Inter-BSN Interference Investigation for Body Sensor Netwoks

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***Abstract*—Recently, much interest has been involved in the design of Body Sensor Networks (BSNs). It is extremely desirable to maintain high reliability for BSNs. One of the main causes that deteriorate BSN performance is inter-BSN interference, which refers to the interference due to simultaneous transmission of several BSNs in the proximity of each other. This paper investigates how often and severely the inter-BSN interference exists in the common scenarios. The interference duration and the interference level are utilized as two metrics to measure the interference. The results of our simulation imply the significance of mitigating the inter-BSN interference effect. Moreover, it provides a guideline for the inter-BSN interference mitigation scheme design, and a test bed to test whether a mitigation method can be effectively applied in a specific scenario as well.**

Keywords—body sensor network; inter-BSN interference

I. INTRODUCTION

Recent advances in sensors, low-power integrated circuits, and wireless communications have enabled the design of wireless Body Sensor Networks (BSN), where physiological body parameters collected by various miniaturized sensor nodes can be delivered via the central node to the concern agents [1-4], such as medical staff, medical database, emergency, and immediate family, ensuring continuous and non-intrusive remote health monitoring.

However, a reliable and efficient health monitoring application based on wireless body sensor networks (WBSN) must overcome a number of hurdles before it can be safely deployed. One of the problems arise here is the inter-BSN interference which deteriorates the BSN performance and impacts the reliability of communication in BSNs. Inter-BSN interference refers to the interference due to the simultaneous communications of wireless BSNs in proximity of each other. When the sensor nodes transmit data in respective BSN at the same time in the same vicinity, interference is introduced which reduces the reception probabilities and throughput achieved by all the networks.

The existing literatures on inter-BSN interference (IBI) that can be found are [5-7]. [5] highlights the existence of the inter-user interference effect in BSN from the perspective of network architectures. In [6], the authors make a preliminary investigation of the adverse impact of inter-user interference, in particular, the performance degradation over various number of interferers and distance. It is found that the IBI reduces packet delivery rate almost by 35% in the presence of eight or more interfering BSNs around, thus inter-BSN interference problem has to be handled carefully. [7] proposes a decentralized inter-user interference suppression algorithm for BSN. This algorithm provides an adaptive inter-user interference suppression strategy by utilizing non-cooperative game theory and no regret learning algorithm. Each BSN measures the interference from other BSNs and then adaptively selects a suitable channel and transmission power. These interference mitigation methods are preliminary either due to its infrastructure cost or low convergence.

Although [6] shows how severe the IBI affects performance when BSNs congregate together, none of the researches has studied how often the BSNs tend to congregate together and the common number of interferers, which would provide us an overall and thorough understanding of the significant existence of IBI. This paper aims at addressing this problem from this perspective. Moreover, the simulation results of this work also aim to provide a guideline to develop inter-BSN interference mitigation method.

II. EXPERIMENTAL AND SIMULATION SETUP

A. Experimental Setup

The objective is to investigate how often and severe the IBI exists in a real BSN congregated scenario. In order to achieve this goal, we have performed a case study in Thoracic Oncology Clinic of Cancer Hospital & Institute, Chinese Academy of Medical Science (CAMS). The floormap of Thoracic Oncology Clinic is depicted in Fig. 1. Patients first register at the registration counter, then wait at the consultation waiting area. The total waiting time a patient spends at the waiting area is about 60 minutes.

According to the statistical data of the last year from CAMS, the average number of patients in a day can be categorized into three periods.

Peak time: 8:00 to 9:00 and 14:00 to 15:00, 96 patients.

Moderate time: 9:00 to 10:30, 13:30 to 14:00, and 15:00 to 16:00, 75 patients.

Off-peak time: 10:30 to 12:30 and 16:30 to 17:30, 60 patients.

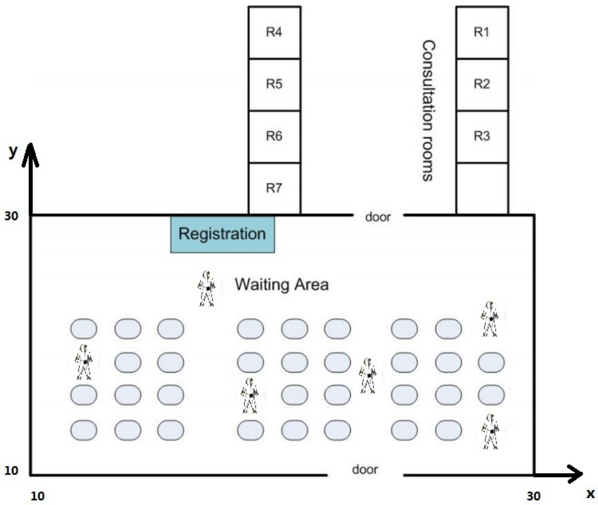


Fig. 1. The floormap of Thoracic Oncology Clinic.

These data are average data within one year. According to the statistical data, the average area per person (BSN) is from 8 m^2/person to 20 m^2/person. Additionally, each person (BSN) moves with a speed between 0.2 m/s and 2.2 m/s.

B. Simulation Setup

The destination, speed, and direction are all chosen randomly and independently. The BSN wearers are constrained to move randomly and freely within the range restriction of 20m by 20m. We set the number of BSNs moving around to be 20, thus the average area per person is 20m^2/person, representing the lowest density case.

