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Crisis Management Team Simulation

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1 Introduction

Information and knowledge build the basis to make a decision. Gathering information and making use of one's own knowledge to make a decision, is a complex process. But the difficulty grows if the decision needs to be made in a team. For a team to make a decision, the team members need the same basis of information and knowledge. This basis is shared within the team. The problem with knowledge is a) that it resides in a context and b) is not very easy to formulate, so it can be transferred (from one person to another). Therefore knowledge sharing is a nontrivial task. In several scenarios, effective decision making is crucial for the success or the positive outcome of the scenario and often needs to be made in teams, according to the complexity of the situation. Thus an effective team process is necessary to help the team gather information, share knowledge and information to build a common basis of information and knowledge within the team. This basis is called a Shared Mental Model (SMM). Based on the data in this SMM, the team then can make decisions.

Within the course of my master studies, I develop a simulation of german crisis management teams. The goal of the simulation is to research team processes leading to an effective establishment of a Shared Mental Model inside such teams. This work will examine related work that has been done in this and related areas.

2 Related Work

This section discusses related work for this topic. **R-CAST** and **C-RPD** are both projects based on the Recognition Primed Decision Model (RPD) published by [5]. RPD comes from the area of naturalistic decision making and describes decision making as it is done by human beings. **OperA** is a project that tackles the area of Knowledge Management and what an organization can do to improve Knowledge Management.
All three projects address parts that are important for such a crisis management team process. Knowledge management is important for the team, to be aware of possible solutions and alternatives, RPD to finally make a decision.

2.1 R-CAST

The **RPD enhanced Cognitive Agents for Simulating Teamwork** (R-CAST) project is carried out by the Intelligent Agent Labs at Pennstate University under the leadership of John Yen together with Xiaocong Fan and Michael McNeese. Starting with CAST, the approach has

been enhanced by the Recognition Primed Decision model (RPD) which is described in the next section.

2.1.1 RPD Process

RPD has been introduced by Gary Klein and is part of the naturalistic decision making (NDM), describing the decision making process performed by human beings. The RPD process is shown in Figure 1. The main concept of RPD is that a decision is made based on the

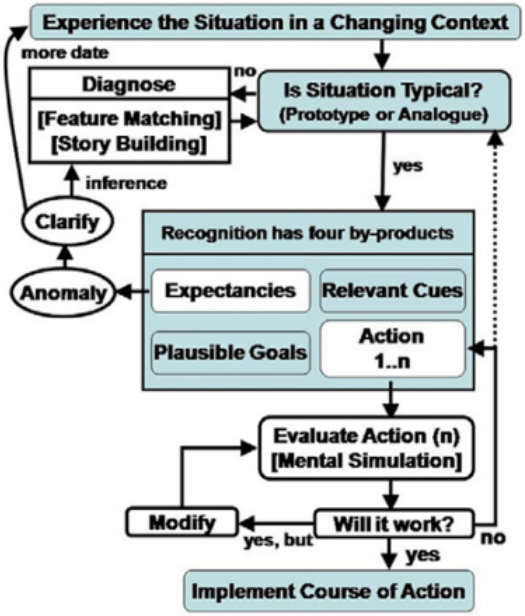

Figure 1: The RPD process defined by [6]

experiences a decision maker (DM) has. The DM retrieves information which he matches with the information about situations he has stored in his experience knowledge base (EKB). If the gathered information match a situation, the DM can exploit the knowledge that is attached to this experience, i.e. he already knows:

- what will happen in the future (expectations)
- relevant cues to look for
- plausible goals and actions he has to carry out to resolve the situation

This allows the DM to quickly make a decision instead of deeply analyzing the retrieved information. After identifying a situation based on his experience the DM does two things:

- he mentally simulates the Course of Actions to see if the solution will work
- he simultaneously checks if all conditions for the situation hold, i.e. if the gathered information still matches the situation or if a reconsideration is necessary.

During the RPD process, three typical situation can be identified:

Situation 1 An experienced Decision Maker (DM) recognizes a quite familiar situation. The cues and Courses of Actions are clear, as well as the expectations. Thus the DM is aware of a solution.

Situation 2 The DM couldn't match the information to a typical situation or he matches it to multiple experiences. Therefore, more information needs to be gathered. If one expectation fails, the chosen situation needs to be reconsidered.

Situation 3 A complex situation that needs to be imagined (i.e. mentally simulated) before it can be executed.

