technical Challenges and Solutions: (1) Two types of sensor devices exist in a body sensor network: multiple simple sensor nodes and a powerful aggregator. A simple sensor node can be a Band-Aid like tape sensor that uses film batteries, with the only functions of sampling and reporting. On the other hand, an aggregator is comparatively more powerful, carrying a better processor, more storage, multiple radios and rechargeable batteries. This asymmetric topology triggers our asymmetric QoS design, in which most work of admission control and resource scheduling are done on the aggregator. The sensor nodes are passively polled by the aggregator to reply with requested data within specified time periods. (2) Existing sensor devices on the market adopt different radio platforms, such as the CC1000 on the Mica2, CC2420 on the MicaZ and Telos, and Bluetooth on the Intel Imote. It is not wise to have a BodyQoS design tightly bound to underlying MAC implementations. Instead, we propose a virtual MAC (VMAC) in BodyQoS that abstracts common MAC functions for QoS support. VMAC sits on top of real MACs and is materialized by calling the underlying real MAC functions. To port the whole BodyQoS system from one radio platform to another, only tens of lines of codes need to be modified.

Demo Setup: Our demo setup mimics a workout where a person is wearing a body network is present. As shown in Figure 2, one Micaz reports EKG data (QoS stream) to the aggregator, and another Micaz reports sweat data (best effort stream). A third Micaz works as the aggregator and the fourth Micaz mimics noise from a co-existing body network. Packet transmissions and receptions are indicated with LEDS. Both the required and actual delivered bandwidths (#packets per 2 seconds) are displayed on the laptop screen in real-time.

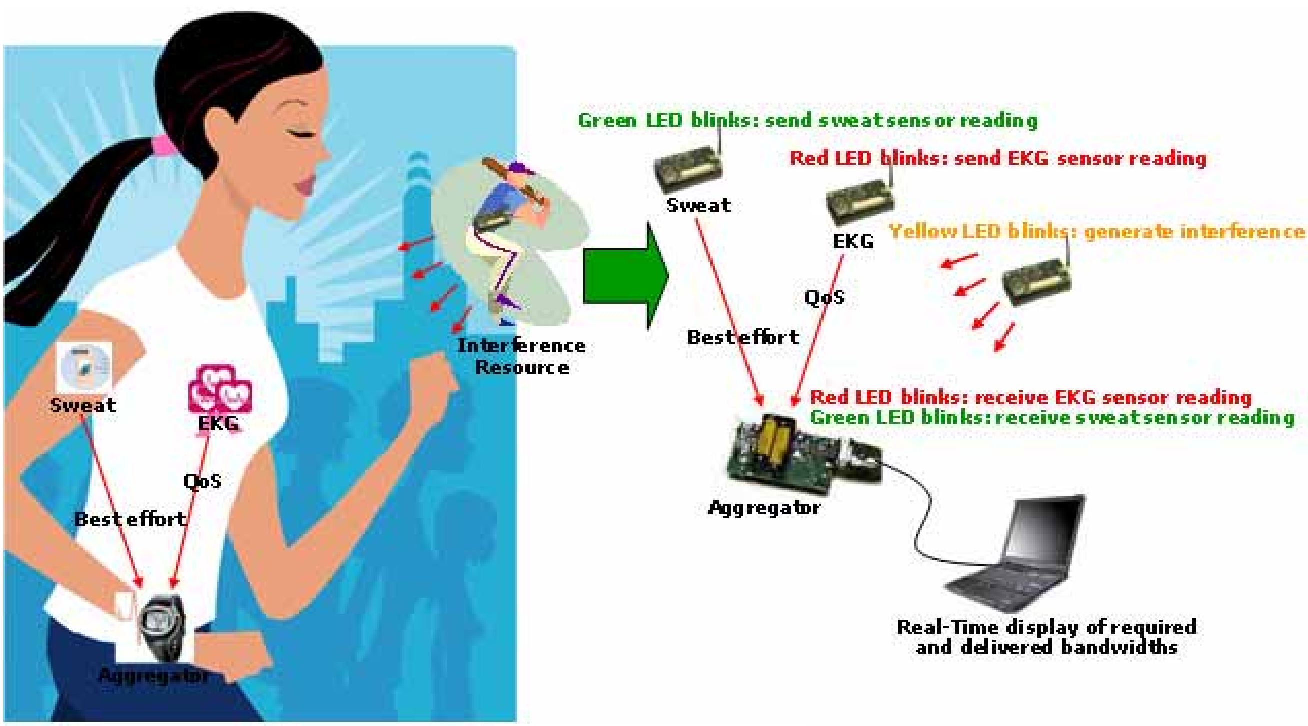

Figure 2: Demo Setup

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