Smart Meeting Room Booking System

Sohel Zafarkhan Mulla[1], Pawan Sayabsing Thakur[2], Tushar Zumbar Tambe[3] ,

Vaishnavi VijayJaveri[4] &Dr. N.R. Wankhede[5]

Late G. N. Sapkal College of Engineering
Department of Computer Engineering

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Abstract -This paper proposes the creation of a sensible meeting room through the incorporation of a PIR sensor and an AWS IoT button that permits the booking system to reflect a more precise availability of meeting rooms consistent with the particular occupancy status. the web of Things (IoT) devices are controlled employing a Wi-Fi module that permits them to attach to the remainder web service and to integrate with the open source Meeting Room Booking System (MRBS). so as to guage the system a storyboard evaluation was conducted with 47 participants. All participants filled out the User Experience Questionnaires (UEQ), described the merchandise using three words and expressed their opinion through open comments. Finally, 19 participants took part during a real-life simulation of the smart meeting room and evaluated the system using the UEQ questionnaire. supported the positive acceptance reflected within the evaluations, results show that the proposed system is taken into account very attractive and useful by the participants.

***Key Words*:**Internet of Things (IoT), Ambient Intelligence, Smart Meeting Room, Room Occupancy, User Experience, Smart Environments

1.INTRODUCTION

Meetings happen when two or more people got to coordinate or agree on something formally arranged [1]. Meetings are essential events in any organization as they're wont to share knowledge and knowledge or discuss and take important decisions [2]. during a more precise definition, a gathering is an activity that features a start and end time previously defined and is scheduled within the agenda of the attendees [3]. Statistical studies show that office workers spend around 30-70 percent of their daily time period in meetings [4].

According to [5], the duration of a gathering can't be determined exactly beforehand. albeit having a well-defined agenda, meetings are often over before scheduled time, for instance, if there have been no unexpected interruptions and therefore the meeting flowed very quickly.

Even if the meeting organizer is confident that the meeting will take less time than expected, he or she might still book a period longer than required for the meeting, as a precaution. during this context, in [5], the subsequent patterns were reported when scheduling meetings:

• Meeting is over before the schedule time.

• Meeting doesn't occur in the least.

• Other resources required might not be available, for instance a projector or a computer, and this prevents the meeting from happening.

Even though the situations mentioned above, there's no feedback mechanism to tell users if the meeting actually happened or not. as an example, it's possible that although a room has been reserved beforehand, it's left unused thanks to a last-minute cancellation. Therefore, if another user wants to order the room at that point, he or she wouldn't are ready to , since room availability wasn't appropriately handled by the system.

To address problems just like the one mentioned above, during this paper a sensible meeting room management system is proposed, which provides real-time support to attendees through an easy access to the space state and real-time occupancy status. consistent with [6] a sensible meeting room (SMR) are often monitored by several sensors to gather information in real time like temperature, humidity, and detection of individuals. In our proposal, we integrate a PIR sensor for movement detection, a microcontroller to watch the sensor's behavior and to attach to internet, an actuator that permits users to form an area available if they conclude the meeting before time, a real- time occupancy status display module, and eventually an internet API service. Additionally, as a part of the system architecture, the indicated system is integrated with the open source MRBS. additionally, to guage the system two different user experience studies were applied, one running a storyboard and another having participants interacting with the particular system. In both studies, the info was collected using the UEQ standardized questionnaire for UX evaluation.

The paper is organized as follows: section II briefly discusses the related work, section III describes the proposed

SRM system, section IV shows evaluation process and results, and eventually section V shows conclusions and future work.

2. Related work

Most of the research found regarding meeting room systems focuses on improving programming software to assist users to pick optimal meeting time [7] [8], while others build smart meeting rooms where audiovisual content is automatically recorded for viewing within the future [9] [10] [11]. However, these systems don't address the matter of creating available meeting rooms that are reserved but aren't really occupied. In other words, users can't identify the particular state of a gathering room, since these rooms don't detect the presence or absence of individuals and thus cannot warn that an area is not any longer getting used.

There are currently some meeting room applications [12]

[13] [14] that have the functionality to make reservations and show the availability of the rooms through an interactive screen placed outside each room. they supply synchronization with booking systems like Microsoft Outlook and Google Calendar. However, these systems aren't freed from cost, and don't correctly handle room's availability, since all booking mechanisms are operated manually by users. Another related system is described in [5] which is predicated on a wireless sensor device connected to a mesh network. The occupancy status isn't integrated into the booking application because it uses Microsoft Outlook software. The system needs manual action to work out a room's underutilization. Another work worth mentioning is found in [2]. The proposed system is using PIR fusion modules which was the mixture of three or four PIR sensors integrated with its own management system. However, this technique used embedded modules to attach to LAN through existing coaxial cable.