If the expectancies do not hold during the execution of the chosen actions, the DM has to clarify the information. This will either lead to a story telling mode, where the DM will try to build a plausible combination of the information to fit a situation or the DM has to completely reconsider the situation.

Complex situations need a mental simulation before the actions can be executed, i.e the DM mentally checks wether the actions will solve the situation or not. If not, he can modify his actions before carrying them out.

2.1.2 Collaborative RPD

R-CAST extends the RPD model by a collaborative aspect during the process to support decision making in teams. If the decision maker itself does not have any matching experiences, he can ask other agents (i.e. team members) to match the information with their experiences. If the decision maker needs to closer examine a situation and thus lacks for information, he can either start a searchtask to look for information himself or ask other agents to look up information. These agents can then proactively deliver information to the decision maker because they are aware of the situation. Additionally, agents that are asked to seek information for the decision maker are implicitly asked to monitor the expectancies for the situation.

2.1.3 Assets and Drawbacks

[6] identified several drawbacks when comparing R-CAST with RPD:

- The concepts of goals, cues and expectations are not fully specified
- R-CAST does not provide specific activities to carry out actions for cues and goals
- In contrast to the RPD model R-CAST only supports Expectation Monitoring during evaluation and not as a permanent task
- if a strategy is found in the experiences that does not perfectly work out after mental simulation or in real world, the strategy is completely thrown away instead of trying to improve the strategy.

R-Cast does not consider possible different roles of agents in a team, with each role having different capabilities and responsibilities. It also does not make any assumption about how knowledge or information is communicated and if the receiver can understand the information.

2.2 C-RPD

The Computational-Recognition Primed Decision Model (C-RPD) [6] project is carried out by the Department of Computer Sciences at the Amirkbair University of Technology in Tehran, Iran under the lead of Alireza Nowrooz.

The motivation for this project were the shortcomings of existing works, such as R-CAST[2] or fuzzy-RPD. Rescue Agent Simulation, a RoboCup league, served as testbed for C-RPD, for which a model for fire brigades has been implemented and tested.

The aims of this project were a correct and complete implementation of the RPD model using a broad understandable modeling language - UML - leading to an activity diagram in Fig.2 on page 5.

2.3 Proposed Model

C-RPD uses two databases: one for situations and one for solutions, having a one to many relation between those two databases. The model declares several independent components that fulfill certain tasks demanded by RPD consisting of

