Presence Detection in SmartRoom: Experimental Performance Evaluation

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***Abstract*—SmartRoom system constructs a digital service environment to assist collaborative activity when many participants are physically present in a room. The service intelligence can benefit from knowledge of user presence and activity in the room. In this work we report our experiments with the Innorange Footfall technology. It applies passive radio detection of mobile devices in WLAN. We consider particular scenarios for use of such user presence detection in SmartRoom services. Based on these scenarios we implemented a prototype and evaluated its performance.**

SmartRoom system provides a set of digital services for assisting such collaborative activity as conferences, meetings, and lectures [1]. Activity is spatially localized in a room, although remote participation is also possible. Its digital equipment consists of devices with sensing, processing, network, and user interfacing capabilities. A device hosts one or more agents—knowledge processors (KP). Using the Smart-M3 platform [2] a knowledge sharing environment is constructed—SmartRoom space. KPs publish common information and make its semantic relation. Each service is formed by cooperation of several KPs in the SmartRoom space.

Human participants become SmartRoom users. They participate in the ongoing activity by accessing and using services via their personal mobile devices (e.g., smartphones). The corresponding KPs play the role of SmartRoom clients [3], [4]. For instance, each current speaker controls the slide show (e.g., "next slide", "previous slide"). In parallel, any spectator can browse digital content shared by prospected speakers.

We continue our development on user presence detection is SmartRoom [5]. We employ the location estimation approach for real-time information on user presence associated with network activity of personal mobile devices. Known methods of passive radio detection are applied to measure received signal strength indication (RSSI) for each device at any time. In this work we consider how to use derived knowledge of user presence in SmartRoom services.

For our problem we selected the Innorange footfall technology (http://www.innorange.fi/). It provides a dedicated sensor for wireless traffic detection. 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. Whenever a device generates network traffic to the WLAN, each traffic unit has received its RSSI value at the sensor.

We focus on the following scenarios for SmartRoom, which were introduced in [5].

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.

S_2: *User joins and leaves during the main activity.* Real-time status of every user provides important information for the activity agenda (its current status and update whenever needed).

S_3: *Activity statistics.* Based on user presence knowledge the system evaluates resources that each participant has contributed to the activity. Then SmartRoom can determine "the top participants" or provide other summary metrics.

We define a discrete model of user presence state in the SmartRoom. The model is depicted in Fig. 1 as a state diagram. Each state $s = (r, d, l)$ has the following Boolean parameters.

r: whether the user is registered in the system (registered).

d: whether the sensor is detected user's device in the room (detected).

l: whether the user accessed the system using her SmartRoom client (logged in).

The total number of possible states is 2^3. Depending on the state the user presence can be ranked into one of the following levels: absent, virtual, physical, and full. User cannot unregister herself in the system. User may leave the room or stop accessing the system using her client. For instance in scenario S_2, user status can be visualized on the activity agenda screen in dependence on current presence level.

Consider the states when d is changing and r remains fixed (either registered or not). Scenarios S_1 and S_2 are based on detecting the transitions between such states. Scenario S_3 does not require instant presence detection, and we do not analyze it further in this work.

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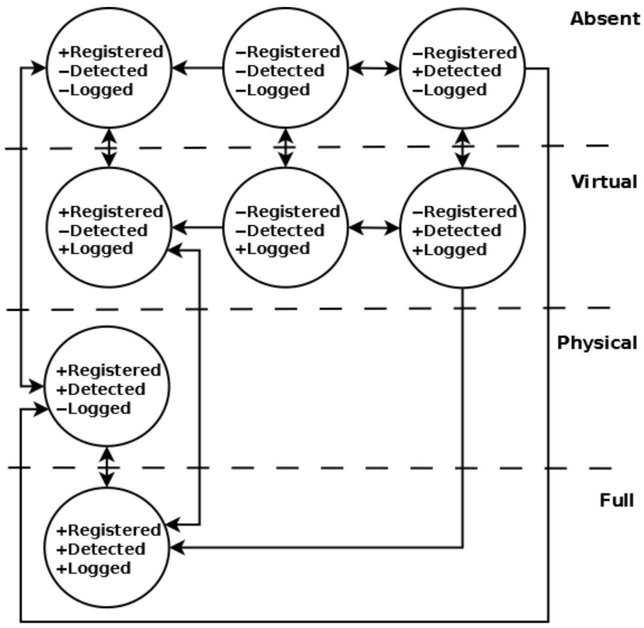

Fig. 1. Discrete measure for user presence: presence levels, constituting states (r, d, l), and possible state transitions

Scenario S_1 uses the unidirectional transition

$$+\mathrm{R} -\mathrm{D} -\mathrm{L} \ \rightarrow \ +\mathrm{R} +\mathrm{D} -\mathrm{L}. \tag{1}$$

User arrival is detected before starting the main activity. Then a welcome service is activated at once for this user, before her client is started.