In contrast to all or any approaches mentioned, the proposed architecture provides a real-time occupancy status display module, an AWS IoT button that acts as an actuator, a Wi-Fi module to attach to the web, and an internet API service deployed to the cloud. Moreover, the proposed architecture is additionally scalable, since the other device are often added with the minimal effort. The modules mentioned above, and therefore the system architecture is described in next section.

3. Proposed System

during this section, the planning and development process of the SMR system and its implementation is explained. This section is organized as follows: subsection A describes management application and real time occupancy module, subsection B explain how the system is integrated with MRBS, subsection C shows the planning and development process of the wireless module, subsection D lists room policies, subsection E explain the implementation of the AWS IoT button, and eventually subsection F shows the steps to deploy the SMR system to a gathering room.

A. System overview

The management system may be a web-based application hosted within the cloud. thanks to its responsive design, it's a cross–platform application. From this application, users can manage booking, see a room's availability, search available rooms and obtain reminders.

An external module to possess real-time access to the occupancy status of an area is found outside every room. Also, users have access to ascertain all booked meetings during the day. This module is described in Fig. 1.

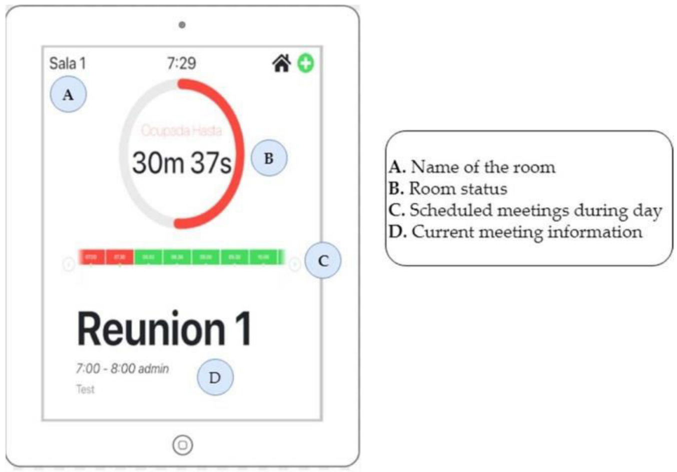


Fig. 1. Real-Time Occupancy Status Interface.

For the back-end layer, a microservice architecture was implemented [15]. Then, just in case the system grows, additional have small services running on their own processes and communicating with one another through a light-weight mechanism. an internet API service was built using REST protocol. This service is that the one responsible of allowing the whole system to speak with itself; it receives requests from clients and sends response messages to them. Additionally, all important data is retrieved and stored during a MySQL database. The service is deployed to the cloud, so it might be employed by any client that features a valid token. Fig. 2 presents a diagram of the system architecture. It are often seen that the online API service is that the most vital module of the system.

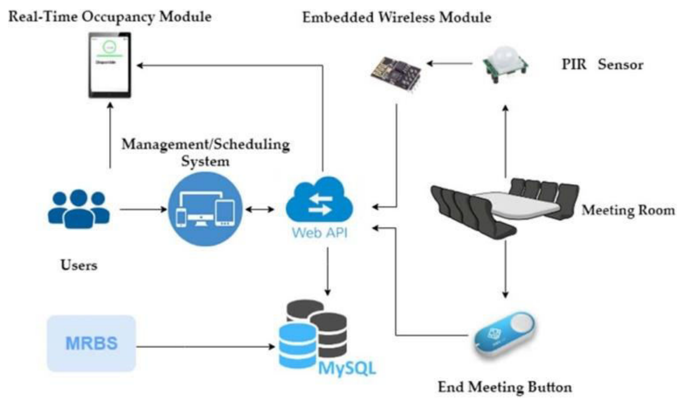


Fig. 2. System Archiquecture.

B. Synchronization with the MRBS

The proposed system has the power to figure as a standalone version or to figure alongside the Meeting Room Booking System (MRBS). The MRBS is an open source system wont to manage meeting rooms. MRBS may be a web application supported PHP with support for MySQL database. MRBS allows users to form reservations for a selected room at a selected time, checking the supply of the space before creating the reservation. consistent with [16], the system is currently in use by many large organizations round the world, which prompted us to use it to include the mixing with sensors and modules proposed during this paper.

