User Presence Detection in SmartRoom Using Innorange Footfall Sensor

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***Abstract*—The SmartRoom system constructs a digital service environment to support collaborative activities where participants are physically localized in a room. The environment intelligence increases when services become aware of knowledge on user presence and activity in the room. In this abstract we consider the Innorange Footfall technology, which uses passive radio detection in WLAN. The technology is built into a sensor that provides real-time data for user presence detection and activity tracking. We suggest scenarios for the use of Innorange footfall sensor and describe the integration into the SmartRoom system.**

Keywords—Smart spaces, Smart-M3, Collaborative environment, Presence detection, Indoor location.

The SmartRoom system provides a set of digital services for automation of such collaborative human activity as conferences, meetings, and lectures [1]. Activity is spatially localized in a room. Its digital equipment consists of devices with sensing, processing, network, and user interfacing capabilities. Using the Smart-M3 platform [2] a knowledge sharing environment is constructed—a smart space [3]. A device hosts one or more agents—knowledge processors (KP). Services are formed by cooperation of KPs.

Human participants are SmartRoom users; they participate in the ongoing activity by accessing and using services via their personal computers, typically mobile (e.g., smartphones). The corresponding KPs are SmartRoom clients [4]. For instance, the current speaker controls her/his slide show. In parallel, spectators browse digital content shared by prospected speakers. When we describe design details of the system we preferably use term "user".

The intelligence of SmartRoom services and their delivery can be extended by utilization of real-time information on user presence in the room. We consider the following scenarios for the SmartRoom system.

S_1: *User arrival to the room.* Before starting the main activity, the users arrive and gather in the room (first-time join) and preparing/waiting the forthcoming activity. Detection of user arrivals activates personalized welcome services and provides runtime initialization for starting the main activity. For example, everyone can see who is ready to make presentations.

S_2: *User joins and leaves during the main activity.* Real-time status of every user provides important information for the activity agenda. For example, the system moves or cancels a planned presentation if its speaker is absent, or the system notifies the speaker that her/his talk is expected to start soon.

S_3: *Activity statistics.* Based on presence information the system evaluates resources that each participant provided to the activity and then it determines "the top participants". For example, a possible metric is the time the participant has spent in the room.

For implementation of the above scenarios we consider the location estimation approach, which is based on the known methods of passive radio detection using received signal strength indication (RSSI). The Innorange Footfall technology provides a possible solution (http://www.innorange.fi/products.html). In general it aims at real-time information on how services are used, where the bottlenecks are, how they can be avoided. It is possible to discover how people are moving between the service points, from where they are coming, and where they are going to. The solution benefits from its low implementation cost and accuracy satisfactory for typical instances of scenarios S_1, S_2, and S_3.

For the SmartRoom case, the Innorange Footfall technology provides a dedicated sensor (e.g., TP-Link WDR3600). Its custom OpenWRT-based software module continuously analyzes MAC addresses of mobile devices operating in the SmartRoom WLAN. The sensor observes movements of mobile devices in the spatial sensor-centered area. A user device generates network traffic to the WLAN, and every traffic unit has received a RSSI value at the sensor. The closer the device is to the sensor the higher the RSSI value is [5].

Innorange Footfall sensor is mounted preferably near the center of the room to achieve the maximum possible coverage of the room spatial area. After the installation the calibration is needed for accurate evaluation of the WLAN RSSI threshold. If the RSSI value exceeds the threshold the device is treated as present in the room, see Fig. 1. This decision making is real-time, especially important for scenario S_2.

Our architectural solution for the integration of Innorrange Footfall sensor into the SmartRoom system is shown in Fig. 2.

The sensor regularly sends its measurements to the backend processor, which is a mediator for the SmartRoom smart space. The smart space is maintained by Smart-M3 semantic information broker (SIB). The corresponding KP runs on a dedicated

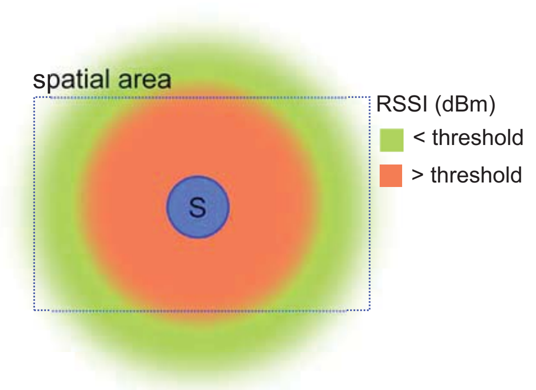

Fig. 1. Schematic view on spatial RSSI-based coverage

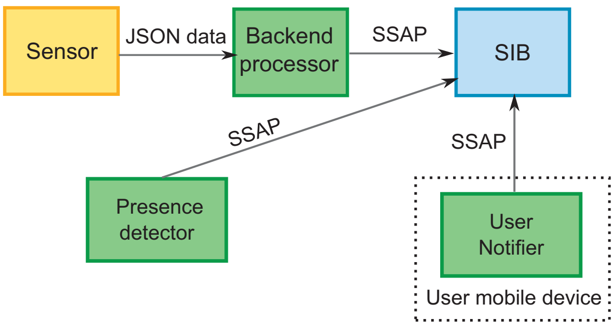

Fig. 2. Attaching Innorange sensor to the SmartRoom system

computer. For the sensor the KP is an HTTP endpoint; its implementation uses the flask web framework. Communication with SIB is by Smart Space Access Protocol (SSAP) of Smart-M3; the KP part (SSAP client) uses the Python Smart-M3 library. The published data are MAC address, RSSI value, and timestamp.

The presence detector is an additional KP. It subscribes for updates of device presence data in the smart space. Any update is mapped to the related user using MAC address. The correspondence of users and MAC addresses is defined by registration service. (User provides her/his MAC address only if she/he agrees.) The registration is web-based; each user makes it in advance and remotely, e.g., when the organizers provide an initial program of the activity.

This scheme allows direct communication with the user device. Whenever updated information on device presence is available the presence detector or another delegated infrastructural KP can send requests to the user mobile device. For this case, the device runs (daemon mode) the user notifier software, e.g., it welcomes the user and launches SmartRoom client. This property is important for scenario S_1.

The latest device presence time is an additional attribute for utilization in scenario S_3. After the "$\mathrm{MAC} \leftrightarrow$ user" mapping the time is associated to the user profile. As a result, the presence histories (activity tracks) for users can be constructed for further analysis.

SmartRoom ontology [1] represents services and participants. Each participant is related (as a user) to her/his mobile device. Properties of the device, such as MAC-address, become linked with the participant representation. In addition, each participant is related to its profile, which contains information on the presence, e.g., estimation of recent presence in the room and the history of past activity.

We performed experiments with deployed SmartRoom system and attached Innorange footfall sensor. The room spatial area is 13×7 m^2. The sensor is mounted in the center. User devices are for different mobile platforms: Symbian, Android, Windows Phone. The calibration leads to RSSI threshold -35, which allows to determine correctly the device presence in about 80..90% of cases.

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