Collaborative and Argumentative Models of Meeting Discussions

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Abstract

We report in this paper experiences and insights resulting from the first two years of work in two similar projects on meeting tracking and understanding. The projects are the DARPA-funded CALO[1] project and the Swiss National research project IM2[2]. The findings from these two projects have been shared and compared in order to come up with a joint ontology as a model for argumentative discussions in meetings. We highlight the complexity of the problem in modeling interaction and discourse in argumentative discussions and we propose a solution based on the construction of a specific knowledge base.

1 Introduction

Corporate meetings contain a wealth of tacit knowledge, which might play a central role in the construction of corporate or project memories. As remarked in (Corrall, 1998), meetings provide opportunities for face-to-face contacts and electronic interaction, fostering learning groups and holding 'best practice' sessions. They are part of a large repository of knowledge, which includes network and discussions and remain tacit knowledge unless manually processed and stored as meeting minutes. We believe that computer-supported tracking and understanding of meeting discussions is a crucial application of Knowledge Management, since it would leverage the extraction and structuring of tacit knowledge from meetings to a corporate-wide scale.

1.1 Corporate Memories

In the building of Corporate/Project Memories, each business event in becomes a document. Meetings are collection of "business" events since they typically contain decisions on issues, action items and official presentation of information.

We are aimed at transforming meeting business events into information sources. In particular, we would like to map meeting events into information sources for further exploitation in business processes (e.g. decision making, planning, assessment, rationale capturing). Additionally, we want to structure information and turn it into knowledge in order to:

- analyze it by means of statistics, projections, assessment, mining;
- search and provide explanation of phenomena;
- plan future business activities.

1.2 Meeting Tracking and Understanding

The goals of the IM2 project are outlined in two possible scenarios. In the first scenario, we consider a collaborative work situation where somebody missed one meeting (new/sick/distant employee) and needs to know about any important points discussed, the discussion's outcomes and important decisions. The second scenario involves high-level management where meetings become part of the corporation's knowledge base and used for:

- tracking/documenting progress of a project over years;
- tracking/documenting performance of a team/employee;
- monitoring communication/leadership inside a team.

In the CALO project, the personal assistant aids users in performing office-related tasks such as coordinating schedules with other users, providing relevant information for completing tasks, making a record of meetings, and assisting in fulfilling the decisions made in the meetings.

[1] http://www.ai.sri.com/project/CALO
[2] http://www.im2.ch

A typical meeting discussion of the kind supported by CALO and IM2 will be a short (15--30 minute) meeting between approximately 3--8 participants. The participants may engage in any number of common meeting-room activities including short slide presentations describing ongoing work, the planning of project tasks and milestones, briefings about completed work, the making of important decisions, or assigning action-items for post-meeting fulfillment. These activities are likely to be realized in many communicative modes including the use of a whiteboard to draw project plans, explicit reference to elements in physical or virtual documents, and elementary verbal interaction.

In the both projects we studied models for representing knowledge that could be extracted from meetings records. Meetings are among the richest forms of human interaction. Meetings can be of various types depending on the purpose and the context where they take place. We are particularly interested in modeling discussion or collaborative meetings. This type of meeting has typically two clearly defined dimensions: *decision making* and *conflict resolution*.

We propose a rich argumentative model to capture these two dimensions. The argumentative model we propose provides an abstract description of the discussion's rationale by outlining the important points discussed, the conflicts arisen and, hopefully solved, and the decisions that have been made. Our model is made of several layers; each of them captures a particular aspect of the discussion.

The Meeting Ontology

A model of meeting discussion is only one, although complex, component of larger meeting ontologies, namely the Multi-Modal Discourse (MMD) ontology (Niekrasz et al. 2005) and the IM2/M4 meeting ontology (Marchand-Mallet, 2003). In both projects substantial effort has been invested into coming up with a general and useful conceptualization of the domain. One common finding is the need of separating information about the dynamics of the meetings and the content or subject matter. This requirement is highlighted by the fact that potential user are likely to ask questions about meetings combining at least the following four dimensions:

1. the set up of the meeting;
2. the content of the meeting: topics;
3. the dynamics of the meeting: discussion;
4. the outcomes of the meeting: decisions;

An example of possible query, which involves the first three of the four dimensions, is:

> "Why the person sitting in front of me rejected the proposal John made to buy a new computer?"

