Safety Science 47 (2009) 1163–1174

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Agent-based analysis and support for incident management ☆

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ARTICLE INFO

Article history:
Received 30 August 2006
Received in revised form 15 January 2009
Accepted 16 January 2009

Keywords:
Error detection
Incident management
Formal analysis
Handling incomplete information
Agent-based support

ABSTRACT

This paper presents an agent-based approach for error detection in incident management organizations. The approach consists of several parts. First, a formal approach for the specification and hierarchical verification of both traces and properties. Incomplete traces are enriched by enrichment rules. Furthermore, a classification mechanism is presented for the different properties in incident management that is based on psychological literature. Classification of errors provides insight in the functioning of the agents involved with respect to their roles. This insight enables the provision of dedicated training sessions and allows software support to give appropriate warning messages during incident management.

1. Introduction

The domain of incident management is characterized by sudden events which demand immediate, effective and efficient response. Due to the nature of incident management, those involved in such processes need to be able to cope with stress situations and high work pressure. In addition to that, cooperation between these people is crucial and is not trivial due to the involvement of multiple organizations with different characteristics (e.g., police, health care, fire department). As a result of these difficulties, often errors occur in an incident management process. If such errors are not handled properly, this may have great impact on the successfulness of incident management.

Research within the domain of computer science and artificial intelligence is being performed to see whether automated systems can improve the current state of affairs in incident management (see e.g., Oomes and Neef, 2005; Storms, 2004). One of the problems is that the information available is incomplete and possibly contradictory and unreliable. As a result, more advanced techniques are needed to enable automated systems to contribute an improvement of the incident management process.

This paper presents an agent-based approach to monitor, analyze and support incident management processes by detecting occurring errors and providing support to avoid such errors or to limit their consequences. The approach is tailored towards the characteristics of incident management. First of all, the approach includes a method which deals with incomplete information. In addition, a diagnostic method based on refinement within the approach can signal whether certain required properties of the incident management organization are not satisfied, and pinpoint the cause within the organization of this dissatisfaction. The approach is based on the organizational paradigm nowadays in use in agent systems (Boissier et al., 2005; Giorgini et al., 2004) which allow the abstraction from individual agents to the level of roles. Such an abstraction is useful as typically specification of the requirements in this domain is done on the level of roles (e.g., the police chief should communicate a strategy for crowd control). In case errors are observed in role behavior, they are classified to have more insight in what kind of errors are often made by a particular agent participating in the organization, in order to propose a tailored training program for this agent. In the future the approach as a whole can be incorporated in cooperating software agents for monitoring and providing feedback in training sessions, and software agents which can even monitor incident management organizations on the fly, giving a signal as soon as errors are detected, and providing support to avoid their occurrence or to limit their consequences.

Section 2 introduces the domain of incident management and, more specifically, the situation in the Netherlands. Moreover, Section 3 presents an overview of the entire approach. Thereafter,

☆ This paper is partly based on Hoogendoorn, M., Jonker, C.M., Treur, J., Verhaegh, M., 2006. Agent-based analysis and support for incident management. In: Klusch, M., Rovatsos, M., Payne, T. (Eds.), Proceedings of the Tenth International Workshop on Cooperative Information Agents (CIA 2006). LNCS 4149, pp. 109–123.

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0925-7535/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ssci.2009.01.002

Section 4 introduces the formal language used to specify traces and behavior. Section 5 presents an approach for handling incomplete information by means of enrichment rules whereas Section 6 presents a simple example of a specification of properties in the form of a hierarchy. Furthermore, Section 7 presents the classification scheme for errors, including specific incident management decision rules. Results of a case study are presented in Section 8 and finally, Section 9 is a discussion.

2. The domain of incident management

In this Section, a brief introduction to the domain of incident management in the Netherlands is given. In the Netherlands four core organizations are present within incident management: (1) the fire department; (2) the police department; (3) health care, and (4) the municipalities involved. The first three parties mentioned each have their own alarm center in which operators are present to handle tasks associated with the specific organization.

