Abstract

The latest advancements in Internet of Things (IoT) and wearable technologies have revolutionized the healthcare sector and created a new paradigm known as the healthcare IoT (HIoT), which promises personalized medical assistance and reliable patient monitoring, anywhere and anytime. HIoT, which is an IoT-based healthcare system, is expected to interconnect medical and non-medical devices with computing facilities comprising cloud, fog, and edge servers. These systems are interfaced by healthcare service providers, patients, and medical personnels. One of the challenges of developing IoT-based healthcare systems is to integrate diverse components and stakeholders into single compact system and offer secure, efficient, and reliable healthcare services. This dissertation presents the details of the studies conducted and the results obtained to improve the abovementioned challenges.

An essential component of IoT-based healthcare systems is the wireless body area network (WBAN). A WBAN is a short-range communication network, which consists of a hub and multiple physiological sensor nodes deployed on the surface of a human body or implanted within tissues or muscles. Based on the positioning of these sensor nodes, WBANs are classified into two categories — (a) in-body/implant sensor-based, and (b) on-body sensor-based. In the in-body sensor-based WBANs, guaranteeing quality-of-service (QoS) and prolonging network lifetime are major impediments due to the placement of sensors inside human body and the limited capacity of power unit. In this Thesis, first, we propose a novel energy-efficient medium access control (MAC) protocol for IEEE 802.15.6 standard complaint in-body sensor-based WBAN. We propose a modified superframe structure and design a novel emergency event handling scheme to address the critical events of in-body sensors. One of the crucial issues in on-body sensor-based WBAN communication is coexistence with other wireless networks such as wireless local area network (WLAN) operating in the unlicensed ISM band. The coexistence of these heterogeneous wireless networks in the unlicensed spectrum band leads to cross-technology interference, which in turn, decreases the individual network performances. Therefore, we propose a theoretical framework to analyze the coexistence throughput of on-body sensor-based WBAN in the presence of WLAN users.

The abovementioned approaches improve the performance of WBAN, which is used for individual patient-centric health monitoring. However, in recent years, the focus has been shifted to group-based patient monitoring. In this context, one of the promising solutions is *body-to-body network* (BBN), which enables co-located WBAN users to form a cooperative group and share their network resources with one another for effective physiological data uploading. This cooperative framework

of BBN reduces the packet collision rate and retransmissions, thereby minimizing the effect of interference due to coexistence, and enhancing network reliability. The success of the BBN framework depends on the collaboration and willingness of WBAN users to share their resources. However, in general, the WBAN users are self-centric and unwilling to share their resources without proper incentive. Therefore, in this Thesis, we focus on designing an incentive mechanism for BBNs, for motivating users to collaborate and enable efficient and fair network resource allocation among multiple WBAN users.

Finally, we focus on the mobile edge computing (MEC)-assisted WBAN system, which brings the computing services and storage facilities closer to WBAN users, thereby improving their quality-of-experience (QoE). In the MEC-assisted WBAN system, the users offload their tasks to the MEC server, so that the overall delay of task execution can be reduced significantly. However, with the increase in the number of WBAN users, the computational load on the MEC server increases, which results in continuous power consumption and energy inefficiency. Therefore, in this Thesis, we conceptualize the problem of energy minimization of MEC-assisted WBANs, using an economic framework and design an incentive mechanism that motivates WBAN users to compute locally and opt for partial task offloading to the MEC server. Consequently, we propose two incentive mechanisms to determine the amount of computing task and the corresponding reimbursement to WBAN users. Firstly, using the non-cooperative game theory, we propose a Stackelberg game to model the interaction among the MEC server and WBAN users. Secondly, using the cooperative game theory, we propose an incentive scheme based on the Nash bargaining framework.

Keywords: Wireless Body Area Network, Internet of Things, Body-to-Body Networks, Quality-of-service, Game Theory, Resource Sharing, Mechanism Design, Healthcare IoT