Sensing Task Handover for Indoor Clustered Wireless Sensor Network

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***Abstract*—This paper presents the proposal of implementing sensing task handover initiation control for wireless sensor network deployed in indoor environment. The structure of the wireless sensor network is based on indoor clustering so that sensor nodes are grouped in different clusters according to room partitions. For such a network, a simple and efficient multi-node handover initiation control method is proposed for the decision of handover initiation by comparing the combined received signal strengths and the number of effective nodes between two neighbouring clusters. Experiments were conducted to test the possibility and evaluate the performance of the proposed method. The results show that sensing task handover is possible to happen at accurate time while crossing boundary between two clusters by applying the proposed method.**

Keywords-component:* *Sensing Task, Handoff, Handover, Indoor Environment, Wireless Sensor Network

I. INTRODUCTION

Initially, the terms "handover" were first used in cellular network or satellite communication to support mobility [1]. When wireless technology advances, mobile handover was also applied in today's computer network to transfer connection between access points. Most of the researches in this area are focused on vertical handover [2] in hybrid networks. Multi-criterion handover scheme [3], [4] is also one of the main topics in this stage.

The emergence of wireless sensor network (WSN) and its applications in indoor environment reveal new needs of handover scheme in the future ubiquitous network. Unlike the traditional single-base multi-user model, WSN consists of stationary nodes (SN) located at strategic locations as service providing bases, mobile nodes (MN) moving around SNs to collect continuous data, and a base-station data-sink connected to a server computer for centralized database and management [5]. This new scenario allows MNs to obtain service from more SNs simultaneously.

If a MN is moving to aggregate sensor data from surrounding SNs, the fusion of data from different sources can be linearly combined and processed. However, sensing task could be ambiguous if WSN is deployed in indoor environment. For example, the temperature at two neighbor rooms is assumed to be different. If A MN is moving from one room to another, it is possible that the MN receives sensor data partially from the SNs in the first room and partially from the other through wireless connections. Thus, the fusion of sensor data from the two rooms becomes inaccurate because the MN can only be considered in either room.

The objective of our study is to find the best solution that is able to initiate sensing handover at accurate time and place while MN crossing boundary between the two rooms. In this case, MN is only possible to accept the optimized service of SNs in the most appropriate room each time without interruption.

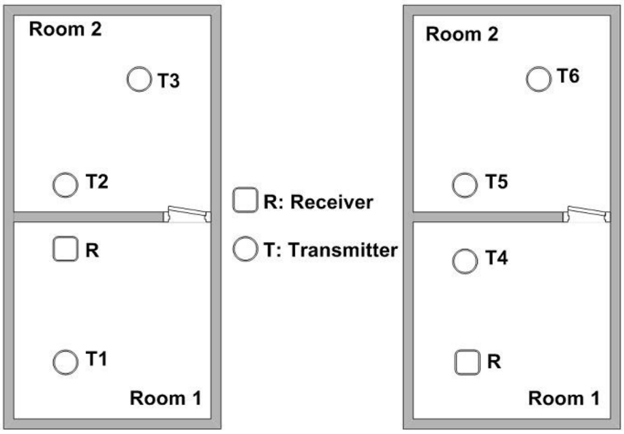
II. RELATED WORKS

In the past researches of WSN, handover issue is generally not particularly considered because most WSN applications assume outdoor deployment. Recent researches move further and beginning to consider indoor applications such as indoor positioning and tracking [6]. At first, WSN is only used as auxiliary control network for assisting mobile handsets to maintain continuous connectivity [7]. WSN is also used to help fast handover between wireless local area networks (WLANs) [8].

When WSN based systems become more popular for implementing indoor applications, handover schemes and mechanisms for WSNs are emerging to ensure QoS and connectivity [9]. These kinds of WSN applications such as healthcare monitoring and hospital equipments generally require both mobility and un-interruptible vital signal monitoring. For target tracking and positioning, [10] proposes an energy efficient method for handover between cluster-based networks. Multi-sink network structure is considered in [11] using soft-handover scheme for IP-based WSNs. So far, the purpose of using handover in WSN is only to maintain continuous data path for achieving required QoS. In this paper, the main objectives are not just to maintain connectivity in indoor environment, but also to provide reasonable data fusion selection scheme and accurate handover trigger from different nodes located in different rooms.