This integration occurs within the Web API, as shown in Fig. 2. Since MRBS is an open source, and don't provide a public API,

the same database structure to create the system was preferred. this suggests that, when both systems are synchronized, they're going to use an equivalent database.

C. Wireless transmission

An embedded programming module is employed within the system for processing the inputs and outputs from a given meeting room. The ESP8266 ESP-01 may be a Wi-Fi module that permits microcontrollers access to a Wi-Fi network. This module is self-contained and may be programed to act as microcontroller also. it's two GPIO [17] pins: GPIO0 and GPIO2 which allows to possess some devices connected thereto (in this case a PIR motion sensor [18] was connected to a GPIO2 pin). When the PIR motion sensor detects human presence, it'll send high inputs to the module; otherwise it'll be a coffee input. The ESP module was programed via Arduino UNO [19], using the Arduino IDE. Arduino has its own programing language, which essentially is C++ with some additional methods and functions. After uploading the code to the Wi-Fi module, the Arduino board was removed and replaced by alittle breadboard power supply module of three .3V, as shown in Fig. 3.

Fig. 3. Wi-Fi module.

Once the module is connected to the web via Wi-Fi, a service account is employed to urge a legitimate token from the online API. Then, the module is consistently asking to the online service if the space is currently reserved. If the online service responds true, the PIR sensor starts sending input signals to the module. Then, the system could be ready to release an area supported room policies. this is often explained intimately in subsection D.

D.Room Policy

Two rules associated with the motion sensor were defined to work out if a gathering really starts. These rules are:

1) As of the beginning of the scheduled meeting time and if no movement is detected within the room for quarter-hour, the system will release the space and send a notification to the attendees. this first time is configurable and may be changed by users, which mean it could change counting on user's needs.

2) If the primary rule isn't met and therefore the system continues detecting movement after quarter-hour, the meeting is taken into account as consolidated. After this, the space only might be released by the actuator placed inside thereon, this is often explained in subsection E.

Based on these two rules, the system can determine if the participants presented themselves or to not the meeting, and if they didn't show up, the space is released within the system in order that it are often employed by people.

E. End Meeting Button

The system also uses an AWS IoT Button [20]. this is often a programmable Wi-Fi button (see Fig. 4a) that permits participants to place the space available just in case a gathering ends before scheduled. The system implements an AWS Lambda function which is named once the user clicks on the AWS Button. Basically, a legitimate token from the online service is taken then the system releases the space so it are often employed by somebody else.

F. Room Setup

Deploying the system to an area consists in placing the wireless module on the ceiling of the space (Fig. 4b), setting the AWS IoT button at the exit of the space (Fig. 4a) and eventually setting the real-time occupancy status module at the doorway of the space.

Fig. 4. Some Smart Meeting Room Management System modules. (a) AWS IoT button; (b) Wi-Fi module deployed in the ceiling of a room.

4. EVALUATION PROCESS

To evaluate the SMR system, two different user experience studies were applied and are described below.

A.Storyboards

BBefore initiating the event of the system, it had been decided to demonstrate to potential users some scenarios where they might interact with the foremost important features of the system. so as to guage this and obtain feedback from end users, a storyboard technique was conducted. Basically, a storyboard script including scenarios to check , supported room occupancy availability.

Thestoryboard consisted as follows: a professor is walking around a gathering room. Since every room has its own current status display placed outside of the space, he notices that the space is out there all day. He decides to book the space twice that day, once within the morning and once within the afternoon, for one hour in both cases. When the primary meeting starts, the status of the space changes to busy, therefore it's not available to be reserved. Since the meeting ends half-hour before expected, the meeting organizer proceeds to release the space through a button located at the exit of the space. Then the status of the space changes to available and may be booked by the other person within the system.

During that very same day, the professor gets an emergency call from his wife, and as a result, he has got to leave and he won't be ready to attend the second meeting. He notifies the attendees, but he forgets to cancel the meeting within the system, therefore the meeting room remains reserved. When it's time to start out the second meeting, the status of the space changes to busy again. At an equivalent time, two other persons are trying to find a gathering room for a last-minute meeting. They walk round the room and realize the space status is busy, but actually the space is empty. one among them continues trying to find an area within the system and suddenly, notices that an equivalent room that was busy a couple of minutes ago, was listed on the search result as available and prepared to be booked. Then, the meeting room is reserved for half-hour. When these two people meet for the meeting, the meeting organizer asks how could he have booked the space if it had been busy quarter-hour ago? the opposite person explains to him that the system releases the space after quarter-hour, if no motion is detected.

