

## Smart Meeting Rooms: A Survey and Open Issues

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**Abstract.** Smart Meeting Rooms (SMR) definition is evolving and in this article we present the evolution of such definition side by side with several projects that have been developed during the last decade. We also present the features and evaluation methods used in literature and we make a discussion on the open issues.

**Keywords:** Smart Meeting Rooms, Intelligent Environments, Ambient Intelligence

### 1 Introduction

Ambient Intelligence (AmI) deals with a new world where computing devices are spread everywhere, allowing human beings to interact with physical world environments in an intelligent and unobtrusive way 1. AmI concept can be introduced in several different environments and involves several disciplines which can be summarized in five main areas: Human-Computer Interaction (HCI); Sensors; Networks; Artificial Intelligence; Pervasive and Ubiquitous Computing 2.

In 3 a generic AmI environment is proposed and authors refer two main components, an intelligent layer and an operational layer, and their interaction with the space and themselves. The Operational layer is composed by reliable sensing information, and actuation capabilities, such as sensors nets, Robots, communications, etc. The Intelligent layer must incorporate AI methods and techniques and the tasks reserved to this Intelligent Layer are: Interpret the environment's state; represent the information and knowledge associated with the environment; model/simulate/represent entities in the environment; learning about the environment and participants preferences; interact with humans and with the environment.

Intelligent or Smart Meeting Rooms (SMR) is a subdiscipline of Ambient Intelligent Environments 4 and is generally defined as an environment that should support efficient and effective interactions among their occupants. The generic goal of a SMR system is normally referred as a system that supports multi-person interactions, locally or distributed, in the environment in real time 5, but also as a system that is able to remember the past, enabling review of past events and the reuse of past information in an intuitive, efficient and intelligent way 16, so as to make the meeting process more efficient 6. In 7 they consider that a SMR should mainly support the

decision making process considering the emotional factors of the intervenient participants, as well as the argumentation process.

In summary we can define SMR as spaces used by groups in their interaction on the decision making process that are capable to identify, maintain and reuse the information created by groups, generating knowledge from this information. Where to be aware of meetings events, contents and emotional state of users is a determinative to maximize the group performance on the Decision Making process.

## **2 SMR Features**

In literature we can find several attempts to design these SMR, and [16] give a good summary on existent projects. From the analyses of several projects we are able to categorize them in two sections: the projects that focus on the Operational Layer which only cover Pervasive and Ubiquitous Computing, HCI, Sensors and Networks areas, who approach the problem based on an Information System approach [8-11]; and the ones that are also targeting the Intelligent Layer which propose developments in semantic processing and thus falling down on the Artificial Intelligence (AI) area [9,10,11,13,14,15,16,17,22]. As we consider that the Intelligent Layer and AI are a decisive characteristic for AmI spaces we will focus this article on the second category. We will now detail the functionalities that can be observed from the literature review. In [6] work are identified the following features:

### **2.1 Meeting Capture**

This features include audio and video processing as well as contextual information like temperature, room layout, agenda, calendar schedules and notes. Example projects are SMART [8], SMART M3 [17] and [522].

### **2.2 Meeting Recognition**

This section includes features like Person Identification; Speech Recognition; Summarization [16]; Attention Detection – like detecting who is looking at what or whom during a meeting; relevant Hot Spot Recognition that refer to parts of a discussion in which participants are highly involved like heated arguments, points of excitement, etc; Activity Recognition [16], that distinct individual activities and group activities where the group ones are the most important and include human social behaviors, like proposing an idea, commenting, expressing a positive opinion, and requesting information. Example projects are M4 (Multi Modal Meeting Manager) [9], AMI (Augmented Multi-party Interaction) and ORIGAmI [10,11,13,14,16]. In this last section are also attempts to recognize the people emotions and social aspects of people [21].

### 2.3 Semantic Processing

Here are included: Meeting Annotations<sup>16</sup>, or the process of creating labels for the meeting shots which consists of acquiring descriptors and then labeling data with them; Meeting Indexing, that mainly use events as an index to access meeting information. At a more raw data level, a temporal search is the most used approach to navigate on data streams; Meeting Browsing is a commonly present feature that acts as the interface between the smart meeting system and end users. It consists of visualizing, navigating, and querying meeting semantics as well as media content. Emotion aware <sup>217</sup> and argumentation support <sup>7</sup> which consist on describing the emotional state of the meetings participants and use that knowledge to establish facilitation support <sup>21</sup> and/or argumentation strategy definition.

## 3 SMR evaluation methods

The criteria used to evaluate a smart meeting system include user acceptance, accuracy, and efficiency <sup>6</sup>. It is possible that some proposals use more than one type of evaluation.

User acceptance is measured by conducting user studies and analyzing user feedback.

Accuracy tests the recognition mechanisms by means of different objective methods: recognition rate, precision and recall. Where **precision** can be used as a measure of the ability of the system to identify correct objects only. **Recall** is used to test the ability of the system to recognize all correct objects.

Efficiency is usually employed to evaluate a meeting browser. The only know evaluation metric proposal we are aware is a browser evaluation test (BET) that uses the number of observations of interest found in the minimum amount of time.