A trigger for starting up an incident management organization is typically a call to the national emergency number, which is redirected to the nearest regional alarm center in which all three parties have their own alarm center. The call will be redirected to the most appropriate alarm center of the three parties. In case the operator of that alarm center considers the incident to be severe enough to start up the full incident management organization, he informs the alarm centers of the other organizations as well. Initially, the three alarm centers will send the manpower they think is appropriate for the incident reported. After the manpower has arrived on the scene, each part of the organization in principle acts on its own, each having a different coordinator of actions. In the case of the fire department this is the commander of the first truck to arrive, for health care it is the paramedic of the first ambulance and for the police there is no such coordinator as they have a supporting role. Each of the coordinators is in charge until the dedicated operational leaders of the organization arrive at the scene. The responsibilities of the organizations are briefly described as follows: the fire department takes care of the so called "cause and effect prevention", the health care organization is in charge of providing medical care, and the police takes care of routing of the various vehicles and crowd control. After the initial phase without structural coordination, an organization is formed in order to coordinate all actions of the individual organizations in case this is still necessary. The fire department is usually in charge of the operational side of this organization and the mayor of the municipality is in charge of the policy part. The mayor is responsible for the formation of the disaster staff for coordinating policy decisions, and is therefore informed of the situation. The operational coordination structures are formed after deliberation between the various parties on the scene has resulted in a mutual demand for such a coordination structure. In case it is decided to form the operational and/or disaster staff, the operators of the alarm centers start warning the relevant people.

In case the full coordination structure is in place, the organization resembles the structure shown in Fig. 1. This is a partial picture, as the full picture would be too complex to explain in a brief manner. For more details on the full coordination structure, see Municipality of Amsterdam (2003).

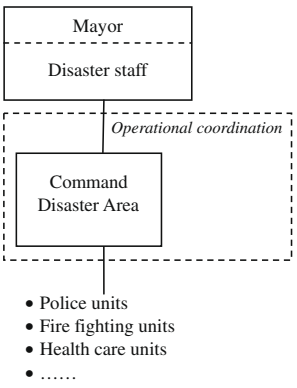

Fig. 1. Full coordination structure for incident management.

3. Approach overview

An overview of the entire approach to support incident management presented in this paper is shown in Fig. 2. As can be seen in the figure, the approach consists of several components (indicated by the boxes).

As a starting point of the approach first of all formal traces are used. Such a formal trace consists of information concerning the current and past state of affairs, including the communications that have occurred, the actions that have been performed, etcetera. In the case of this paper, traces are obtained from disaster reports, which contain precise information on the most important and relevant information of occurrences during major disasters. In order to enable specification of such a trace, including the for incident management essential time parameters, a formal, logical, approach is used throughout this paper. A second starting point in the approach is the specification of properties that should hold within an incident management trace. Identification and validation of these properties is performed using domain experts. Hereby, first properties are identified using documents such as disaster plans, disaster prevention plans, and training documents. To be more precise, the properties are extracted from the process definitions of the incident management processes as written down in these documents. Thereafter, the rules are shown to a domain expert working in the field of incident management in order to validate them. Only one domain expert is used due to the fact that the descriptions in the underlying documents are already the result of consensus among domain experts. The only matter of validation that takes place is the correct interpretation of these descriptions in the documents. The resulting properties can be specified in the same formal language as the formal traces, enabling the automated verification of such properties against these traces. This formal approach is introduced in Section 4. The identification and specification of the properties to be verified is addressed in Section 6.

After having obtained a formal trace and properties to be verified against such a trace, one additional step is identified in the approach before starting the verification process for these properties, namely the enrichment of the trace in case essential information is missing. Typically, traces in incident management lack complete information needed to verify the essential properties against such traces. For example, the internal judgment of the incident management workers is not always directly observable from communication activities. Therefore, a trace enrichment method is introduced that derives such elements from the trace based upon the observed occurrences. This approach is presented in Section 5. Following the enrichment of the trace is the verification of the properties against the trace using a checker tool accompanying the adopted formal language. Once it is observed that certain properties are not satisfied, these properties are classified according to certain human error types (introduced in Section 7). Using this information, the most effective way to intervene within the processes to avoid unwanted chains of events can be used. This is however not specifically addressed in this paper. The whole approach is illustrated using a case study presented in Section 8.