Semantic Meeting Information Application: A Contribution for Enhanced Knowledge Transfer and Learning in Companies

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Abstract:

Big efforts of financial and human resources are spent for face-to-face and virtual meetings in today's business. Besides coordination and decision purposes, a huge amount of knowledge is either exchanged or generated, and represents a valuable source for feeding the intellectual capital of a company. Multi-modal meeting recording and meeting information systems store meetings and make them accessible. However, there is still a lack of integration into knowledge management and e-learning systems. To overcome this problem, we propose an enhanced semantic meeting information application. Design and development of this application are part of the MISTRAL research project, which aims at enhanced semi-automatic procedures for semantic annotation as well as semantic enrichment of multi-modal data streams.

1 Introduction

Face-to-face and virtual meetings increasingly take place in today's business processes. As stated in [1], managers and knowledge workers spend between 25% and 80% of their working time in meetings. Further, [1] reports that the median number of participants in the analyzed meetings was nine (9). From literature investigation we could identify the following most common meeting purposes: reconciliation of conflicts, facilitating staff communication, group decisions, solving problems, learning and training, knowledge exchange, reaching a common understanding, exploration of new ideas and concepts (see e.g. [1] and [2]). Thus, big financial and human efforts are invested in order to create new knowledge or to transfer it between meeting participants. Based on the facts stated so far, it is easy to identify an economization potential by increasing the efficiency of meetings applying improved management methods and technology support, such as electronic meeting systems, group support systems, and meeting browsers or meeting systems (see [3], [4] and [5]).

Furthermore, knowledge addressed and created in meetings should be preserved and made accessible for all meeting participants as well as for all members of a company under consideration of security and privacy issues. Indeed, multi-modal meeting recording applications and meeting information systems are of emerging interest. Thus, it's no wonder that several research projects in that context have been conducted recently or were conducted at present, such as [6], [7], [8], [9], [10], [11] and [12].

Despite the increasing research activity, our extensive recherché has shown that there is still a lack of integration facilities into knowledge management and e-learning systems. This fact motivated us to design and implement the Semantic Meeting Information Application (SMIA) within the MISTRAL research project, which is the main focus of this paper. Further information about the MISTRAL project can be found in [13] and [14].

The goal of this paper is to explain how the architecture of SMIA has been developed and defined, but the focus is set on the derivation of specific system requirements. For this purpose, a general overview over the evolution of the system is depicted as follows: firstly, the overall system is shortly introduced in chapter 2; next, in chapter 3 some scenarios are enlisted that describe the user-centered focus of SMIA; then, based on the findings of chapter 2 and 3, the set of specific requirements for SMIA are depicted (from various points of view); concluding, chapter 5 describes the overall architecture of SMIA, which represents the functional and logical result of the previous chapters; to give some insights into our future work, chapter 6 summarizes findings and describes some of our ongoing research intentions.

2 The MISTRAL System at a Glance

The need for enhanced and improved methods for multi-modal information processing and semantic annotation has motivated us to initiate the research project MISTRAL (Measurable intelligent and reliable semantic extraction and retrieval of multimedia data).
In general, MISTRAL research aims at enhanced semi-automatic procedures for semantic annotations and semantic enrichment of multi-modal data streams. In order to process these multi-modal data streams, the system consists of so-called 'conceptual units' in sequential order for (1) uni-modal data stream processing, (2) multi-modal merging of extracted features, (3) semantic enrichment of concepts, and (4) semantic applications. Furthermore, a benchmarking framework, UI & visualization services as well as security and privacy issues complement the concept units in an orthogonal way. The MISTRAL architectural design is particularly more extensible, interchangeable and flexible than most other meeting recording and annotation systems, such as [6] and [7]. This advantage is gained by the application of an organizational and architectural distributed component-based approach, the usage of Web Service technology, and by service orchestration and choreography. Furthermore, the system supports the management of domain knowledge, provides access to the meeting repository for external applications, and makes mechanisms for trusted feedback available.
In principle, the system is designed to be applicable in a wide range of application fields, which is possible by orchestration and choreography of MISTRAL-internal and external Web Services as well as by exchangeable domain knowledge. Nevertheless, our research work and prototype implementation focus on the field of meeting information processing.
From the MISTRAL meeting recording point of view, the term meeting is seen in a broader sense. It encloses various meeting scenarios (face-to-face meeting at one location, virtual meetings at different locations, and various hybrid forms) as well as seminar scenarios (workshops, conferences, presentations, and the like). Thus, our prototype solution has to be flexible enough to allow the recording of different types of multi-modal data streams.
The architectural design of the Mistral system results from the composition and interaction of its conceptual units. Apart form these units, an additional module called **Data Management System** stores and handles the access of the multi-modal meeting data as well as its metadata, such as creation-specific data given by the recording devices, and extracted or annotated semantic features attached by the conceptual units as described in the following paragraphs.
The **Uni-modal System** consists of five interoperable modules: Video, Audio, Speech-to-Text, Text and Sensory Modules. The *Video Module* is responsible for processing image data in order to grasp features and semantic information (such as meeting participant localization and recognition, movement information as well as gesture and facial expression), and for the recognition of trained objects (like a mobile phone, a briefcase, a notebook, etc.). The *Audio Module* processes sound data for gaining meeting relevant information, as for example meeting participant localization and recognition, voice characteristic features (stress, sex and age group of participants), and information about sound events (phone ring, laughter, clapping hands, and the like). The *Speech-to-Text Module* extracts and transcribes textual information