A more complex query, which seems to involve all four dimensions, is:

> "What were the arguments brought by the person in front of me against the new computer we decided to buy?"

As showed in the IM2 recent study on user queries (Pallotta *et al.*, 2004a) and from the CALO project test questions, it is apparent that the above types of question are possible.

3 Dialogue and Argumentation

The argumentative dimension has been incorporated by IM2 and CALO in different ways. In CALO, the main focus has been on the use of dialogue management architecture to dynamically track the dialogues, by using deep and shallow natural language processing techniques to automatically classify utterances into particular move types; whereas in IM2 a dialogue model has been proposed for corpus annotation. We acknowledge that we agree on a common underlying structure, the argumentative tree, whose construction is achieved in different fashions in the two projects.

3.1 CALO's argumentative dialogues

In the CALO approach, dialogue moves are incorporated within a model of dialogue history much like that of (Lemon and Gruenstein, 2004), but with the addition of deeper dimensions of argumentative structure. The dialogue state is modeled as a tree, with individual moves forming the nodes, and the connections between nodes being the antecedent relation between the moves; separate branches of the tree are separate (although possibly simultaneous) conversational threads (sequences of antecedent-related moves).

The MMD ontology classifies dialogue moves along two nominally independent dimensions: their immediate short-term effect on the dialogue state, and their sometimes longer-term rhetorical or argumentative function. At the shallower, short-term level we represent the utterance’s *information state update effects* – its effects on the instantaneous state of the discourse, see e.g. (Bohlin (Ljunglöf) et al. 1999)[3]. This includes information about currently salient referents (for anaphora resolution) and currently relevant propositional information. Specifically, the update effects at this level are modeled using (Ginzburg forthcoming)'s Question-Under-Discussion (QUD) model: specific classes of move are seen as introducing or removing questions from a QUD stack in the current information state. Particular classes of move have particular update effects; for instance, a **Query** move must introduce its question as the topmost (most salient) question in QUD; a direct **Answer** move must express a proposition that can be unified with an antecedent QUD question. These semantic and pragmatic constraints are articulated directly within the MMD ontology as properties of the dialogue move classes themselves.

More interestingly for the current purposes, the second level of classification describes a dialogue move’s role in the rhetorical and argumentative structure (see e.g. Mann & Thompson 1988; Asher & Lascarides 2003). Relations and update effects at this level are expressed by constraints on a second information-state stack variable, IUN (thus implementing a version of (Larsson 2002)'s Issue-Under-

[3] Models of information state usually incorporate a history of dialogue moves as well as the records we describe here -- in our model, this is available directly from the dialogue move tree itself.

Negotiation model). Argumentative threads are seen as pertaining to particular *Issues*, modeled as questions on the IUN stack. **Introduce** moves introduce new issues, **Proposals** introduce possible alternative answers thereto, **Acceptances** or **Rejections** remove those alternatives. Again, these effects and/or preconditions on the move types are expressed directly as properties of their subclasses in the ontological model. Currently, we treat the two notions of discourse structure mentioned above as independent dimensions of the dialogue tree: e.g. a dialogical **Answer** might function rhetorically as **Proposal**, **Rejection**, **Acceptance** or others.

3.2 IM2's Meeting Description Schema

In IM2 we proposed a description schema to model the content of meeting dialogues from the perspective of their argumentative structures (Pallotta *et al.*, 2004b). The argumentative structure defines the different forms of argumentation used by participants in the dialogue, as well as their organization and synchronization in the discussion. However, practically, when analyzing the dialogue, *adjacency pairs* (Schegloff & Sacks, 1973) are not enough to represent the hierarchical structure of the discussion: consider an answer that refers to two questions in the discussion. In this case, we need to add a relation that links the answer to both of the questions. This relation is called "replies_to", and links an episode to one or more previous (possibly in time) episodes. The replies_to relation induces an *argumentative chain* structure on the dialogue which is local to each episode and which enables visualizing its context. For instance, the context of an "**ACCEPT(clarification)**" will be the episode of the clarification and that of the proposal (if we know that a clarification is preceded by a proposal) as well as the episode where the proposal was uttered (agenda, discussion issue, etc.).