The storyboard described above was conducted in three different groups, and at the top of each presentation a user experience evaluation was performed. Participants were asked to fill out the UEQ questionnaire. a complete of 47 participants completed the evaluation, 80 percent were male, and 20 percent were female. The participant's average age was 21 years.

The standardized UX questionnaire UEQ [21] provides an excel data analysis tool for capturing the experience of users, after they interacted with the merchandise or system. It consists of six-dimension scales, including pragmatic and hedonic aspects. These dimensions are: Attractiveness: Do users like or dislike the merchandise? Perspicuity: Is it easy to urge conversant in the product and find out how to use it? (pragmatic). Efficiency: Can users solve their tasks without unnecessary effort? (pragmatic). Dependability: Does the user feel on top of things of the interaction? (hedonic). Stimulation: Is it exciting and motivating to use the product? (hedonic). Novelty: is that the product innovative and creative? (hedonic). UEQ considers scores starting at 0.8 as positive and starting at −0.8 as negative.

The means (the scale ranges from −3 horribly bad to +3 extremely good) and variance (in parenthesis) of the UEQ dimensions were: Attractiveness 1.41 (0.59), Perspicuity 1.89 (0.93), Efficiency 1.27 (0.61), Dependability 1.12 (0.58), Stimulation 0.45 (1.90) and Novelty 0.62 (1.13). consistent with these results participants were equally satisfied with the judgment of attractiveness and pragmatic dimensions and slightly less satisfied with the hedonic dimension. For testing reliability of dimensions, we calculated Cronbach's Alpha value for every dimension. the worth obtained were: Attractiveness, 0.79; Perspicuity, 0.84; Efficiency, 0.93; Dependability, 0.92; Stimulation, 0.95; and Novelty 0.83. These values show that the reliability is in satisfactory ranges.

In addition, to the UEQ, participants were asked to explain the merchandise in three words and allowed them to enter open comments associated with the system. Most input from participants was that the merchandise is extremely useful (Fig. 5). Moreover, several positive comments like "It may be a good idea; it are often useful" or "it might be a strong tool in business" were received. Some participants were concerned few "> a few couple of scenarios weren't covered by the storyboards, but also, they suggest some great ideas regarding how those scenarios are often addressed.

Fig. 5. Word cloud created using participants input. Each participant could use three words.

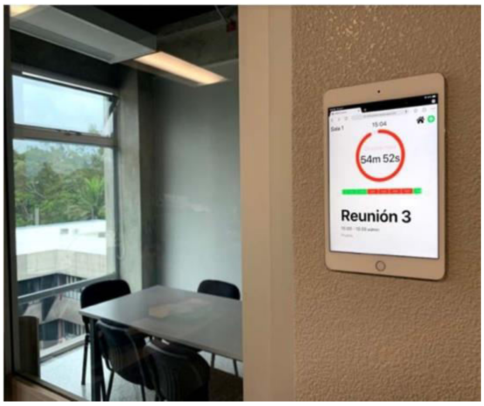
B. System evaluation

All the feedback collected in first evaluation was considered while the system was developed. Once the functional was stable, it had been decided to run an equivalent script described within the storyboard evaluation, but this point during a real scenario, allowing participants to interact with the merchandise.

The SMR system was installed during a room (Fig. 6a, 6b, 6c), then 19 participants were organized in groups of 4. Before a gaggle started interacting with the system, all their questions and doubts were answered, then they were asked to execute equivalent actions as those explained for the storyboard.

(a)

(b)



(c)

Fig. 6. The real-time occupancy module displaying room status. (a) Room is currently busy. (b) Room is out there for booking. (c) Room is busy but no attendees arrived

At the top of each iteration, participants were asked to fill out the UEQ questionnaire as participants did for the storyboard evaluation. Fig. 7 and Fig. 8 show all six dimensions have quite good results and participants were extremely satisfied with attractiveness, pragmatic, and hedonic aspect of the SMR application.

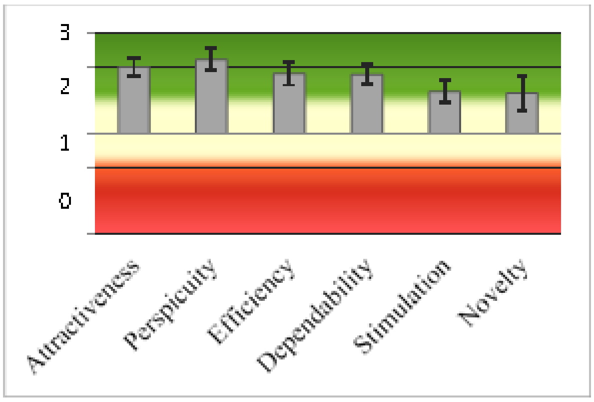


Fig. 7. The UEQ resultant scores or six dimensions' scales.