- Situation recognition component
- Goal tracking component

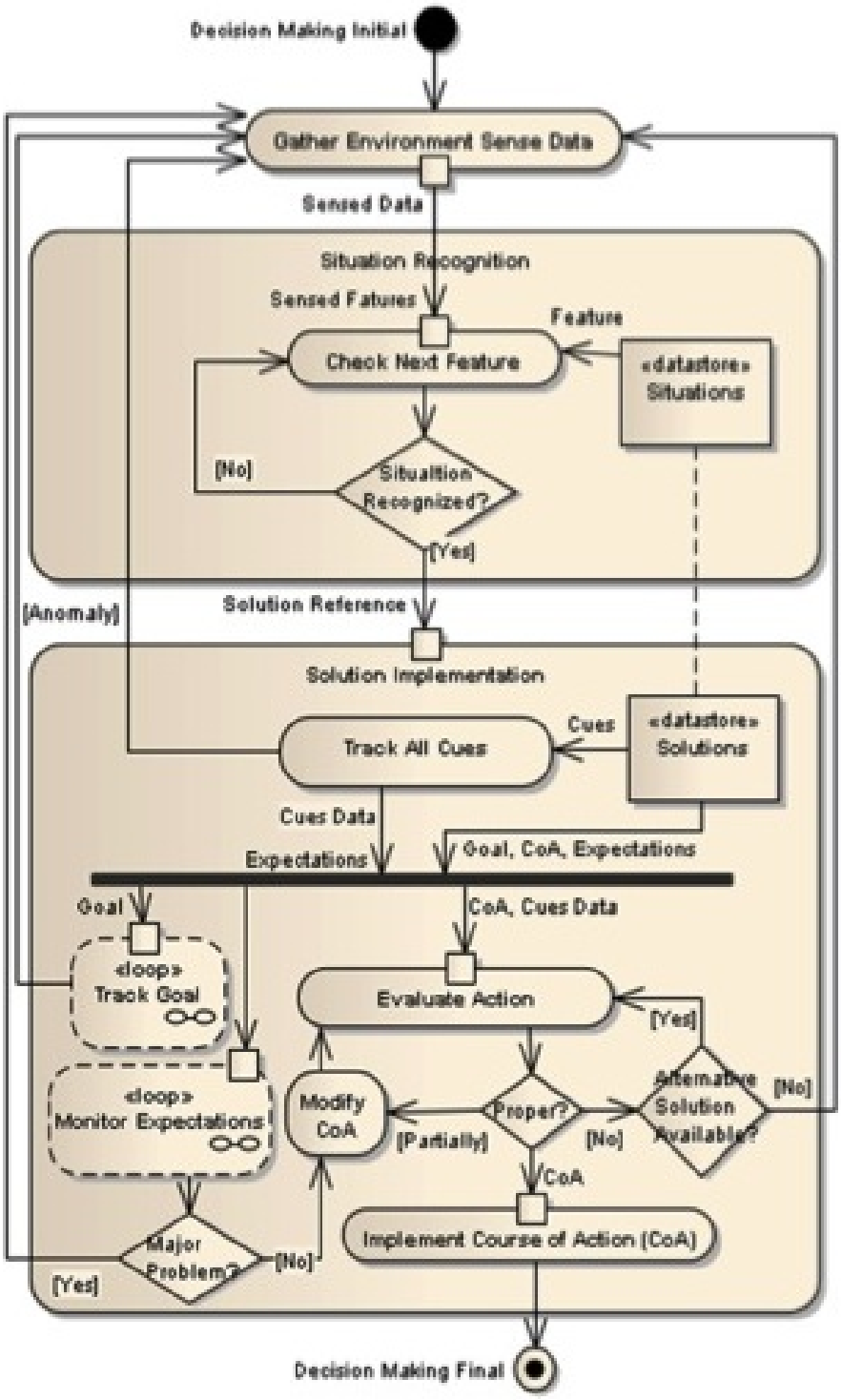

Figure 2: C-RPD activity diagram [6]

- Cue tracking component
- Expectation monitoring component
- Course of action implementing component

which are independent of each other and can work in parallel.

2.3.1 Achievements

The C-RPD project provides an easy understandable UML diagram of the RPD process that can be easily implemented. It eliminates several drawbacks of R-CAST, such as the expectation monitoring. It takes in consideration the hierarchy existing in organizations such as crisis management teams and fire brigades [4] where the top level defines the strategic goals and the lower levels more and more define subgoals and actions that needed to be implemented to reach those strategic goals. This approach is called Mission-Tactic [3].

2.4 OperA

OperA is a model for an open society of organizations and stands for **O**rganizations **per A**gents and is describes in the Ph.D. thesis of Virginia Dignum [1]. It focuses on knowledge management in organizations. An organization is concerned with the management of knowledge flows inside the organization. Thus, knowledge management needs to provide methods and techniques to monitor and guide knowledge management for the organization. From a people perspective knowledge management should provide them with the needed domain knowledge. Following are two of the questions the thesis tries to answer:

- can such a society model support knowledge acquisition and sharing to support knowledge intensive tasks and processes
- how can efficient coordination be achieved without compromising the agent's autonomy

2.4.1 Models in OperA

An OperA model consists of three levels (Fig. 3 on page 7)

Organizational Model An OM describes roles and actions that are intended by the organization. The OM can be split in 4 areas: a social structure, interaction structure, normative behavior and communication structure.

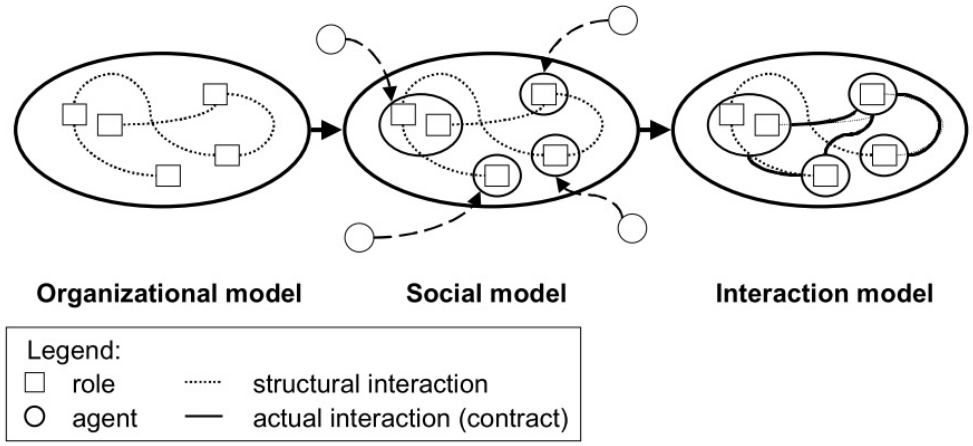

Figure 3: Organizational framework for agent societies [1]

The **communication structure** defines the ontology and language used in the organization. The **normative structure** describes the frame for agent behavior envisioned by the organization. The **social structure** describes the capabilities and relations between roles. The **interaction structure** describes states the agents must achieve.

