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Dynamic Scheduled Access Medium Access Control for Emerging Wearable Applications

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Context and Motivation

Wearable technology is emerging as one of the key enablers for the internet of everything (IoE). The technology is getting mature by every day with more applications than ever before consequently making a significant impact in consumer electronic industry. In recent years, with the continuous exponential rise, it is anticipated that by 2019 there will be more than 150 million wearable devices worldwide [1]. Whilst fitness and health-care remain the dominant wearable applications, other applications include fashion and entertainment, augmented reality, rescue and emergency management are emerging as well [2]. In this context, Wireless Body Area Networks (WBAN) is implicit and well-known research discipline which foster and contribute towards the rapid growth of wearable technology. IEEE 802.15.6 standard targeted for WBAN provides a great flexibility and provisions both at the physical (PHY) and medium access control (MAC) layers [3].

The wearable devices are constraint by limited battery, miniaturized, low processing and storage capabilities. While energy efficiency remains one of the most important challenges, low duty cycle and dynamic MAC layer design is critical for the longer life of these devices. In this regard, scheduled access mechanism is considered as one of the effective MAC approaches in WBAN in which every sensor node can have a dedicated time slot to transfer its data to the BAN coordinator. However, for a given application, as every node (i.e., connected sensors) has different data transmission rates [4], therefore, the scheduled access mechanism has to adapt the slot allocation accordingly to meet the design constraints (i.e., energy efficiency, packet delivery and delay requirements).

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Problem Description

The scheduled access MAC with 2.4 GHz of operating frequency, highest data rate (i.e., 971 Kbps), and highest payload (i.e., 256 bytes) provides the maximum throughput in IEEE 802.15.6 standard. However, the performance of both packet delivery ratio (PDR) and delay in this configuration is very poor starting from -10dBm and lower transmission power [5]. The presented study is focused on this particular PHY-MAC configuration and to understand what is the maximum realistic achievable throughput while operating at the lowest transmission power for future IEEE 802.15.6 compliant transceivers. In addition the objective is to enhance the performance under realistic mobility patterns i.e., space and time varying channel conditions.

Contribution

In this paper we address the reliability concern of the above mentioned wearable applications while using IEEE 802.15.6 (high data rate supported) PHY-MAC configuration. The objective is to enhance the system performance while exploiting m-periodic scheduled access mechanism. We proposed a throughput and channel aware dynamic scheduling algorithm which provides a realistic throughput under dynamic mobility and space and time varying links. First, various mobility patterns are generated with special emphasis on space and time varying links because their performance is most vulnerable under the dynamic environment. A deterministic pathloss values (as an estimate of the channel) are obtained from a motion capture system and bio-mechanical modeling. Consequently, signal to noise (SNR), bit error rate (BER) and packet error rate (PER) are calculated. The proposed algorithm during the first phase uses this estimated PER to select the potential nodes for a time slot. Whereas in the second phase, based on the nodes priority and the data packets availability among the potential candidates, finally a slot is assigned to one node. This process is iterated by the coordinating node until the end of a super frame.

Results

The proposed scheduling scheme has a significant gain over a reference scheme (i.e., without dynamic adaptation). On average, 20-to-55 percent extra packets are received, along with 1-to-5 joules of energy savings though at the cost of higher delay ranging from 20-to-200 ms while operating at low power levels (i.e., 0 dBm, -5 dBm, -10 dBm). It is recommended that the future wearable IEEE 802.15.6 compliant transceivers can successfully operate at -5 dBm to -8 dBm of transmission power; further reducing the power levels under dynamic environment can degrade the performance. It is also observed that the achievable throughput of different time varying links is good under realistic conditions until the data packet generation rate is higher than 100 ms.

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