from the oral talks of meeting participants. The *Text Module* processes speech-to-text transcriptions as well as additional meeting relevant documents (agenda, presentation slides, project documents, lecture notes, etc.) in order to deliver further semantic information, such as extracted hi-level concepts, content summaries, text classifications, and content clusters. The *Sensory Module* processes multi-modal sensor data within the scope of meeting scenarios, which is restricted to particular interactions with a presentation device (computer), such as selected or opened documents, click-data streams, and visited URLs. This information is especially useful in combination with the other modalities stated above.

The **Multi-modal System** combines uni-modal features and semantic information in order to gain further features. It extracts more abstract features, checks the confidence of comparable uni-modal features, and provides feedback to the Uni-modal System for error handling.

The **Semantic Enrichment System** can deliver further high-level features and additional semantic information by means of a particular knowledge base for meeting models. On the one hand, the system is responsible for conflict detection, e.g. a person can not sit in the foreground and stand in the background at the same time. On the other hand, the system performs semantic conclusions, e.g. a person who opens the meeting, introduces the other participants, asks the most questions and closes the meeting, is assumed to be the 'moderator'.

The **Semantic Application System** can be seen as the 'customer' of all semantic meeting information provided by the other systems, i.e. it builds the front-end of the Mistral system for a particular application purpose. Conversely, external customers (i.e. users and external systems) can also provide useful feedback, so the Semantic Application System serves also as a trustful and secure feedback provider for the internal systems.

A can be seen, the overall Mistral system consists of a set of powerful interacting sub-systems that are able to contribute to define the architecture of the Semantic Meeting Information Application (SMIA). Nonetheless, the concrete functionality of SMIA is mainly located within the Semantic Application System. Due to the fact that any application is as useful as its applicability in real-life situations, the next chapter describes scenarios defining the practical needs of users respecting the main target field of SMIA, i.e. knowledge transfer on the job.

3 Illustrative Examples Scenarios

As already argued in chapter 1, the focus of the semantic application is set on the integration of meeting information in knowledge transfer and e-learning activities within companies. A set of illustrative example scenarios addressing knowledge management issues as well as e-learning aspects are given in the reminder of this chapter. The aim is to give an idea about the specific needs in context and to provide the basis for the requirements presented in chapter 4.

Scenario 1: Joe and Bernie are active members within the project 'Collaborative Tools'. Joe belongs to the database group and is a mySQL expert. Bernie belongs to the Java group and is responsible for the 'view' components. Joe has missed the last meeting and wants to get an update. In case Joe should miss a meeting for this project, he has previously defined some relevant information in his profile: (a) provide a short meeting abstract as well as a list of present and absent participants, and (b) show detailed textual information concerning the topic 'data storage' and provide links to the corresponding meeting recordings. Apart from that, Bernie has to give a report on all decisions made about the user interface layer. Further, he has planned to involve all meeting participants who have actively contributed to this topic in any past project meeting. Thus, Bernie defines a proper search query and receives the relevant text sections, the corresponding recording segments, and information about the participants.

Scenario 2: Sue has recently returned from her sabbatical and is the nominated project manager of the new customer project 'Intrusion Detection System', which is currently in the planning status and will be started soon. For the purpose of using synergies and reusing knowledge from other projects, she wants to identify similar issues, problems and tasks from

other projects over the last three years. She provides particular memos and a detailed project description conducts a ‘search by example documents’ over the meeting corpora. Further, Sue wants to get all positive and negative company-related arguments (i.e. ‘pros’ and ‘cons’ based on subjective statements during meetings) about open source software solutions that are applicable for her project. By means of the system, she firstly defines a search query to get all relevant information over the last five years annotated by date and by a rating level (‘cons’ correspond to ‘-1’ and ‘pros’ to ‘+1’). Afterwards, she selects the corresponding time-series visualization and analyzes the statistical increase/decrease of ‘pros’ over the time-line.

