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Team Communication and Mental Models

Influence of Communication on Mental Models

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Contents

1 Introduction

A crisis management team is set up when a (crisis-) situation occurs that can not be resolved within the normal organizational structure. The team assess the crisis situation, develops a strategy to bring relief the situation and then provides operational units with tactical information.

The work of crisis management teams is heavily based on information. Each team member is assigned a different focus of work. To resolve a crisis situation, the team members must coordinate their actions and cooperate through sharing information and knowledge. To achieve this cooperation, the team members need to know the tasks and topics of other team members, to provide them with helpful information. This knowledge is stored in a mental construct - called shared mental models - that is used by humans to reason about the world they live in.

Experience has shown that in times of high work load team effectiveness increases through anticipation and prediction of their team-mates' needs (3). This applies when the members share a similar understanding of the situation (11). Such a mutual understanding is called a shared mental model (cf. (9)) or team mental model (cf. (7)).

In (10) Salas, Sims and Burke identified four types of shared mental models: equipment, task, interaction and mental model of team members.

This mutual understanding is established by sharing information. In order to share information, team members need to talk to each other. The author's master thesis will take a closer look into communication and mental models in crisis management teams. For what reason is the analysis of communication in crisis management teams of interest?

Everyone who ever had the chance to work in a crisis management team or had the to chance to see such a team working, knows that there is a great gap between the ideal process and the real world. This is because each team member has a different personality and background that influence their behaviour. Garrecht lists several factors she identified influencing team work (5) and thus hinder the flow of information.

2 Background

2.1 Agents and Multi Agent Systems

In (12) Wooldridge and Jennings define an agent as

> ... an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives.

A multi agent system contains such agents and provides an infrastructure to specify communication and interaction protocols (cf. (2), p. 29).

2.2 Agent Architectures

Several concepts for agents exist in literature - logic-based, reactive, layered and BDI agents (cf. (2), p. 29). BDI stands for Belief, Desire, Intention and describes an architecture where agents store their assumptions (beliefs) about the state the world is in, in a so called belief base. Desires express target states the agent pursues. The agent thus has intentions when performing certain actions to achieve a target state.

2.3 Agent Communication

FIPA[1] and DARPA Knowledge Sharing Effort (1) have both developed an agent communication language (ACL):

- the FIPA-ACL (4)
- KQML (Knowledge Querying and Manipulation Language)

enabling agents to express their intention via communication.

Both languages rely on the speech act, described by Searle in 1960 and enable agents to express their intention when sending messages. The FIPA-ACL is integrated in the multi agent platform JADE, which provides several features for monitoring and debugging agents.

The FIPA-ACL supports agent communication with the following concepts:

Messages Messages are passed between agents. They carry some meta information as well as the content to be communicated. Such meta information usually is the *sender*, the *receiver*, a *topic-id*, the used *language*.

Communicative Acts A communicative act describes how a certain message has to be interpreted (cf. speech act theory). FIPA compliant agents do not necessarily implement all communicative acts, except the *not-understood* act, indicating the agent did not understand the received message.

[1] Foundation for Intelligent Physical Agents

Interaction Protocols In addition, the FIPA defines interaction protocols which are pre-agreed message exchange protocols. They specify how an agent has to react on a certain message and telling the agent what to expect from other communication partners. An easy interaction protocol is shown in fig. 1

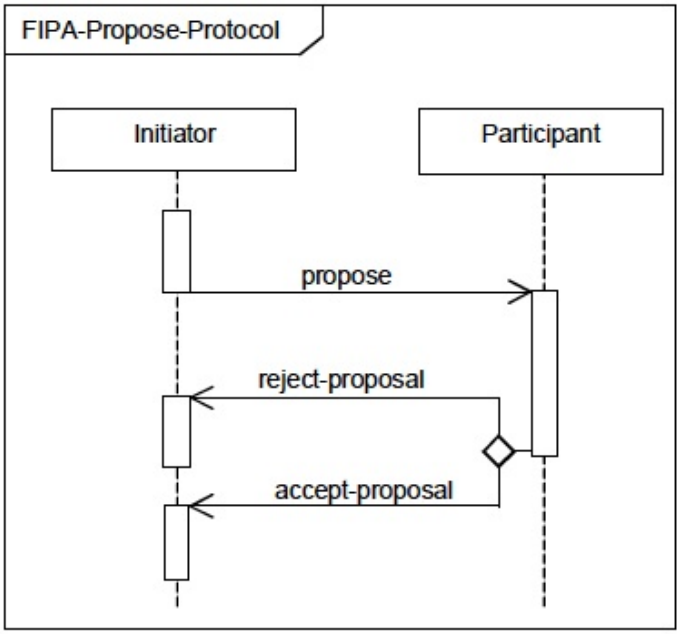

Figure 1: The FIPA-Propose-Protocol

Ontology In (2) Dignum quotes a statement by West Churchman implicating that knowledge can only be transferred from one person to another when both have the same context under which they interpret the knowledge. In FIPA-ACL, ontologies are used to tell the receiving agents the context within they should interpret the received content.

