

Distributed Resource and QoS Management in Wireless Body Area Networks

Abstract

A Wireless Body Area Network (WBAN) is a collection of intelligent body sensor nodes, which are placed in or on the body to monitor the physiological parameters of patients. The sensor nodes placed on the body are resource-constrained in terms of energy consumption rate, mobility, interference, and resource availability. Therefore, in the presence of interference from the other coexisting WBANs, the link quality between WBANs and access points (APs) varies significantly, which increases the packet loss rate and decreases the network throughput. To address this situation, in this Thesis, we first propose a link quality-aware resource allocation scheme in WBANs, which consists of two phases — temporal link quality measurement and sub-channel allocation among the WBANs. In the former, we predict correlations among different aspects of link quality. Based on the available correlated link qualities, the sub-channel allocation phase divides the available bandwidth into several sub-channels in order to maintain the quality of service (QoS) of the network. Additionally, we propose an energy-efficient resource management scheme for WBANs with fault tolerance in order to provide fair resources and connectivity to WBANs.

The resource allocation problem alone is not sufficient to improve the overall performance of the network in terms of service delay and network throughput. In the presence of increased traffic load and group-based mobility of WBANs, the performance of WBANs degrades significantly, thereby affecting the service delay and network throughput. Also, the mobility of WBANs affects connectivity between a WBAN and an AP dynamically, which varies the link quality significantly. To address the connectivity problem and provide QoS, in the Thesis, we propose a dynamic connectivity establishment and cooperative scheduling scheme, which minimizes the packet delivery delay and maximizes the network throughput. First, to secure reliable connectivity among WBANs and APs dynamically, we formulate a selection parameter using a price-based approach. Thereafter, we formulate a utility function for the WBANs to offer QoS using a coalition game-theoretic approach.

The aforementioned approaches minimize the service delay of the network and increase the network throughput. However, in a resource-constrained environment, the data transmission process in WBANs affects the successful packet transmission rate significantly. Therefore we propose an opportunistic transient connectivity establishment algorithm for WBANs. Additionally, limb/body movements induce dynamic changes to the on-body network topology, which, in turn, increases the network management cost and decreases the lifetime of the sensor nodes periodically. In addition, the mutual and cross-technology interference among coexisting WBANs and other radio technologies increase the energy consumption rate of the sensor nodes and also the energy management cost. To address the problem of increased network management cost and data dissemination delay, we propose a network management cost minimization framework to optimize the network throughput and QoS of each WBAN. The proposed framework tries to minimize the dynamic connectivity, interference management, and data dissemination costs for opportunistic WBANs.

We exploit the distinct features of WBANs throughout the works discussed in this Thesis and analyze the effectiveness of considering it as an important attribute of QoS. We also use the concept of utility formation and envision the problem of resource sharing among the sensor devices as a cooperative coalition game. The corresponding results explain the mutual benefits achieved by the sensor devices in comparison with the

approach that does not encourage cooperation among the sensor devices. Moreover, rigorous analysis of the MAC protocol of IEEE 802.15.6 standard is performed to maximize data transmission reliability, which is an essential QoS attribute. The necessity of achieving a trade-off between performance metrics, in order to maintain QoS in the presence of contradictory demands, is also discussed in detail.

Keywords: Wireless body area networks, energy efficiency, QoS, load balancing, network cost minimization.