Sensors in a Smart Room: Preliminary Study

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Abstract

Petrozavodsk State University (PetrSU) has started development of smart rooms aiming at making the PetrSU educational and research processes of a higher automation and quality level. An important component of such rooms is sensors, which allow monitoring the current physical environment state. This paper reports our work-in-progress results on sensor use in PetrSU smart rooms. First, we selected classes of sensors for use in PetrSU smart rooms. Second, we introduce an ontological model for representing sensor-related data in smart spaces. Third, we propose an architectural Smart-M3-based solution for connecting sensors to the smart room space. We also discuss basic scenarios with sensing data that we plan to implement in the smart room.

Index Terms: Smart spaces, Smart-M3, Smart room, Sensors.

I. Introduction

Petrozavodsk State University (PetrSU) has started development of smart rooms, which are specialized for holding conferences, lectures, meetings, and other events. Human participants are localized in space and time to share related information and to collectively produce new knowledge. These processes are supported with computational equipment and services deployed in the room as well as with external services available elsewhere (e.g., in the Internet). The development is based on smart spaces [1]. The M3 concept — Multidevice, Multidomain, and Multivendor [2] — aims at interoperable information smart spaces for various domains, spanning from embedded domains to the Web. Smart-M3 [2] is an open-source platform that implements M3-based smart spaces (M3-spaces).

This work-in-progress paper presents our preliminary study of such an important component of PetrSU smart rooms as sensing devices. At the current phase we focus on engineering requirements and high-level design solutions. We consider certain classes of sensor equipment that allows dynamic tracking changes in the internal physical environment of the room. We select classes of sensors appropriate for monitoring physical parameters of the room (light, noise, temperature, participant joins and leaves, etc.). Our proposed architectural solution is based on Smart-M3 platform and supports regular sensed data sharing, following the approach initially approved in [3], [4]. We present some use cases that show how sensed data can be used in the smart room to extend its existing services and to provide new ones.

The rest of the paper is organized as follows. Section II considers the recent PetrSU smart room design; we pose sensing facilities for the smart room services and corresponding ontological model to represent sensed data in the M3-space. Section III overviews sensor devices, which we propose for applying in PetrSU smart rooms, and provides our architectural solution for sensors connection to the M3-space. Section IV introduces possible scenarios that we plan to implemented on top of our sensor-based design. Section V concludes the paper.

II. Smart Room Architecture

PetrSU smart room is a room for holding conferences, meetings, lectures, trainings, and some other activities important for the university research and education processes [5]. Smart

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room provides a set of services that simplifies activity organization and participation as well as automates technical functions of information acquisition, sharing and transformation. The automated and intelligent support simplifies the human activity, allowing participants to concentrate on the problems the event is devoted to, not on technical details of information acquisition, sharing and transformation. Smart room generalizes Smart Conference system [6] to support an extended set of scenarios.

Figure 1 shows the high-level architecture of smart room. It is constructed on the top of Smart-M3 platform [2]. The M3-space is maintained with a Smart-M3 Semantic Information Broker (SIB). Currently we use the Redland SIB implementation [7]. Smart room Knowledge Processors (KP) share the space, publishing and retrieving common information. Each KP communicates with the SIB by Smart Spaces Access Protocol (SSAP). Smart room service set consists of several groups, listed below.

Conference system: is a core smart room service set. It includes an agenda, projector, and mobile clients. Agenda describes the activity plan held in the room. For instance, a conference agenda is a list of talks (conference program). Projector visualizes slides and other information of the current presenter. Agenda and projector have own screens in the room.

External services: are accessed from the web. They provide information and processing facilities that can be used in the smart room. For instance, smart room discussions use blog services, as it was initially proposed in [6]. Another example, is information trackers that finds appropriate knowledge collected in the web, e.g., presenter's citation index from Google Scholar.

Internal services: are deployed locally in the smart room. They accumulate knowledge appeared in the room and derive new knowledge. For instance, personalized reports sent to each participant after the conference.

