A Critical Thinking Environment for Crisis Response

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ABSTRACT

Building up a proper understanding of a large-scale incident is an important and difficult process. We envision a working environment for decision makers in crisis management situations that allows them to work with information in various ways. That will stimulate them to think critically in processing the information they receive – all in support of rapid sensemaking and decision making. To realize this ambition, we combine various technologies into an integrated support concept called the Critical Thinking Environment (CTE), aimed at tackling critical issues in sensemaking.

Keywords

Decision Making, Decision Support, Critical Thinking, Crisis Response and Management

INTRODUCTION

One of hardest tasks for a decision maker at the beginning of a large-scale incident is building up an understanding of the situation. This requires associating information that arrives over time to obtain explanations for events. In new and ambiguous situations, this is a demanding process because standard pattern-matching and recognition-primed strategies of experts (Klein, 1998) will not work. Decision makers will need to construct a story around existing information and infer the missing information (Pennington & Hastie, 1993). We envision a working environment for decision makers in crisis management situations that allows them to work with information in various ways and that stimulates them to think critically in processing the information they receive – all in support of rapid sensemaking and more informed decision making. To realize this ambition, we propose to combine various support concepts and technologies into an integrated support concept, called the Critical Thinking Environment (CTE). The CTE should provide decision makers with the means and methods to assess available information from various viewpoints, and under various assumptions. The CTE concept uses various technologies from the COMBINED Systems project (Burghardt, 2004) such as the Critical Thinking Tool (Schraagen, Eikelboom, van Dongen & te Brake, 2005; Van Dongen, Schraagen, Eikelboom & te Brake, 2005, the Semantic Network Engine and the Distributed Perception Network (Pavlin, Maris & Nunnink, 2004). The COMBINED Systems project is a Dutch research project that investigates the joint use of various technologies for crisis management, with a specific focus on emergent distributed observation and decision making. The CTE concept presented in this paper has not been fully constructed, although the major building blocks that it consists of have already been developed within the COMBINED Systems project.

THEORETICAL BACKGROUND FOR A CTE

The CTE is a *sensemaking* tool for information workers. Sensemaking is a process that is at the heart of decision making. The term sensemaking refers to a set of cognitive activities that every decision maker engages in, in one form or another, and which help to give meaning to events and improve his understanding of the situation, such as . There have been many models and interpretations of sensemaking (e.g. by Dervin (1983), Weick (1995, 2004), Klein (2004), Russell (1993)), but they all explicate the importance of proper sensemaking in human and organizational behaviour and performance (Weick 2004). For our purposes, we use the notional model of sensemaking of Pirolli and Card (Pirolli, 2004), a model that is grounded in the intelligence analysis domain, but applies to other domains as well.