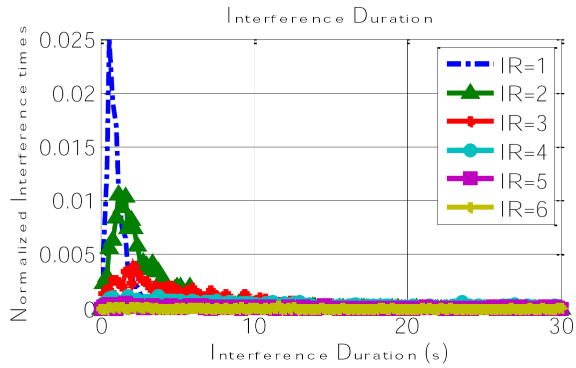
In the simulation, we used two metrics to measure the IBI: interference duration (ID) and interference level (IL). ID refers to the duration that there is one or more other BSNs within the interference range of the tagged BSN. It is a significant metric because the length of interference duration and its ratio to the total simulation time implies the generality/prevalence of IBI. In the simulation part, for each BSN we record the distributions of interference durations during the whole simulation time. For instance, if BSN1 experiences inter-BSN interference from 1st to 3rd second, and the transmission returns to its normal state at the 4th second, we add 1 time at the interference duration of 2 seconds. This process is repeated over all the time index of a specific BSN, and then over all the BSN users. And the final results are normalized by the number of BSNs and total simulation time.

Interference level refers to the level of service degradation due to inter-BSN interference. Since the performance degradation is closely related to the number of interferers in the same vicinity, we measured the number of interferers as the interference level in this paper. The interference level provides a guideline for the inter-BSN interference mitigation scheme design. In this paper, we recorded the number of interferers within the Interference range (IR) of a specific BSN at each time index over all BSNs involved, and the final result is also normalized by the number of BSNs and total simulation time.

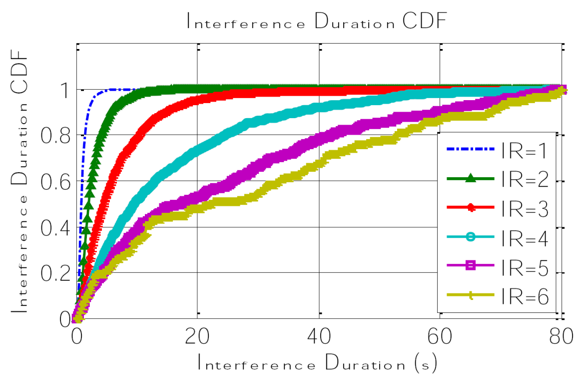
III. Simulation Results

We measured the two metrics based on the simulation settings aforementioned, and the simulation results are shown in Fig. 2 and Fig. 3.

Fig. 2(a) shows the normalized interference times over different interference duration. The points on the graph indicate the normalized summation of the times of interference duration for total number of BSNs in the scenario. Different curves indicate the cases for different interference ranges. Its Cumulative Distribution Function (CDF) is shown in Fig. 2(b). It can be seen that for IR=1 the most possible interference duration is 2 seconds, while it is 3 seconds for IR=2, and it keeps increasing when the interference range gets large. It is intuitive to understand because when the interference range gets large, there is more chance for BSN to experience IBI.



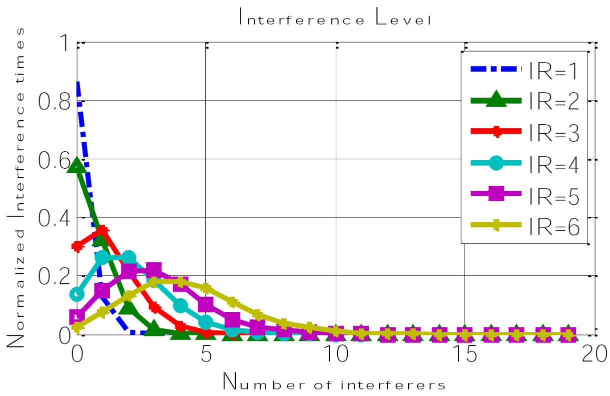
(a) interference duration



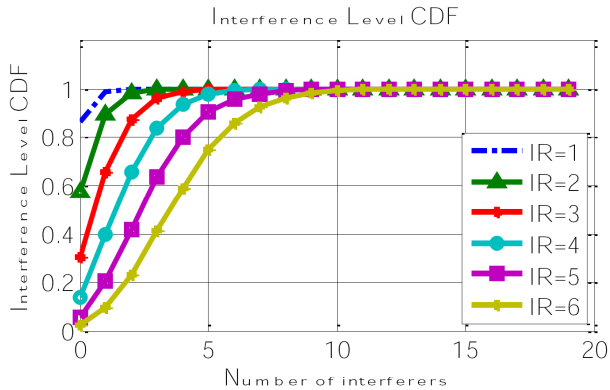
(b) interference duration CDF

Fig. 2. Simulation results under the scenario that the personal occupancy area is 20 m^2 / person.

Fig. 3(a) depicts the normalized interference times for different number of interferers, while Fig. 3(b) shows its CDF. It can be seen that when the interference range becomes larger, the most likely number of interferers also increases. For example, for IR=1, for most of the time, the interferer number is 0, and it is 1 for IR=3. For IR=6, the maximum number of interferers that one specific BSN experiences is 11. It is straightforward because for the same scenario, when IR increases, the number of BSNs fall within the IR of one specific BSN also increases. Thus, it can be seen that the interference level becomes severe.



(a) number of interferers



(b) the CDF of number of interferers

Fig. 3. Simulation results under the scenario that the personal occupancy area is 20 m^2 / person.

IV. Conclusion

This paper addresses the significance of the inter-BSN interference problem from the perspective of its prevalence. Simulation results imply that inter-BSN interference effect exists widely and severely in the BSN congregated scenario. In addition, the simulation results are compared among three different scenarios, so that a guideline can be concluded for the inter-BSN interference mitigation scheme design, and the simulation work in this paper can be regarded as an input to test the effectiveness of the inter-BSN interference mitigation methodologies.

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