

EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: BODY AREA NETWORKS FOR INTERDISCIPLINARY RESEARCH

Recent advancements in integrated circuits, wireless communication, and MicroElectroMechanical Systems (MEMS) technology has enabled low power, nano-technology wireless sensor nodes strategically deployed on the human body to be used by different applications, such as health monitoring, assisted living, and telemedicine. This new area of research is known as Body Area Networks (BANs) [1], [2]. BAN applications cover a wide area such as sports, entertainment, military, ubiquitous health care, and many other areas. BAN has multiple opportunities of interdisciplinary research where researchers from different areas of science and technology jointly put their efforts to improve the human body monitoring and performance. Due to these joint efforts, BAN is now evolving into Body Area Nano Networks (BANNs) as well [3], [4]. The BANNs are further extended with Internet of Nano Things and Internet of Bio-Nano Things technologies.

Since sensor nodes in body area networks are small and compact in size, therefore, they are equipped with limited rechargeable batteries having limited energy sources. To improve the operational lifetime of these sensor nodes, energy harvesting techniques can be used. In fact, variety of sources in human body and in ambient environment can be used to scavenge energy. These energy sources can be biochemical (glucose, and lactate), biomechanical (blood pressure, heart beat, breathing, and locomotion), and ambient sources (sun, RF towers, cell phones, and routers). However, research in energy scavenging for sensor nodes relying in body is still in its infancy stage [5].

In order to communicate, the sensors in body area networks rely on wireless radio spectrum. As mentioned by Federal Communication Commission (FCC) [6], the wireless radio spectrum is not available in abundance, due to its spatio-temporal utilization, and fixed spectrum assignment policy. Therefore, it is required to use dynamic spectrum assignment techniques by using cognitive radio technology [7]. The cognitive radio technology has numerous applications ranging from smart grid [8], cloud computing [9], cognitive radio sensor networks [10], [11], and body area networks [12]. The wide acceptance of cognitive radio technology in different applications is due to this capability of using under-utilized wireless radio spectrum a.k.a., white space [13].

The objective of this Special Section in IEEE ACCESS is to showcase the most recent advances in interdisciplinary research areas encompassing BAN. This Special

Section brings together researchers from diverse fields and specializations, such as communications engineering, computer science, electrical, and electronics engineering, educators, mathematicians, medical, and specialists in areas related to BAN. We invited researchers from academia, industry, and government who discussed challenging ideas, novel research contributions, demonstration results, and standardization efforts on the BAN and related areas.

In this Special Section, we included five articles in the domain of Body Area Networks. More specifically, this Special Section has focused on recent developments in Body Area Networks. The first paper is an invited article written by a renowned IEEE Fellow (Prof. Abbas Jamalipour) in the domain of BANs. The remaining articles are gathered into the following four areas: (a) Communication technologies for Body Area Networks, (b) Authentication, biometrics, and security in Body Area Networks, (c) Cache management and mobility in Body Area Networks, and (d) Medium access control protocols for Body Area Networks.

I. COMMUNICATION TECHNOLOGIES FOR BODY AREA NETWORK

For communication in BANs, there can be several standards and technologies which one may think to use. One such technology is to use cloud computing for data management of BANs [14]–[17]. One such standard is IEEE 802.15.6, which support data rates upto 10 Mbps. However, in order to achieve higher data rates upto Gbps, mmWave is a promising technology. These mmWave bands provide higher data rates, provide large bandwidth, can easily co-exist due to directional antenna, and also provide good isolation. Despite these advantages, mmWave based communication for wearable devices bring some challenges as well. For instance, health related issues, mmWave propagation features in highly dense indoor environment, and RF circuit design, should be carefully considered while choosing mmWave. Considering the importance of mmWave in BANs, we included one article on mmWave on highly dense indoor environment.

The article entitled “Millimeter wave networked wearables in dense indoor environments” by Kiran Venugopal, and Robert W. Heath, Jr., presents communication possibilities for wearable networks in dense indoor environments. Authors used millimeter-wave (mmWave) bands as potential candidate for Body Area

Networks communication. In this regard, authors first discussed potentials and challenges associated with mmWave for wearable networks. Authors then considered the unique features of mmWave frequencies such as reflections from walls and blockage of signal due to human body. Authors concluded that Giga bits per second (Gbps) achievable ergodic rates for mmWave in BANs can be achieved by using directional antennas and an antenna array in appropriate position in human body. However, authors mentioned that this Gbps data rate may suffer due to user location, density of devices in wearable networks, and body orientation as well.

II. AUTHENTICATION, BIOMETRICS, AND SECURITY IN BODY AREA NETWORKS

Authentication, biometrics, and security in Body Area Networks are important aspects to consider while designing future protocols. The importance of authentication, security, and biometrics get more attention when new context aware applications are paving their way in WBANs. These applications range from using biometric data in legal actions, and recruitment of employees. This data can be used to see the health activity of users. Thus, considering the importance of this topic, we have included one article on biometric authentication in this Special Section.

The article entitled “Biometric authentication using noisy electrocardiograms acquired by mobile sensors” by Hyun-Soo Choi, Byunghan Lee, and Sungroh Yoon, presents an authentication scheme for ECG signals collected through one-chip-solution mobile sensors. In fact, the authors designed a cascading bandpass filter for noise cancellation. Authors used support vector machine and compared nine classifiers through extensive experiments.

III. CACHE MANAGEMENT AND MOBILITY IN BODY AREA NETWORK

Mobility is almost essential in Body Area Networks because users move in their vicinity. And it may happen that one user wants to communicate with other user. Thus, sensors mounted on BANs should also consider the mobility aspect. Mobility can be individual or group mobility, i.e., movement of a group of users. Thus, we have included an article on mobility aware caching scheme in WBANs in this Special Section.

The article entitled “Cache management in cloud based body area networks” by Jong-Hyoun Lee, Neeraj Kumar, and Naveen Chilamkurti, presents a mobility aware caching scheme (MACM). MACM is proposed to assess data from the stored database in cloud based Body Area Networks. This algorithm handles a disconnection problem without generating extra overhead. MACM outperformed other existing schemes in terms of hit ratio, energy efficiency, and delay.

IV. MEDIUM ACCESS CONTROL PROTOCOLS FOR BODY AREA NETWORKS

Medium Access Control (MAC) protocols in Body Area Networks play an important role for channel access. These MAC protocols in WBANs generally categorized into two broad types: the first one is contention-based, while

the second one is schedule-based MAC protocols. In the first category, wireless sensor nodes in BANs rely on Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA), while in the second category, Time Division Multiple Access (TDMA) access methods are used by the nodes. Considering the importance of MAC protocols, we have included one article on MAC issues in WBANs.

The article entitled “A heuristic self-adaptive medium access control for resource-constrained WBAN systems” by Muhammad Mahtab Alam, Elyes Ben Hamida, Olivier Berder, Daniel Menard, and Olivier Sentieys, presents a latency-energy optimized traffic aware dynamic MAC protocol for Wireless Body Area Networks. Moreover, authors presented a heuristic based approach to re-configure and re-adapt the wake-up schedules of the nodes in WBANs.

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