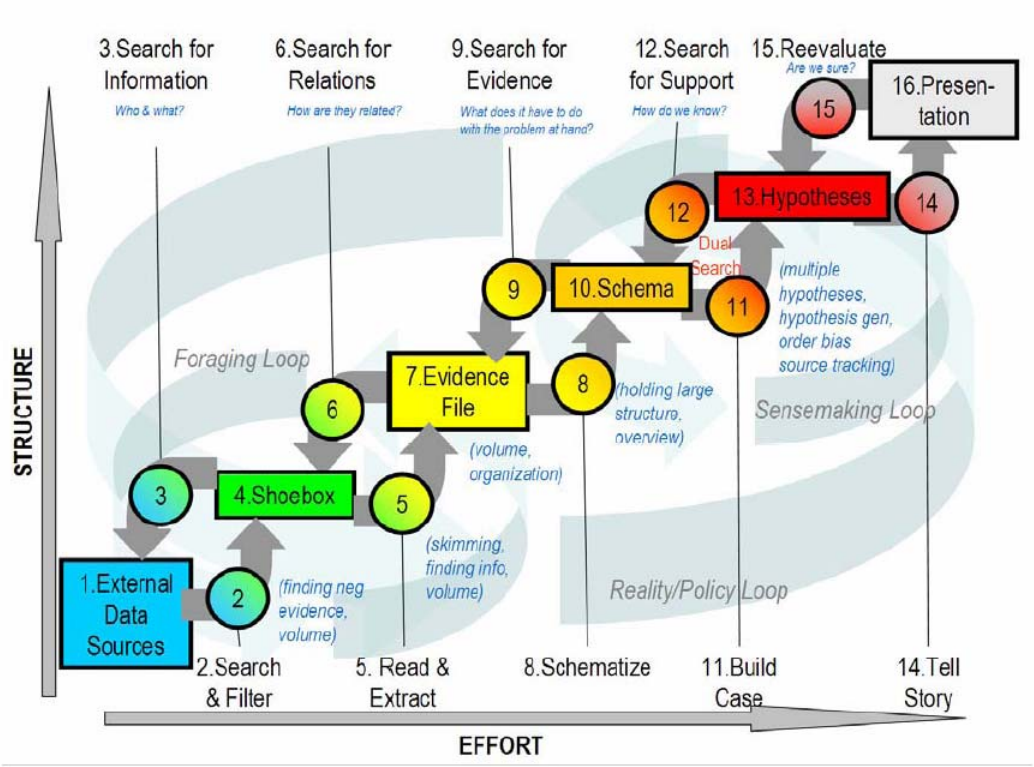

Figure 1. Notional model of sensemaking for intelligence analysis (Pirolli, 2005)

Pirolli and Card assert that sensemaking is a mixture of bottom up and top down processes, see figure 1. At any given point in time, the decision maker should have the opportunity to go back to add more information, or to go forward to work with new hypotheses. Consequently, a support tool for sensemaking should be able to move up and down these loops, and support the decision maker in both directions. Furthermore, Pirolli and Card point out several critical issues for both loops, mainly with respect to data overload and attention management. Even in a small crisis, the amount of information can be huge, and may include anything from messages from field workers to readings from sensors. Pirolli and Card point out that effective foraging for sensemaking depends on:

- Time costs of information operations
- Balance between time spend on scanning, recognizing and selecting information items
- Shifting attention to a new topic
- Costs related to follow up searches

Three of the issues in the list above are related to the issue of 'how much time do I spend on looking for information and how successful will this be'. It is important that a support system, such as the CTE, addresses these issues, so the decision maker acquires essential information as soon as possible and is alerted when new information on a specific matter arrives. In crisis management, acquiring information on a new topic is usually done by attracting an additional expert to the decision making team. Because of time pressure, it is usually quicker to consult a knowledgeable person than to self-acquire that knowledge, but support systems might provide basic facts.

The effectiveness of the sensemaking process itself is influenced by:

- Human working memory capacity limits when processing information on evidence and hypothesis
- Failure to generate alternative hypotheses

- Confirmation bias; people fail to focus on the disconfirming evidence for a hypothesis

The issues mentioned here are recognizable in crisis management as well. Because of his responsibility to control a crisis, a decision maker might be tempted to stick with an initial belief about the nature of the incident, without searching for alternatives or without taking disconfirming evidence in consideration. By supporting the decision maker to overcome these limitations and biases, the CTE will help to improve the quality of the entire sensemaking process. It will stimulate the decision maker to consider more evidence to support his decision and to keep an open mind for alternative explanations and countermeasures.

INTRODUCTION OF THE COMBINED SYSTEMS TOOLS

Even though the sensemaking model of Pirolli stems from the intelligence analysis domain, we believe it is also applicable to crisis management – the same leverage points exist in both domains. By combining three technologies, we can cover most of Pirolli and Card's sensemaking process (Pirolli, 2005), and tackle most of the issues mentioned in their paper. We will introduce the tools shortly before discussing their use in the CTE.