Case studies and features comparison are also very used to exemplify and demonstrate the outcomes of a proposal.

## 4 SMR projects

We will now explore some of the existent projects but our approach on this topic will be focused only on the projects that also complement the AI area of AmI Environments.

Some works in literature are focused on developing ontologies for context specification in a specific domain to reach the goals of knowledge sharing across distributed systems. For instance, CONON <sup>18</sup> introduces an extensible context ontology for pervasive computing environments. Eleni Christopoulou et al. focused on an ontology-based context modeling, management and reasoning process developed for composing context-aware UbiComp applications from AmI artifact. COBRA <sup>19</sup> proposed by Chen et al., used an ontology to describe person, places and intentions. Huq et al. <sup>20</sup> diverged from CONON and COBRA general purpose ontology model and proposed a model divided into two parts. On the one hand they

proposed a Smart Space domain or a general ontology, adding the concepts of Environment, Service and Platform, which could be reused for other smart spaces. MTO and IGMTO ontologies 10 were proposed as an extension and complement of the previous ones and their mean is to be used to define the logical context of a meeting, like participants, GDSS techniques used, topics discussed by participants and they preview the existence of a property that is able to connect this Task information with the knowledge of the meeting participants produce.

IConAwa system 25, an intelligent context-aware system, developed for proactively providing mobile users with context-aware information, a rule-based context reasoning in a multi-agent approach. For context and the point of interest representation are used ontologies. Knowledge sharing and knowledge reuse are also provided by using the ontology models.

In terms of architectures the Smart-M3 17 23 is an interoperability platform operating on principles of space-based information exchange. The authors defined an architecture consisting of knowledge processors (KP) and a semantic information broker (SIB) concepts. The SIB stores and makes available information inserted to it by KP and they use a communication mechanism called the smart space access protocol, or SSAP. This SSAP is the main integration point in the architecture, and any KP or SIB that implementing it can participate in the system. The KP co-operating in different scenarios are extremely loosely coupled in the Smart-M3 world, though they may have dependencies outside the Smart-M3 platform, so they argue that the appearance or disappearance of KP will have little effect on other KP. Authors included an Ontology API but the focus is to use it only as a translator for SSAP and RDF to Objects. We were not able to identify any kind of autonomy that could be given to this SIB, neither any kind of process for governing ontologies and there is any evidence suggesting that the task performed is somehow stored on the RDF Triples Store.

## 5 Discussion

Not all literature proposals fall on all the features identified in section 2 but what we want to highlight is that Meeting Recognition are the features where we can find more AI methods used to automatically recognize the meeting events and possibly to act in order to support the meeting facilitation process or to help the participants individually in the decision process.

Surprisingly in Semantic Processing we are not able to find much evidences on the usage of AI. The approach identified is more a presentation approach where the user is able to navigate on the meeting contents mainly thought time and events labels.

The most part of projects on SMR focus on aspects connected to Pervasive and Ubiquitous Computing, HCI, Sensors and Networks. This is clear, for instance on the ontologies proposed to be used on SMR 1920 or Smart environments 25 where MTO and IGMTO are an exception 10. Such advances on Pervasive and Ubiquitous Computing, HCI, Sensors and Networks are important but we believe they are not enough to achieve the concept of Ambient Intelligence, due their lack of Artificial Intelligence mainly on the level of Knowledge Management.

Some exceptions can be identified like 24, 23, 25, 17, 13 and 10 who proposed definitions of context and semantic processing of that information in order to be able to define the context of a smart space. Smart-M3 propose a generic architecture suitable to different kind of AmI Spaces 23 introducing the concept of domain ontologies for knowledge management despite their general approach as services without any kind of initiative, autonomy and reasoning services 23.

However only in 13 and 10 this concept goes further, because the others try a higher level approach who targets any area of application, like houses, public spaces, etc. In 13 and 10 they detail that a meeting space as a specialization of Smart Spaces. The authors argue that the space should know what people are discussing during the meetings, in order to the space to be able understand the meeting contents, what participants are discussing and try to provide intelligent contextual feedback. For this they propose a Ontology for defining a meeting task context 10 and a model to use this task identification to define a context. Despite they don't specify how the contextual feedback is provided they state the path to achieve it and made the necessary proposals to achieve such goal.

## 6 Conclusions

In this paper we presented the features that Smart Meeting Rooms present on the literature. We crossed this features and the projects were they appear with the general architecture for Ambient Intelligence Environments. Based on this we've made a discussion about the fulfillments of the AmI characteristics that should be present in SMR projects highlighting when they exist and exposing our concerns about the author's proposals. We also presented some existing projects in literature as well as how the community is evaluating their proposals.

We can conclude that most of the work in literature doesn't put SMR as a very specific environment and they try to feet such space on a more general approach. We believe this generic approach will fail to target the specific needs of these environments on the support of meetings and support of decision making process. Other conclusion we can provide is that efforts to take into account the participant emotions and the social events that are present in meeting environments are few. As humans we are strongly influence but such kind of aspects, and in SMR environments mainly in group meetings this as to be taken into account.

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