III. PROBLEM ANALYSIS

To understand the influences to accurate handover decision, we deployed WSN in two adjacent rooms of an office building. The sizes of the two rooms are similar (about 100 m^2). The wireless technology used for radio transmissions among sensor nodes is based on IEEE 802.15.4 standard. In this experiment, we assigned three transmitter and one receiver nodes allocated in the two rooms as shown in Figure 1.



a b

Figure 1. Indoor wireless sensor network deployment; (a) scenario 1: receiver is near to boundary, (b) scenario 2: receiver is far from boundary.

The first and second scenarios in Fig. 1(a) and 1(b) were designed to measure received signal strengths (RSS) from the transmitters in the two rooms when the receiver node was located near and far away boundary respectively. Three main parameter measurements were evaluated for the purpose of handover decision: (1) received signal strength indicator (RSSI), (2) link quality indicator (LQI) and (3) rate of connectivity (ROC). ROC is defined as the total number of effective connections for the target room over the maximum number of connections held during a sampling period for all rooms.

The results of measurement and evaluation are shown in Figure 2. By comparing the location of transmitters in Figure 1 and the measurement results in Figure 2(a), we concluded that RSS become weaker if penetration loss of wall is considered. Different wall materials and thickness result in different attenuations [12], [13]. Therefore, it is possible that the attenuation caused by wall penetration is higher than the attenuation caused by long distance path loss, or vice versa.

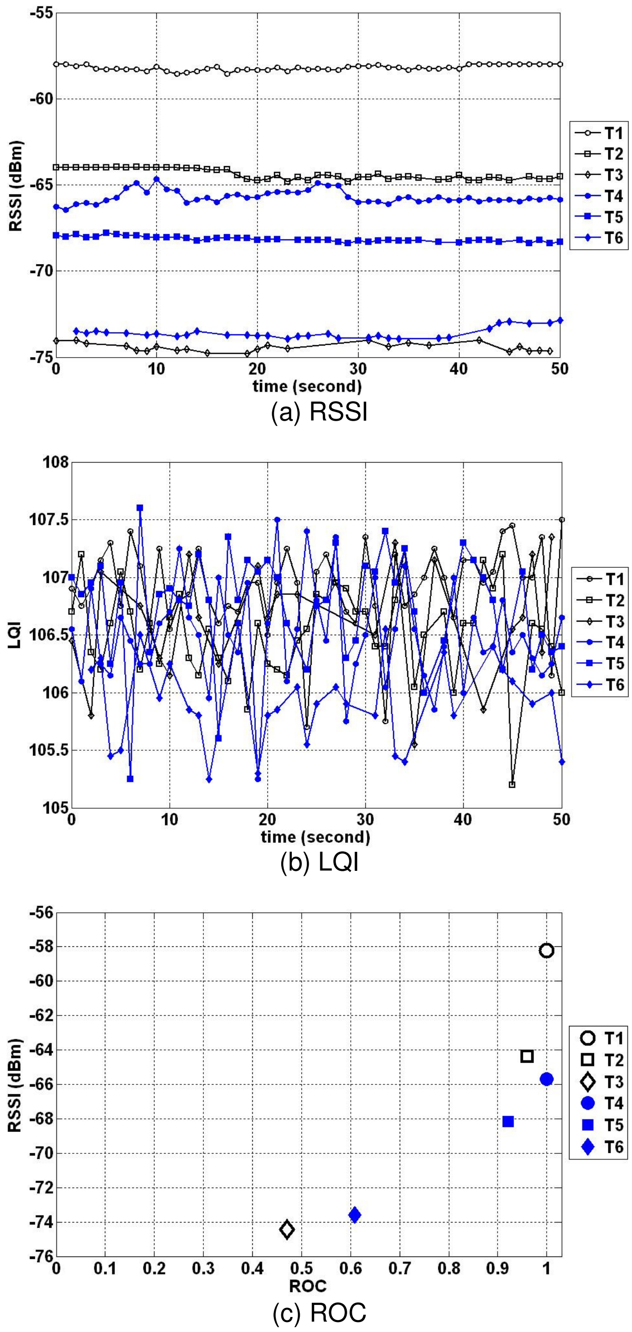


Figure 2. Signals measurement and analysis.

In Figure 2(b), we can find that the LQI caused by both long distance path loss and wall penetration (T6) is lower than others. Thus, it can be used for threshold filtering. Figure 2(c) illustrates the statistical plot for average RSSI versus ROC. This figure indicates that the rate of connectivity is proportional to RSS.