Episodes may have an empty "replies_to" relation. There can be more than one episode, which replies to the same episode. Episodes can overlap in time, as for instance in cases where the acceptance of a justification is provided as a backchannel during the presentation of the justification.

Categories such as **REQUEST**, **ACCEPT**, **REJECT** might correspond to dialogue acts. In this case we have refined the concept of dialogue act and adjacency pairs by specifying the role of dialogue acts contribution within the discussion.

We also realized that there is an invariant structure of discussion episodes, which can be obtained by a more general schema by simply varying the internal parameter.

The general structure of a discussion is the following:

DISCUSS(issue) ←
PROPOSE(solution/idea/alternative/opinion)*.

PROPOSE(solution/idea/alternative/opinion) ←
(REQUEST(explanation/justification)),
(CHALLENGE(solution/idea/alternative/opinion)),
ACCEPT(solution/idea/alternative/opinion) |
REJECT(solution/idea/alternative/opinion).

REQUEST(explanation/justification) ←
PROVIDE(explanation/justification).

PROVIDE(explanation/justification) ←
ACCEPT(explanation/justification) |
REJECT(explanation/justification).

CHALLENGE(solution/idea/alternative/opinion) ←
DISCUSS(solution/idea/alternative/opinion).

ACCEPT(solution/idea/alternative/opinion) ←
PROVIDE(explanation/justification).

REJECT(solution/idea/alternative/opinion) ←
PROVIDE(explanation/justification).

The only structural constraints are restrictions imposed to the backward looking relation "replies_to", which are graphically represented above by arrows. In fact, we require that an argumentative episode "replies_to" the parent argumentative episode in the tree, as for instance, in:

replies_to(ACCEPT(explan.),PROVIDE(explan.)).

This model can be also viewed (reversing the arrow) as a structure of expectations in discussions. As remarked in (Dascal, 1992), "conversations cannot be described in terms of conditions of *well-formedness*". Conversations can be modeled by structures of expectations, or in terms of 'conversational demand' (Dascal, 1977). Such expectations do not impose rigid constraints on the structure of the conversation since they are only presumptive and thus defeasible. Defeating expectations of conversational demand is comparable to flouting Gricean conversational maxims, entailing, instead of ill-formedness, a non-standard meaning.

4 Collaboration and Negotiation

Meetings exhibit longer-term negotiative and argumentative patterns, which present an extremely difficult challenge to automatic understanding. Due to their psychological roots but unclearly-defined semantics, an account of meeting structure at this level is both extremely difficult yet extremely useful. In support of this essential (and perhaps ultimate) goal for the understanding system, we specify a model to capture the semantics of these long-term negotiative structures.

In both CALO and IM2, we use a model based on the Issue-Based Information System (IBIS) put forth in (Kunz & Rittel 1970) and exemplified in systems such as Compendium (Bachler et al. 2003) and techniques such as Dialogue Mapping (Conklin et al. 2001).

The IBIS model abstracts from the dynamics of the discussion, which needs to be modeled as well in order to extract the IBIS structures from *meeting events*. Relevant meeting events are special types of Dialogue Acts that have an argumentative force. This type of Dialogue Acts, which are called Argumentative Acts, are backward looking acts with forward looking expectations. Their presence imposes an Argumentative Structure to the dialogue.

These models are critical for deriving meaningful user-level structure from the discourse, turning the meeting into a useful shared-memory resource. We derive our conceptualization in great part from the AKT reference ontology[4] and the meeting-oriented additions made in (Bachler et al. 2003). These include notions of meeting Artifacts -- physical or virtual information-bearing documents – and long-term negotiative behaviors around them, such as the reading of an *Agenda*, assigning *Action-Items*, and following up on *Decisions*.
These objects are instantiated through composition of the rhetorical and argumentative structures described above.