Scenario 3: Herby is a member of the senior staff, responsible for software design and leader of a program developer group. He wants to be informed about ‘software design’ issues discussed in meetings of all past projects. In addition, for him and his groups, he wants to be informed about ‘Java’-related problems discussed in those meetings that they have attended.

Scenario 4: Mona is senior trainer in the company, and therefore, responsible for many training activities. Her current task is to work out some courses for further vocational trainings for the next year. In order to address practically orientated subjects, she has decided to investigate ‘hot topics’ from ongoing and recently completed projects. Thus, Mona searches for the main topics addressed in all meetings which took place within the last two years. She identifies ‘multi-media retrieval’ as relevant emerging topic because of its high frequency of occurrence. For training preparation, she is also interested in identifying related problems and solutions as well as experiences and open issues. In addition, she is looking for experts who could support and advise in the process of training material production.

Scenario 5: Simon is member of the database group. He has enrolled for the course ‘J2EE Basics’ at the e-learning system of the company. Based on his preferred learning style, he wants to get illustrative examples by audio-visual media. According to the lessons’ subjects the system delivers corresponding real-life problems and solutions discussed in meetings and workshops. Furthermore, he uses background information that is dynamically compiled from relevant information on the Web, from intranet documents and from meeting information.

Scenario 6: Miriam has just finished her master’s degree in computer science. She has been recently employed and assigned to the Java programmer group. In order to get familiar with the problem solving style and the software design practice of the company, she has to complete an experiential-based training on the job by utilizing the meeting information system. Firstly, according to her design and development tasks, she has to become acquainted with comparable tasks from other projects before starting her work. And secondly, Miriam has to work on her tasks but in case of problems and questions, she can get information from an automatically generated FAQ database or she can consult an expert.

4 Semantic Meeting Information Application Requirements

This chapter is based on Mistral’s general objectives, which deal with processing meeting information for knowledge transfer and e-learning activities in companies. For this purpose, this section also follows the example scenarios described in the previous chapter. Thus, the main requirements for the first prototype of SMIA are depicted in the following sub-chapters from three different perspectives: viewpoint of user roles, viewpoint of information needs and functional viewpoint.

4.1 Requirements from the Viewpoint of User Roles

(1) Personalized support for meeting attendees and absentees to enhance knowledge development, retrieval and integration, e.g. user-tailored access to meeting information by semantically enriched annotations (for applicability concerns see scenarios 1-5 in chapter 3).

(2) Adaptive knowledge transfer to other members of the company, e.g. depending on position and current job tasks (see scenarios 3 and 5).

(3) Supporting trainers, tutors and staff members responsible for vocational training, e.g. identifying interesting and emerging topics or recurred problems (see scenarios 2, 4 and 6).
(4) Personalized access for learners to practically orientated knowledge corresponding to lesson topics and course material, e.g. best practices, FAQs, problems, and model solutions (see scenarios 5 and 6).

4.2 Requirements from the Viewpoint of Information Needs

(1) Retrieval and combination of basic meeting information

- Organizational information: meeting data (e.g. date, place, duration), project relevant information (e.g. project description), and additional meeting-related documents (e.g. agenda, description of products, organizational chart).
- Participant information: invited persons, attendees and absentees, roles and activities of participants, spatial and temporal information.
- Tracing of object and sound occurrences: spatial and temporal information.
- Meeting content and time-specific information: speech-to-text and related documents, topics and content abstracts, click data streams.

(2) Retrieval of meta-knowledge inferred from the basic meeting information

- Discovering knowledge assets addressed in meetings: either following the topics in the agenda or representing 'off-subject' knowledge for further reuse.
- Identification of questions/answers and problems/solutions.
- Clustering similar topics as well as their frequency-based co-occurrences.
- Compiling 'pros' and 'cons' according to a particular term or subject.
- Discovering and providing best practices and specific problem solutions.
- Automatic generation of a topic-specific or meeting-related FAQ.
- Providing a meeting-specific dynamic background library.
- Provision of learning material according to given concepts as well as providing model answers and automatically generated tests in order to assess knowledge acquisition.