Social Model The heart of the SM is the agent. In OperA an agent explicitly differs from an role - which is not always clear in literature. A role is an organization description of individuals whereas agents have their own perspective and objectives. An agent has its own goals and thus will choose a role that contributes to his own goals. **Social Contracts** are used to tell an agent what the society expects from him and on the other hand enable the agent to predict the society's behavior. A role enacting agent (REA) can negotiate such a social contract when joying the society.

Interaction Model The IM defines **scenes** that describes the interaction patterns of agents desired by the organization. Like social contracts **Interaction Contracts** are negotiated between agents and used to describe how an interacting scene is to be played.

2.4.2 Assets and Drawbacks

OperA focuses on the description and definition of contracts between agents and does not make any assumptions of the agents joining the society. This allows the separation of research on agent architecture and organizational structures but can then be brought together to see how an agent behaves in different societies or allows monitoring of different agents in one

society. OperA uses LCR (Logic for Contract Representation) which makes it possible to reason about an agent acting according to a contract.

OperA focuses on the formal description of agent interaction in societies. It does not specify concrete actions how knowledge should be shared but does provide a lot of interesting concepts and ideas to consider when developing a model for crisis management teams.

3 Conclusion

The described projects all cover different important aspects of a team process for crisis management teams.

R-CAST enhances the RPD process by a collaborative dimension, a very important aspect for decision making in teams. R-CAST addresses the importance of situation awareness throughout the team members. But unfortunately it has several shortcomings.

C-RPD focusses on a computational approach of RPD and tries to overcome shortcomings of R-CAST. It takes into account the existing hierarchy of such teams and organizations. Together with the hierarchy it allows team members to have different roles, responsibilities and capabilities.

OperA discusses Knowledge Management in organizations. It focusses on the formal aspects of collaboration and communication, e.g. Social Contracts. These can describe what expectations an agent might have about how information and/or knowledge will be delivered and how it will be dealt with. This is also important to model information flows in crisis management teams.

The presented concepts need to be brought together in order to take advantage of them and to cover all aspects of a team process for crisis management. Crisis management teams have a hierarchy in which the chief of staff sets the priorities for certain goals. The other roles in the team have to aim their work and decisions onto achieving these goals. They all have specialized task but very often they have to collaborate to achieve these goals, e.g. the ordered personnel needs to have something to eat, therefore the person responsible for supplies needs to know how much personnel he has to take care of. The hierarchy concept used in C-RPD incorporated in my work.

When two team members interact with each other, they have certain expectations about how the person enacting in a certain role will behave. This is part of the work in OperA. The concept of Social Contracts together with the thoughts on Knowledge Management may add a lot of value to my project.

Basically the RPD process is a good starting point. I will also incorporate the collaborative extension made by R-CAST - the Situation Awareness - into my work. For now I see Situation Awareness as a sort of lower level Shared Mental Model where participants deal more specific information than it will be used in s Shared Mental Model, where team members will argue about the big picture of an incident and will make general strategic decisions.

4 Outlook

Using a multi agent system approach, I will design agents with the following architecture briefly described. The agents will have a belief base, known from the BDI architecture, as the complementary mental model. Information communicated between two agents, with the goal to establish situation awareness, will be incorporated in the agents belief base and tagged on the agents blackboard as information coming from another agent. The shared mental model will consist of a semantic net containing the teams strategic goals plus a data pool - a shared belief base - modeling information that team members gave to the team, e.g. through writing it on a blackboard. The team members will all be able to contribute goals to the shared mental model, but only certain agents enacting in specific roles will have the authority to prioritize the goals and thereby lead the team. The model will currently be based on MASON [1] and use the JENA framework [2] for semantic nets.

[1] http://cs.gmu.edu/~eclab/projects/mason/
[2] http://jena.apache.org/

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