IV. HANDOFF INITIATION

We propose a multi-base multi-criterion handover initiation control method based on the analysis in the previous section. The handover criteria of the proposed method are composed of general and application specific criteria. The general criterion is defined as

$$w_r(k) = ROC_r(k) \times \sum_{i=0}^{N} \left[\mathrm{u}\left(LQI_{r,i} - \alpha\right) \times \left(RSSI_{r,i} + \beta\right) \right] \quad (1)$$

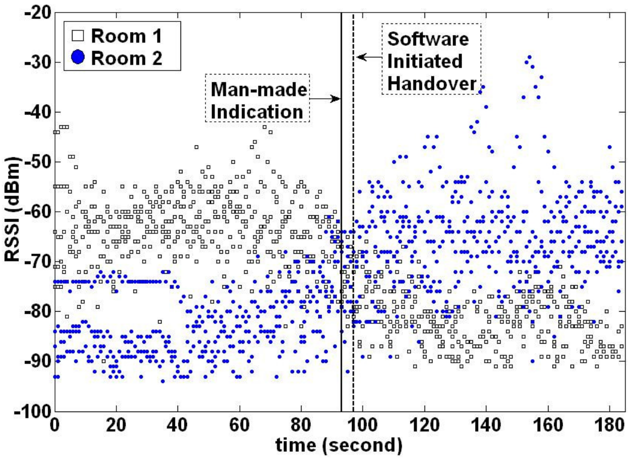
where $w_r(k)$ is the priority weight for room r at sampling instant k. u(x) denotes unit step function. α is link quality threshold. In our case, α = 100 to ensure quality of connection. β is a conversion constant to shift all RSSI values to positive for priority evaluation. It also represents the dynamic range of RSSI. In our case, β = 100. N is the window size of the buffer holding the most current measurements of RSSI and LQI.

In real-time processing, handover initiation is based on the comparison of w_r among all rooms. After comparison, the SNs in room r with highest w_r are selected as the operating group of SNs. The application specific criteria are determined by the type of operation. For example, fine-grained indoor location estimation requires at least three SNs for a target room to operate lateration. Therefore, handoff initiation is triggered when the number of effective or detectable SNs is less than 3.

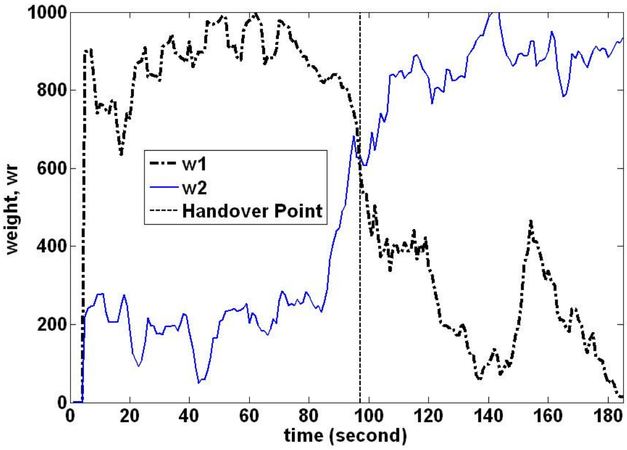
V. EXPERIMENTAL RESULTS

We conducted an experiment to evaluate the proposed method. Five SNs were allocated randomly in each room as in Figure 1. All SNs broadcast signal every 1 second. We also assigned the clusters of SNs in the network based on room division. A MN was moved from Room 1 to Room 2 to measure RSSI and LQI regardless of movement pace and route.

The real-time measurement and handover decision results are shown in Figure 3. In Figure 3(a), square and round symbols represent RSSI measured from the signals broadcasted by the SNs in Room 1 and Room 2 respectively. Since the MN is moving away Room 1 and approaching Room 2, the RSSIs from Room 1 are decreasing, and increasing for Room 2. In this experiment, a man-made indication was signaled when the MN was crossing the boundary between Room 1 and Room 2. The result shows that the software initiated handover time is close to the man-made indication time, thus we are able to prove that the proposed method is accurate for handover decision while crossing boundary. Figure 3b illustrates the estimated priority weights w_1 and w_2 for Room 1 and 2 respectively. By comparing w_1 and w_2, we are able to trigger handover at the crossing point of w_1 and w_2. This also verifies the robustness of the proposed method.



(a) RSSI comparison



(b) Weight comparison

Figure 3. Real-time handover decision evaluation.

VI. CONCLUSIONS

In this paper, we demonstrated the need of new handover algorithm for multi-based WSN. From analysis, we also found that handover decision can be made accurately if we consider RSSI, LQI, ROC and the number of effective bases. A multi-base multi-criterion handover initiation control method was proposed. The proposed method was evaluated in real-time, and we verified that the software initiated handover time is close to the man-made indication time. This shows that handover operation can be handled properly with the proposed method.

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