Semantic Network Engine

The COMBINED Project makes use of a semantic network to store and represent knowledge. The semantic network is managed by a Semantic Network Engine (SNE), developed by TNO Defense, Security and Safety. Semantic networks use directed links to represent semantic relationships between information elements, such as the fact that an object is a specific form of another object, or the fact that two pieces of information deal with the same matter. The SNE used in the Combined Systems project has the following characteristics:

- The SNE is a set of systems that manage and unlatch a semantic network to other applications
- The SNE has various services to access and manage the content of the semantic network
- The SNE includes applications to absorb and represent new information in a structured manner.

The advantage of this particular semantic network is that it can handle the many types of information available in a crisis environment, for instance data, speech, photos, sensor data, and film. The SNE allows for ad-hoc gathering of heterogeneous data and provides services to store unstructured data in a meaningful manner. Furthermore, it is an efficient tool for data logging and event reconstruction in crisis management.

Distributed Perception Network

Another contribution from the COMBINED project to the CTE concept is the Distributed Perception Network (DPN) of the University of Amsterdam (Pavlin et al., 2004).
In traditional approaches to situation assessment, sensory data is processed centrally, either by operators in a control room or by central systems. However, central sensor data processing is not trivial in modern systems, because of the large quantities of information from spatially dispersed sources that need to be processed and resulting issues with inadequate communication and processing capabilities, vulnerability to system failures, and so on. Distributed Perception Networks (DPN) are a multi-agent based approach to the fusion of large quantities of heterogeneous and uncertain information that originate from different information sources. Their main features are:

- The DPN allows for an arbitrary distribution of information fusion processes throughout a system of networked devices
- The DPN is able to configure itself into meaningful information filtering structures during operation (runtime),and adapt to changing sources of information
- The DPN can assist with the gathering of relevant information through automated discovery of relevant information sources.

Critical Thinking Tool

The Critical Thinking Tool (CTT), developed by TNO Human Factors, supports decision makers at the tactical and strategic level, for whom sensemaking is an essential condition for their management responsibilities. During situation assessment, decision makers run the risk of experiencing a framing or confirmation bias. A framing bias

indicates a mental state in which people tend to stick with their initial explanation of a situation, even when contradicting information is available. Being in a confirmation bias means that people tend to focus on information that confirms their initial believes, while actively discarding other information.

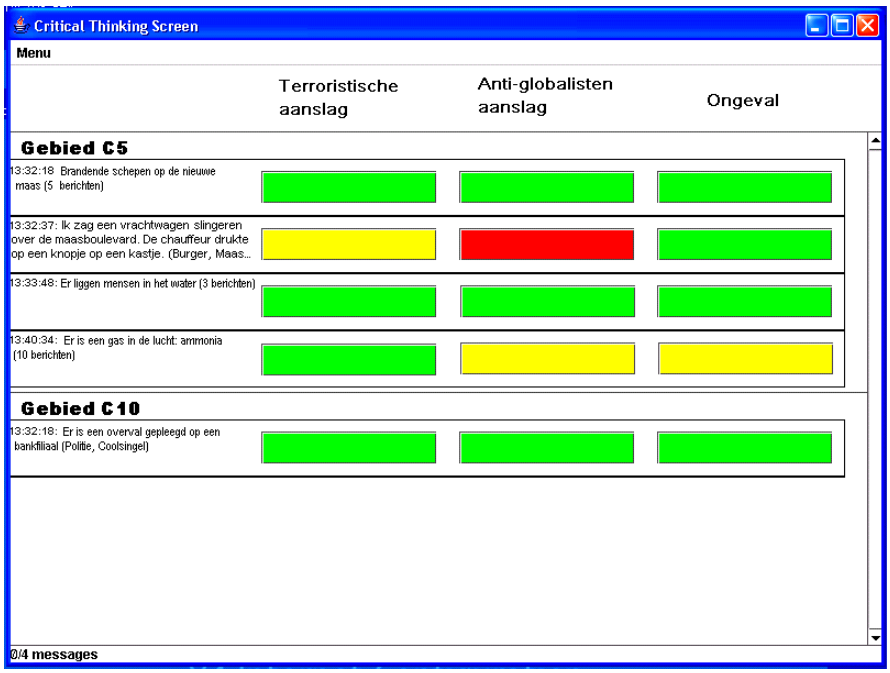

Figure 2. Current interface of the Critical Thinking Tool (in Dutch)