Frame Semantics of Meeting Discussions

Linking together the argumentative and collaborative perspectives of meeting discussions is important in order to understand the various roles of the these components. We propose the adoption of the Frame Semantics (Fillmore, 1977) framework to glue together the above-described aspects of meeting discussions. While Frame Semantics has been mainly used for lexical semantics in the FrameNet project[5], we adopt it as a framework for modeling discourse situations[6].
In Frame Semantics, a *Frame* is a model of a situation made of a number of *Frame Elements* and triggered (or evoked) by a *Target* object[7]. Frames can be organized into a taxonomy and can inherit from multiple frames and they can be decomposed in to *sub-frames*. A frame can be also evoked by another frame, which has it in the *background*. Background frames provide contextual information to the foreground frame. For example, a frame describing the setting of a meeting can be used as a background of the meeting discussion frame. The meeting discussion frame can be decomposed into episodes and each episode made of meeting actions.
In sentence level Frame Semantics, target lexical units evoke frames and frame elements are filled by the grammatical functions. In our case, due to the non-lexical nature of the frames, we need to extend the notion of target and frame elements to cope with a different type of situation. If we are aimed at constructing the frame semantics of a meeting discussion we cannot just rely on semantics of the spoken utterances, but we need to determine what type of action has been carried out and what is its role in the global discussion frame. This means that the addressee will fill a frame element in the action frame together with other information extracted from the utterance and from multi-modal information. The detection of an action evoking a frame, which is a sub-frame of a larger event frame, presupposes the existence of that event.
We used Frame Semantics to build an ontology of Meeting Discussions by conceptually linking several argumentative models. We considered four perspectives and for each perspective one theoretical model:

1. Persuasion: Toulmin model (Toulmin, 1959);
2. Decision Making: IBIS model (Kunz & Rittel, 1970);
3. Episodes: Pragma-Dialectics (van Eemeren and Grootendorst, 2004);
4. Conversational: Meeting Description Schema (Pallotta et al., 2004b) .

Each perspective is made of a system of frames. Frames can be also related to each other by a number of semantic relationships. In general, frame elements can be filled by frame instances. Thus, each frame element induces a frame-to-frame relation. We introduced a new relation to denote *outcomes* of actions. For instance, a "propose" argumentative move produces an instance of an "IBIS proposal".
Frame Semantics allow us to have several perspectives on meeting simultaneously activated. For instance, we can decompose the discussion into stages and have for each stage a set of related actions each evoked by specific dialogue acts and utterance types. The obtained semantic network from the combination of the above perspectives using frame relations is sketched in figure 1.

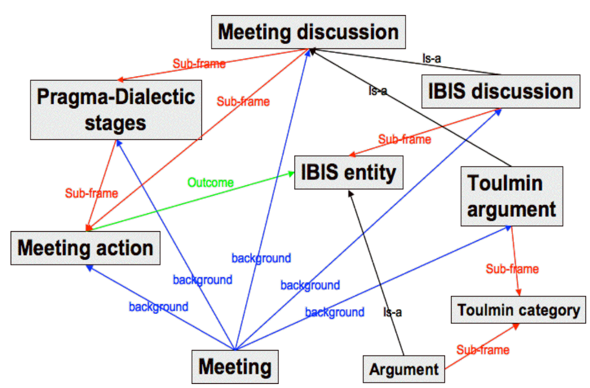

Figure 1. Network for Meeting Discussion Frames

In our network, Pragma-Dialectic stages are used to group meeting actions described in MDS. IBIS and Toulmin modes provide the most abstract perspectives on discussions. However, an IBIS "argument" can be structured as a Toulmin argument (i.e. a sub-discussion). IBIS entities are produced by MDS actions. All the frames are backgrounded by the global "Meeting frame".

[4] http://www.aktors.org/publications/ontology/
[5] http://framenet.icsi.berkeley.edu
[6] We adopt here the perspective of Frames as *Structure of Expectations* much like the notion of *scenario* or *scripts*. However, these types of expectations do not determine any condition of well-formedness and can be defeated. Defeating an expectation has a pragmatic relevance since it signals a non-prototypical behavior in the course of events.
[7] In lexical frame semantics, target units are lexical object. We extend the notion of target to discourse units, which, in case of multi-modal dialogues, might be realized by verbal and non-verbal communicative actions.

5 Conclusions

In this paper we have reviewed applications of argumentation models of meeting discussion within two research projects aimed at building multi-modal information systems and persistent personal assistants. Recently, the importance of modeling argumentation for tracking and understanding meeting discussions has been recognized also in other similar projects (Reidsma *et al.*, 2004; Galley *et al.*, 2004) and a new trend of research has been started. We're moving towards argumentative models to meet the user's requirements for both CALO and IM2 projects, but there is still a big gap to be filled since there are not well-established techniques to perform robust discourse parsing in the domain of recorded multi-party dialogues such as meeting discussions.

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