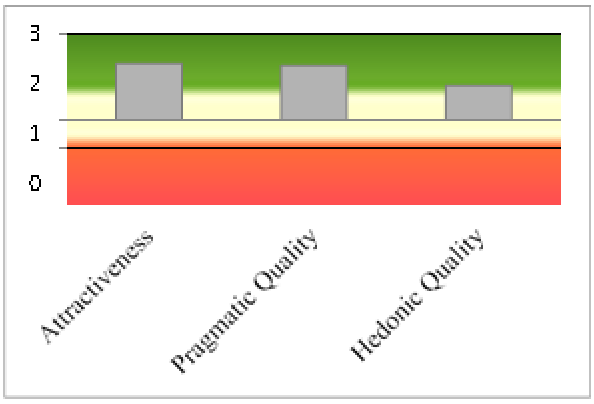


Fig. 8. The UEQ attractiveness, pragmatic and hedonic quality score.

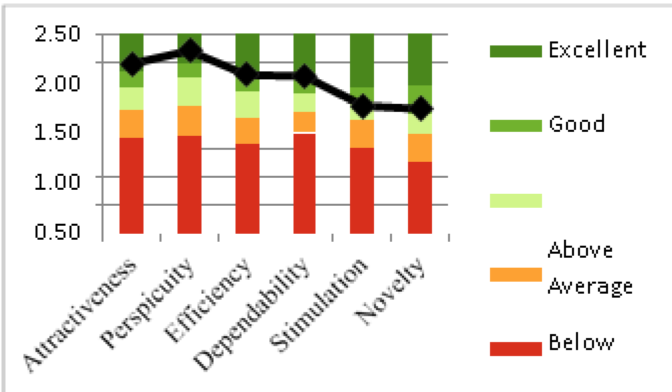


Fig. 9. UEQ resultants scores for six dimensions scales with benchmark data.

UEQ questionnaire [21] also provides a benchmark data set that contains data collected from 18,483 people from 401 studies of various products. The benchmark shows a comparative analysis of how good the evaluated product is, compared to the products within the benchmark dataset. Fig. 9 presents the UEQ results compared to those of 401 studies. Compared to the benchmark data, the evaluated SMR proposed during this paper scored between good and excellent, scoring within the top 10% best results for Attractiveness, Perspicuity, Efficiency and Dependability dimensions.

5. CONCLUSION AND FUTURE WORK

We have created a true smart meeting room system that improves the visibility of meetings room availability by adding a PIR motion sensor and an AWS IoT button. We realized that one PIR sensor was enough for little meeting rooms. for giant rooms we might probably need to use quite one sensor to hide all the space area.

Furthermore, employing a wireless connection, as we implemented, is more efficient and fewer expensive than a wired connection proposed in other approaches. Also, developing an internet service gives the pliability to perform any quite modification or improvement within the behavior of the IoTs devices, and provides the chance to make new services. Concerning to the evaluation of UX, the results of the UEQ questionnaires show a positive acceptance by the users, both for the participants who used the storyboards and for those that did the test within the simulated environment. needless to say, the evaluations of the simulated environment showed superior results to those of the storyboards, specifically within the Stimulation and Novelty dimensions. this is often thanks to the differences between both environments, where the interaction with the particular sensors and devices presents the interaction with the system during a far more complete and interesting way. Additionally, if we compare the results with the overall benchmarks provided by UEQ, the system shows a satisfactory user experience that creates us believe that the implementation of the proposed product within the world would be highly successful.

with regard to future work, there are other scenarios not covered with the proposed system. However, we've collected some important input from users, thus, we will integrate these features later into the system. as an example, if the system stores sensor information, this information could undergo machine learning algorithms and make the system take decision supported those algorithms. we will also make the system more complex by adding sensors for temperature and humidity, for instance, and mix the knowledge provided by these sensors with those of movement detection. during this way, if a sensor detects movements inside the space, which suggests a gathering is ongoing, the system could perform operations within the microcontroller to usher in the well-liked ambience by controlling appliances just like the air conditioning. On the opposite hand, if the system detects that the space is empty, it could close up air conditioners and save energy consumption.

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