The CTT helps to reduce the problems with these biases by visualizing the relation between the evidence and the hypotheses in the interface (Schraagen et al., 2005; Van Dongen et al., 2005). Figure 2 shows the current interface of the Critical Thinking Tool. For each piece of evidence, the user indicates in how far he believes it provides support for one of the hypotheses. The level of support is presented by colours: 'green' if the evidence strongly supports the hypothesis, 'yellow' if the evidence was moderately supportive, 'red when the evidence is not supportive and unlikely to be observed when that hypothesis is true. An experimental test with 60 students revealed that:

- Use of a Critical Thinking Tool in ambiguous situations leads to a higher number of hypotheses correctly chosen, especially in the condition where people were framed by the order of the incoming information
- Use of the Critical Thinking Tool makes people less susceptible to the confirmation bias. They are less likely to choose irrelevant messages to 'fit' the story
- Use of the Critical Thinking Tool does take more time for assessing the evidence.

USE OF THE COMBINED SYSTEMS TOOLS IN THE CTE CONCEPT

Figure 3 shows a schematic overview of how the three COMBINED SYSTEMS tools work together in the CTE concept. The SNE and DPN gather and process input, and the CTT serves as a smart front-end to the users.

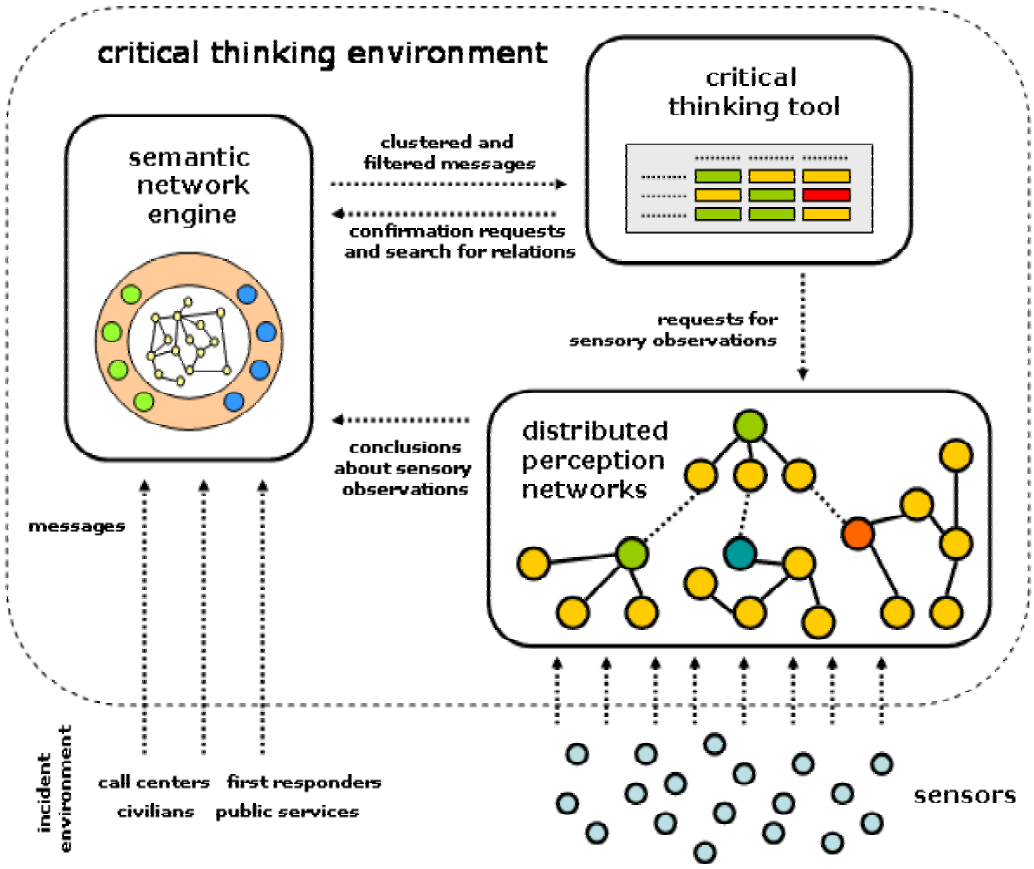

Figure 3. Schematic overview of the COMBINED Systems tools in the Critical Thinking Environment

The three COMBINED Systems tools provide support for almost the entire sensemaking process (figure 1):

- The SNE can support the process in steps 2 and 3 (Search & filter), 6 (Search for relations) and 11 (Build case)
- The DPN can support the process in steps 3 (Search for information) and 5 (Read & extract)
- The CTT can support the process in steps 9 (Search for Evidence), 11 (Build case), 12 (Search for support), 14 (Tell story) and 15 (Re-evaluate)

By combining the tools in this way, we have a firm starting point for tackling most of the leverage points of sensemaking.

Foraging Process

The CTE can reduce costs of information operations because it supports dynamic clustering, filtering and viewing of incoming information. The SNE is specifically useful here because is can be used to discover related concepts via neighbourhoods of nodes, which can be used for clustering of information and reasoning about concepts. The links between the concepts can also help to explain or predict events that have taken place. The DPN is very useful for filtering sensor information, but with small alterations, it can also be used to filter other sorts of information.