(3) Access to statistical information derived from (1) and (2)

- Provide statistics about participants in meetings: meetings attended or missed, role of participants in meetings or projects, activities in a meeting or a project, and the like.
- Show number and frequency of topics related to a meeting, a project or a participant.
- Determining the temporal occurrences of features and concepts.
- Calculate the frequency of subjective emphasis on discussed topics, i.e. the attitude or the opinion of sentences or sections in the scope of a term or a subject related to a meeting, a project or a participant.
- Temporal localization of subjective emphases on topics regarding the time-line of meeting recordings.

(4) Linking meeting information with related information

- Identification of similar meeting information based on specified documents or a meeting scenario (i.e. 'search by example'), a user profile or a group profile.
- Linking relevant meeting topics with related learning material.
- Storage and management of knowledge created and transferred in meetings as integral part of the corporate memory.

(5) Personalized and contextualized information retrieval

- Provide views on the meeting corpus depending on the privacy and security issues.
- Filtering of information assets with respect to role, group membership or access rights.
- Modeling of personal tasks, needs and traits, as well as the combination of user-related and company-related profiles.
- Support the modeling of different concept-based information spaces.
- Support the visualization and scrutinity of user models (view and edit user profiles).

4.3 Requirements from the Functional Viewpoint

(1) Retrieval embraces, on the one hand, the definition of functionalities in order to identify, pre-process, access and recall relevant meeting information form the Data Management System. On the other hand, the system has to manage accessed data and build data structures in order to support users' information needs.
(2) A further functional requirement is the management of different sorts of modeling information, such as user and user group information, context information, and the like.
(3) Adaptation and personalization are also important in order to provide tailored information for users or applications accessing the SMIA.
(4) In particular, information visualization is very important for a useful information access according to the users' information needs Further, information visualization can also provide useful services for external systems in order to fall back upon pre-existing visualizations. Based on the information needs stated so far, the system has to provide search result presentation as a linear list in table form, information-structure-dependent visualization by metaphors for hierarchies, graphs, similarities, and time series. In addition, meeting information (e.g. speech-to-text) and meeting recording information (e.g. video and audio information) has to be properly visualized by the system.
(5) Access to SMIA has to be provided to users as well as to internal applications, such as a connection to the corporate knowledge management system or intranet system, and linking to the e-learning environment. Furthermore, the system has to enable the connection of external modules or services (such as Word Net, DMOZ classification hierarchy, or a service for determining the subjective emphasis on statements and topics).

5 Semantic Meeting Information Application Architecture

Based on the findings, statements, scenarios and requirements stated so far, this chapter gives a rough overview of the design concept as well as over the architecture of the prototype implementation of the SMIA system. The logical layer-based architecture of the system is depicted in Fig. 1 (see next page). The logical architecture of SMIA is the result of analyzing the aspects described in the previous chapters, but it is mainly derived from the group of requirements depicted in section 4.3 ('Requirements from the Functional Viewpoint').

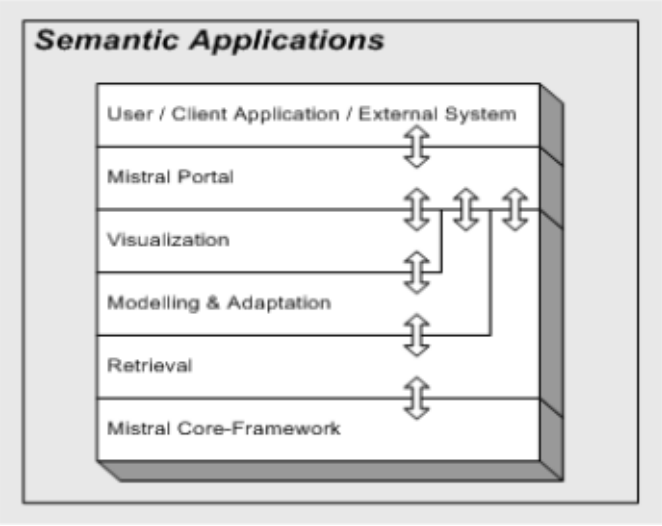

Fig.1: Logical layer-based architecture of Semantic Applications.

The component-based architecture of Mistral and, in particular, its Semantic Application System is illustrated in Fig. 2. This architecture represents the core components of SMIA.