2.4 Information Processing

A team member in a crisis management team gathers information, processes it, shares it and reacts on it. The work of Garrecht (5) lists several factors disturbing the work of crisis management team members. The influence on communication can be summarized as follows:

- the team member is in a state where he is not able to receive any or the complete message. i.e. information gets lost

- the agent is in a state where he fails to process the information due to lack of time or priority setting, i.e. the information is not used
- the agent is in a state where he fraudulently alters the information - intentionally or not, i.e. faulty information is shared within the team
- the agent is in a state where he refuses to share information with the team for personal reasons, i.e. no information is shared with the team

The reasons for this are various and not covered during this work. They are assumed as existing without questioning why. The psychological reasons lie outside the thesis' scope.

2.5 Mental Models and Agent Memory

2.5.1 Mental Models

Literature describes mental models as *"structures held by members of a team that enable them to form accurate explanations and expectations for the task, and, in turn, coordinate their actions and adapt their behavior to demands of the task and other team members"* (9).

They *"are the mechanisms whereby humans are able to generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states"* (8).

2.5.2 Agent Memory

The Jena[2] Apache library allows to store OWL ontologies as RDF graphs and in addition allows querying these graphs with SPARQL. This allows an agent to ask another agent something via a SPARQL query and receive the desired information as RDF snippet. The agent can then add the new information to its own RDF graph, i.e. its memory.

3 Preliminary Work

The Agent OWL example[3] has been extended to a test scenario that provides the following features:

[2] http://jena.apache.org/
[3] agentowl.sourceforge.com

- use of the Jena Apache library to retain information in an RDF graph
- register the agent's actions as services to the JADE Directory Facilitator
- find an agent, providing a specific service and ask it to start the corresponding action. This involves wrapping the action into an RDF description and sending it to the agent by message
- communicate information described in RDF via FIPA messages
- internalise received information into the own memory

3.1 Agent Components

Following is a brief describtion of the agent's architecture. Figure 2 shows the main components of an agent.

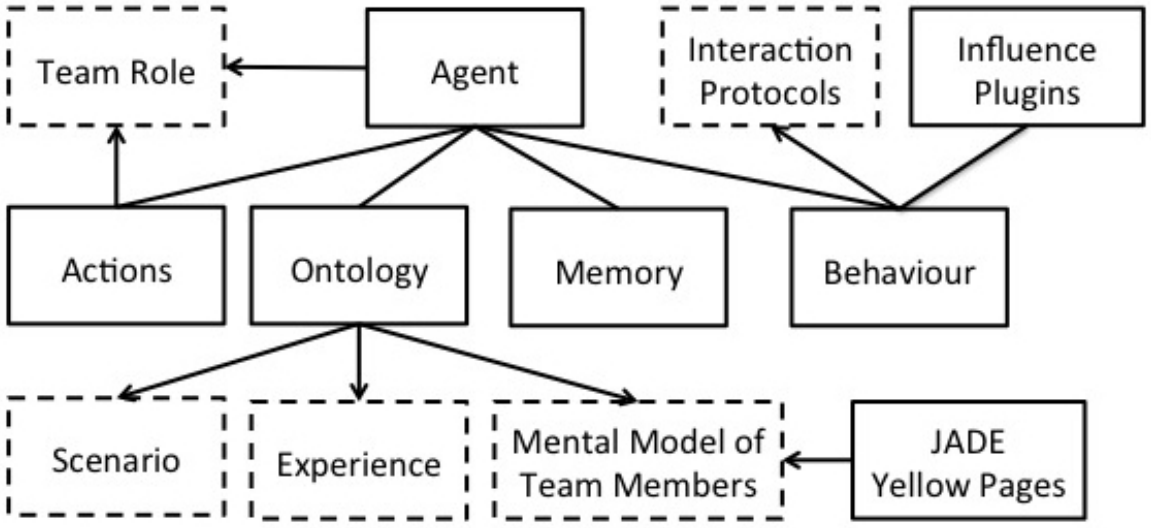

Figure 2: The Agent's Components

The *Agent* class extends the JADE Agent class. *Behaviour*s are used to handle incoming messages and can trigger other Behaviours. By the means of Behaviours, interaction protocols can be realized. Additionally the behaviours are injected with plugins influencing the agent's behaviour. The *Memory* encapsulates the Jena RDF graph, where the agent saves its knowledge. The RDF graph is described though an ontology file that covers the scenario, the experience and parts of the mental model. The team role an agent is assigned to specifies the actions an agent is supposed to carry out during a simulation run.