The reduction of scanning, assessing and selection of information is achieved by making it possible to show how a specific premise is reached, and providing access to the underlying information. Information can be tagged by the system (SNE and DPN), making it easier for the decision maker to track and investigate interesting information. In

the SNE this can be done by following links to adjacent information nodes, in the DPN by requesting information about neighbour concepts and their values.

The CTE reduces the cost of follow-up searches, because as new questions arise during runtime, the context is already available within the CTE.

Sensemaking Process

The CTE effectively enlarges the span of attention for evidence and hypothesis. By providing a versatile working environment that harmonizes with the human creative process of sensemaking, we mitigate the limitations on span of control that decision makers usually experience. This is achieved by providing different ways to visualize the evidence (data) in the CTT.

The CTE stimulates critical thinking, and the creation of alternative hypotheses, either by hand (the operator is stimulated to look for alternatives by critical thinking) or automatically (the SNE provides alternatives that match the available facts and information). Moreover, the CTE could actively fight confirmation bias by highlighting contradicting information in the context of a certain selected hypothesis. This way the decision maker is stimulated to check whether this information is true, or not, in which case the possibility can grow that a specific hypothesis is true.

OUTLOOK AND CONCLUSION

This paper introduces the Critical Thinking Environment. The CTE is integrated support concept aimed at supporting the decision maker during the entire sensemaking process. By reducing the cost of information foraging and by overcoming the human limitation and biases, the CTE is expected to improve sensemaking performance.

The sensemaking theory of Pirolli and Card (2005) is based on research in the intelligence analysis domain. Although the leverage points are recognized as issues in crisis management as well, it does not mean that the sensemaking process is applicable in there. We need to evaluate if the sensemaking model is applicable to crisis management as well, what the implications for the CTE concept are.

At this moment, we are still working on achieving the full technical integration of the tools. To assess its potential in practice, we plan a study in which we will invite practitioners from crisis management to provide feedback on the use of such as environment during incident scenarios.

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