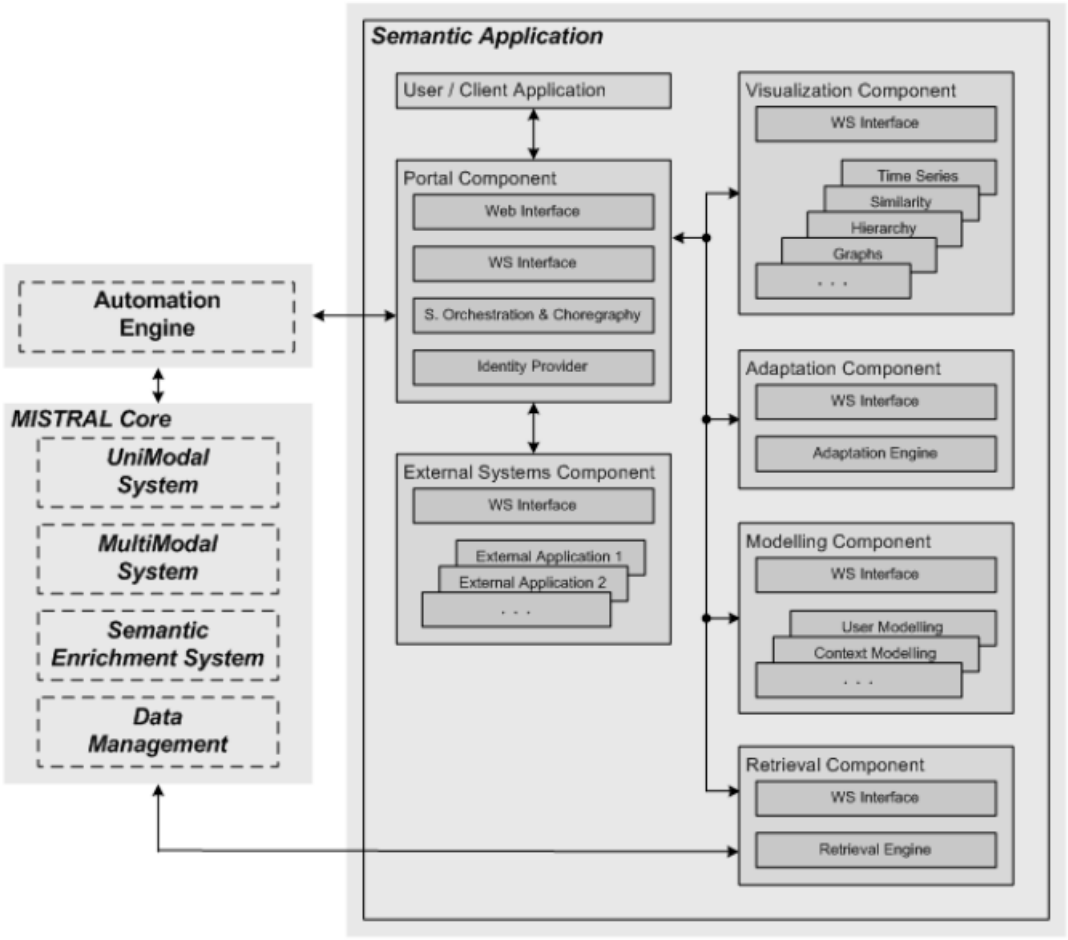

Fig. 2: Component-based Architecture of Semantic Applications System of Mistral.

Each component of SMIA is accessible via a Web Service interface, but due to security reasons access is only permitted for trusted services. The Mistral Core itself can only be accessed by the Automation Engine and by the back-end of the Semantic Application, i.e. the Retrieval Component. Data accessed from the Mistral Core Framework are pre-processed and managed by the Retrieval Engine in order to provide information for other components. The front-end is given by the Portal Component, which is responsible for managing the access of users and external applications using the HTTP portal gateway or Web services. Features and functionality in accordance to specific information needs are composed by service orchestration and choreography applying internal component services (e.g. visualization of a graph and personalized information according to a user model) and externals applications integrated by the External System Component (e.g. Word Net). In order to provide feedback from the semantic application or to delegate specific multi-modal processing to the MISTRAL Core, the Portal Component is also connected with the Automation Engine.

6 Conclusions and Further Work

Indeed, it was not easy to find a (vacant) gap in the research field of multi-modal information processing. Even so, we allow us to state that there is a lack of research with respect to the integration of meeting information into knowledge management and e-learning systems in companies. As the overall Mistral system (see chapter 2) was designed to be very flexible, strong modular and largely extensible from the viewpoint of its applicability possibilities, we could define a concrete functional architecture for our Semantic Meeting Information Application (SMIA) based on a specific set of scenarios and requirements in context (see chapters 3 and 4). At present, there exist prototype implementations of the main modules of

Mistral and we are now working on the integration and combination of them in order to successfully fulfil the specific requirements determined and described in this paper. Thus, the next steps within our work consist of evaluation and refinement of the overall system and of its interacting services.

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