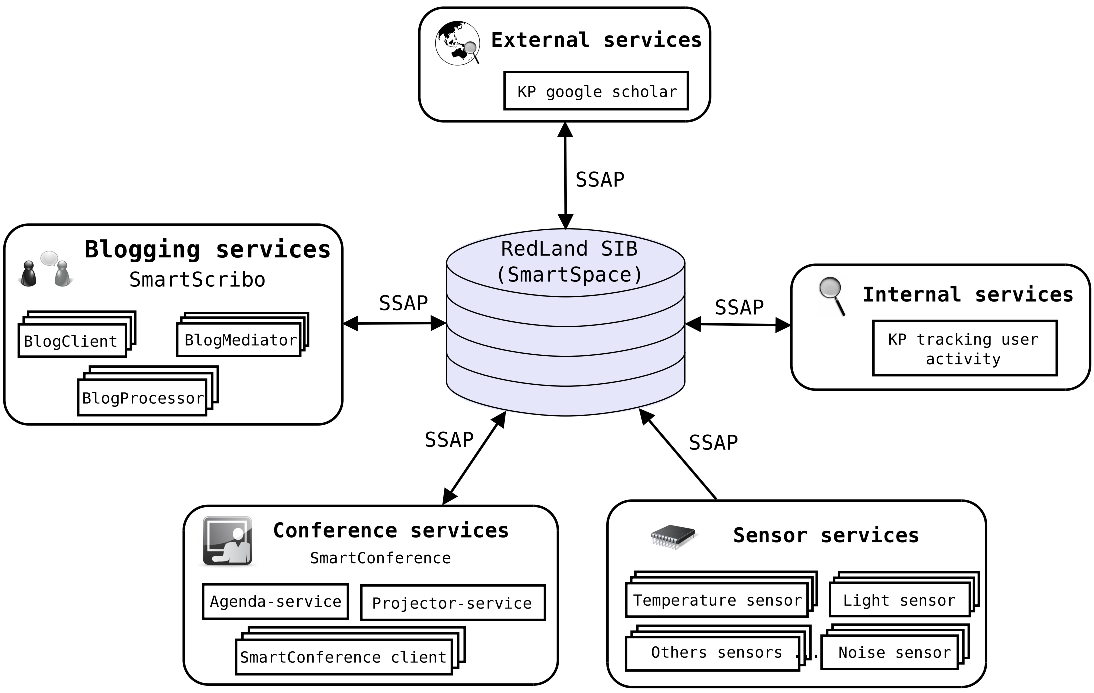

Fig. 1. PetrSU smart room high-level architecture

Sensors: are deployed in the room. They monitor parameters of internal physical environment and publish the measurements into the smart room space.

In this paper we focus on the sensors group. To be used on the smart room M3-space, sensed data need ontological representation. Our solution employs Ontology Semantic Sensor Network (SSN), which is supported by World Wide Web Consorcium (W3C) and fully describes the sensor domain [8]. Figure 2 shows its integration into the smart room ontology.

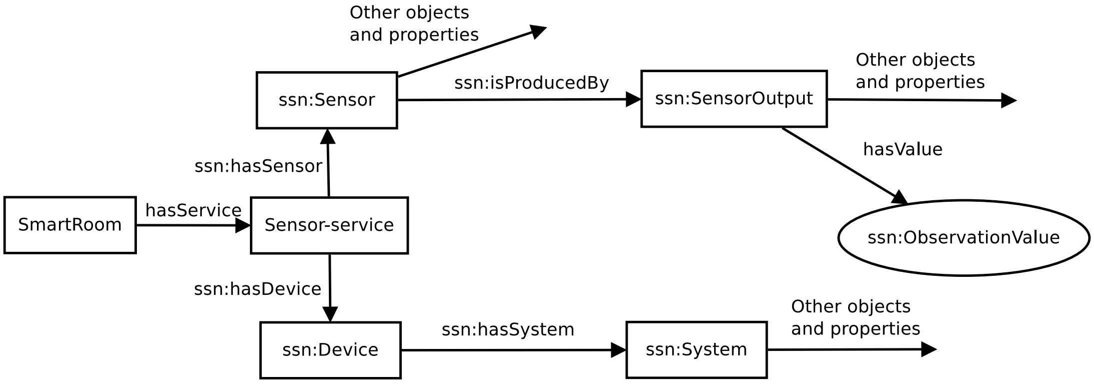

Fig. 2. SSN otology integration into the Smart Room ontology

III. Integration of sensors into the M3-space

Sensor is a device that implements the physical sensing of environmental phenomena and reporting of measurements (through wireless communication). Typically, it consists of five components: sensing hardware, memory, battery, embedded processor, and trans-receiver. There are various sensors, e.g., temperature sensor, pressure sensor, sensor of air condition, sensor of magnetic field, humidity sensor, light sensor. A good taxonomy can be found in [9].

On the current phase of PetrSU smart room development we plan to exploit such simple sensors as light sensor, temperature sensor, and noise detector. In addition to sensors, smart room can be equipped with devices having remote control. Examples are lighting equipment, air conditioner, humidifier, blinds with remote control, digital cameras. The related scenarios are introduced in Section IV.