4 Scope

This section describes the scope of the thesis and the approach to answer the research question

4.1 Hypotheses

The importance of mental models and the fact that working in an crisis management team is mainly based on information processing lead to the following question:

> What is the influence of disturbing factors, alternating communication patterns, on the establishment of shared mental models and team performance in crisis management teams?

The question will be answered by finding evidence for the following hypotheses:

Hypothesis 1 *Immediate spreading of information leads to better team performance.*

The author assumes that the sooner information is spread across team members the better, i.e. more accurate their mental model is. Furthermore, the more accurate model leads to better reactions in either the chosen action or requested resources for an action. This leads to better team performance in both effectivity and efficiency.

Hypothesis 2 *Increased impact on team performance when information is missing on strategic level.*

The higher the level (operational versus strategic) on which information is missing, the greater is the impact on team performance. If a strategy is missing or not communicated, team performance will drop. If operational information is missing, team performance will drop due to the fact, that it is difficult to develop a good strategy (if any). Missing operational information leaves two options:

- elected strategy aims at collecting the missing information or
- no strategy at all.

4.2 Exemplary Simulation Run

This section describes what an exemplary simulation run should look like and what kind of results should be achieved. It is split into three parts.

4.2.1 Setup

The setup for a simulation are autonomous agents, each enacting a specific role in the team with defined responsibilities and some sort of knowledge and experience from which the agent draws its conclusion about what to do. The team members are aware of the responsibilities of others and thus know with whom they need to exchange relevant information.

Only one scenario will be played during the simulation. The crisis management teams needs to deal with a crisis situation, gather information about the current state of the situation, exchange these information inside the team and start actions that change the state of the situation, i.e. the world. Such a scenario thus needs to describe several (interconnected) incidents with which the team has to cope and create the incidents according to a script. The happenings will be based on a flooding scenario called *Weißerritzkreis*, a real world example used to train real crisis management teams in Germany.

4.2.2 Simulation Run

The goal of a simulation run is to alter the team performance by using influencing factors. The results can then be compared with an ideally performing team to see the effect of the influencing factors. These factors alter the behaviours as described in 2.4. An ideal team is a team that always shares relevant information amongst the team members, that always checks the effect of the started actions, and that only starts an action with the right amount of supplies at the best possible time.

The *Weißerritz* scenario will be played multiple times. At each simulation run the team members will be equipped with different plugins influencing their communication behaviour and the alternation of team performance will be examined.

Since the start of an action (with the right amount of supplies at the best possible time) is based on information present in the team when the action is started, the effect of the influencing factors can be measured by comparing the information possessed by team members. For different team roles, different levels of detail are necessary. Information can thus not be compared directly.

4.2.3 Desired Results

The basic assumption of this work is that influencing factors have an impact on the communication behaviour of team members, which will then change the flow of information and thus will have an effect on team performance.

Hence, hints to support staffing decisions for crisis management teams are the desired results.

4.3 Comparing Mental Models

In order to analyze and compare team performances in establishing mental models, a method for comparing mental models needs to be defined. Jonker, Van Riemsdijk and Vermeulen (6) suggest to see the mental model as a black box and make use of a set of questions to query the agent's mind. Therefore, questions need to be developed that query the "correct" model of the scenario (the outside world) and query the agent's mental models.

This, along with an analysis of the played actions, should allow an insight into the reasons for the team's performance and thus allows the draw of conclusions.

Team members traverse the check-plan-act circle[4]. The information present during the planning phase is used for the decision making and should thus be queried and dumped for later analysis.

5 Conclusion

Section 1 introduces crisis management teams and the problems that arise when communication is needed to share information to increase team performance. Section 2 discusses the underlying concepts such as mental models, communication languages and agents. The components for an agent implementation are introduced in 3.1. In section 4 the two hypotheses for the thesis are introduced, section 4.2 describes the approach used to find evidence for the hypotheses and a concept to compare mental models is discussed in section 4.3. Based on these results, the author hopes to be able to draw conclusions to give insight in the fragile communication structure of crisis management teams and the impact of communication on the team performance.

The next steps will be the development of a crisis scenario with the complexity needed to show the impact of faulty communication but abstract enough to be handled within a master thesis. Based on the scenario the agents' experiences have to be defined, i.e. what decision are made based on which information during the simulation. This will enable the author to start the simulation. As a last step the evaluation and comparison of mental model needs to be developed.

[4] A mental circle where the situation is assessed (checked), then procedures are planned and finally the actions are carried out (act), then the action's effect is checked and the circle starts again.

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