Scenario S_2 uses the bidirectional transitions

$$+\mathrm{R} -\mathrm{D} -\mathrm{L} \ \leftrightarrow \ +\mathrm{R} +\mathrm{D} -\mathrm{L}, \tag{2}$$

$$+\mathrm{R} -\mathrm{D} +\mathrm{L} \ \leftrightarrow \ +\mathrm{R} +\mathrm{D} +\mathrm{L}. \tag{3}$$

They periodically happen after the first user arrival.

Our architectural scheme for user presence detection and its use in SmartRoom is shown in Fig. 2. Sensor implements Innorange footfall technology. We experimentally evaluate the time required to detect transitions (1), (2), and (3).

SmartRoom space is maintained by Smart-M3 Semantic Information Broker (SIB). The sensor regularly sends its measurements to the backend processor. The latter runs on a dedicated computer located in the room. For the SmartRoom space, the backend processor is a KP that mediates data coming from the sensor to the SIB. For the sensor the KP is an HTTP endpoint. The transferred data are MAC address, RSSI value, and timestamp.

The presence detector is an additional KP. It subscribes for updates to device presence data in the SmartRoom space. Any update is mapped to the related user using the MAC address of her device. The presence detector KP analyzes timestamps and determines the user presence state and level. This information is used by other services (e.g., agenda service).

Scenario S_1 is implemented as follows.

Step 1. The sensor determines close device and sends the device presence data to the backend processor.

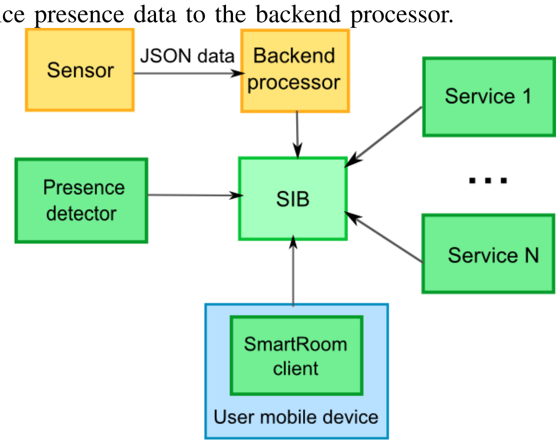

Fig. 2. Architectural scheme for user presence detection: Innorange footfall technology is integrated into SmartRoom system

Step 2. For the first detection of device MAC address the backend processor publishes presence data in ontological form: one individual (class Presence) with two data properties: last seen and enter.

Step 3. The presence detector (notified by subscription) updates the data properties: is present and presence level. The main load is due the data publication into SmartRoom space. The time cost is proportional to the number of detected users and depends on WLAN performance. In our experiments the time cost does not exceed 0.2 s per user.

For the scenario S_2 the essential issue is the leave threshold. It is the time elapsed before considering that the device (and its user) is absent in the room. The threshold is at least $40 \dots 60$ seconds since many WLAN devices appear once in a minute if they do not actively transmit data. The presence detector monitors continuously the last seen property and reacts whenever its value exceeds the threshold. Thus the user is considered as has left the room. Then the presence detector updates the properties is present and presence level. When the device is detected again in the room then the user is considered as re-joining the main activity (similarly as in S_1). The properties last seen and enter are updated.

References

[1] D. Korzun, I. Galov, and S. Balandin, "Smart room services on top of M3 spaces," in *Proc. 14th Conf. of Open Innovations Association FRUCT*, S. Balandin and U. Trifonova, Eds. SUAI, Nov. 2013, pp. 37–44.

[2] J. Honkola, H. Laine, R. Brown, and O. Tyrkkö, "Smart-M3 information sharing platform," in *Proc. IEEE Symp. Computers and Communications (ISCC'10)*. IEEE Computer Society, Jun. 2010, pp. 1041–1046.

[3] A. Vdovenko, S. Marchenkov, and D. Korzun, "Mobile multi-service smart room client: Initial study for multi-platform development," in *Proc. 13th Conf. of Open Innovations Association FRUCT and 2nd Seminar on e-Tourism for Karelia and Oulu Region*, S. Balandin and U. Trifonova, Eds. SUAI, Apr. 2013, pp. 143–152.

[4] ——, "Delivery of smartroom services usign mobile clients," in *Proc. 14th Conf. Open Innovations Framework Program FRUCT*, S. Balandin and U. Trifonova, Eds. SUAI, Nov. 2013, pp. 215–216.

[5] S. Marchenkov and D. Korzun, "User presence detection in SmartRoom using Innorange Footfall sensor," in *Proc. 14th Conf. Open Innovations Framework Program FRUCT*, S. Balandin and U. Trifonova, Eds. SUAI, Nov. 2013, pp. 199–200.