Now let us consider the problem of connecting sensors to the smart room M3-space. We use the same approach as proposed in [4], where the potential of the smart-space-based and sensor-driven computing paradigm was shown. There is a KP for each sensor; the KP access sensor readings, converts them into ontological representation, and publishes the data into the M3-space. Our high-level scheme of any sensor-based data provision service is shown in Fig. 3. It follows the approach from [3], which introduces netgets, specialized networked gadgets with sensors and actuators that let users seamlessly manipulate digital information and data in the context of real-world usage.

We identify the following two options for the realization. Both options can be applied for smart room, depending on a service the sensors implements.

The first option is centralized. A sensor group is managed by a computer (e.g., Rosberry Pi, http://www.raspberrypi.org/). Software for communication with the smart space is installed on the computer, where the sensor KP runs. The key advantage of this option is that it allows applying all features of Smart-M3 computations [10] directly in the KP, e.g., ontology-based subscription or logic programming. On the other hand, a sensor group needs a dedicated

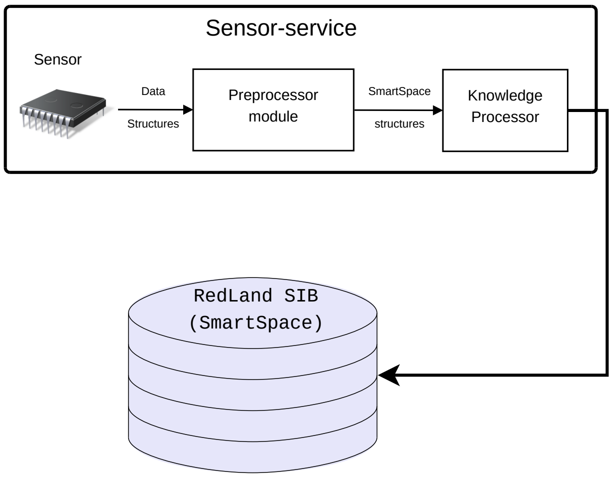

Fig. 3. Scheme of sensor connection to M3-space

computer, and the total cost of the system increases. It also leads to a single point of failure, when a fault of the computer disconnects the whole sensor group.

The second option is a self-contained smart room sensor. There are Smart-M3 KP interfaces that are oriented to low-capacity devices, see the discussion in [11]. Therefore, a simple sensor KP can be implemented directly on the sensor device. The number of additional dependencies (libraries) to be installed at the device is minimized. No additional equipment, such as a dedicated computer, is exploited.

IV. Sensor-based scenarios

A single sensor provides a small amount of information. Nevertheless, many useful scenarios can be constructed based on the total set of measured data and their combination with other knowledge in the smart space. Comprehensive assessment of the current state of the art and challenges of such sensor-based scenarios can be found in [12].

The simplest group of scenarios is when sensing data are periodically shown on the agenda screen. As a result, all participants observe online the current environmental state, e.g., temperature and noise level. The scenario can be personalized when the participant watches the environmental parameters on her/his user device. In this case, the participant defines explicitly or implicitly which parameters are interesting for her/him.

Another group of scenarios is based on analysis of recent parameter values. If temperature low or high then the chairman receives notification with recommendation to open windows or enable thermostat. If the noise level exceeds some bound then the chairman is activated to regulate the discussion. Therefore, there is a group of scenarios that produce recommendations for the organizers. Note that in some cases the organizers can perform the responded actions directly from their mobile devices.

If control equipment is available in the smart room then further automation is possible [13]. That is, the illumination level can be controlled by available lights in the room. It allows responding dynamically to changes of the internal physical environment, e.g., switching the lights off when slides are presented and switching the lights on when a discussion starts. There can be different preset modes of lighting, e.g., event begining, slide show, collective discussion, coffee break. Another scenario is when camera changes its focus to a participant who is talking at that time moment.

There is a group of scenarios that are useful for post-analysis of the event. In this case, the main event activity is extended with related sensed data. For instance, the noise level is assigned with each slide. Thus, we can identify the most popular slides shown and topics discussed.

V. CONCLUSION

This paper has reported our preliminary study on use of sensors in PetrSU smart rooms. We started the development from simple cases, using such elementary sensors as light sensor, temperature sensor, and noise detector. The considered ontological model for sensor data representation in the M3-space is based on the well-known SSN ontology and allows easy integration into the overall smart room ontology. We proposed two architectural options of connecting sensors to the smart room M3-space, both will be used in our further implementation. To clarify the application vision, we introduced basic groups of scenarios that can be implemented based on the above results.

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