A Trainable Information Distribution System to Support Crisis Management

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ABSTRACT

Crisis response and management involve multiple collaborative actors who execute tasks in a dynamic setting. For the effectiveness of collaboration and crisis fighting it is essential that all actors have access to relevant information necessary for their tasks. Managing the information flow, i.e. presenting the right information to the right person at the right time, is of great importance. However, the complexity of a crisis event makes it very difficult to keep an overview of all ongoing activities and information flow within the entire crisis environment. In this paper we address the problem of selecting and distributing information to users as a function of their characteristics, tasks and the state of their workflows in a collaborative setting. In particular, we propose a trainable system for information distribution that will be able to support the dynamic nature of collaborative processes and provide users with task-relevant information. We expect that this will reduce problems due to information overload and will lead to more effective collaboration between all actors in the crisis management environment.

Keywords

Crisis response and management, trainable information distribution, dynamic workflow model, adaptive user profile.

INTRODUCTION

Crisis response and management situations involve multiple actors from national organisations and local emergency teams that collaborate to carry out certain tasks, as in large-scale emergencies like for instance a plane crash. In these fast-changing environments, information is collected from a variety of sources, including sensors, observers and rescue workers. Managing the information flow and presenting the right information to the right person at the right time, is of great importance. However, in the dynamic setting of a crisis event, it is very difficult to keep an overview of all the ongoing activities and information flow within the entire environment. Different actors have different tasks and roles to fulfil. Actors are not fully aware of what is happening and are not aware of what they might need to know. The complexity of this organisation makes it difficult to determine for which actors newly available information will be relevant.

In the past, situations have occurred where actors did not receive adequate information which hampered the execution of tasks or lead to mistakes and subsequently, more damage (e.g. French Minister of the Interior, Equipment, Transportation and Housing , 1999). A brute force approach would be to distribute all information to all actors. This however would lead to an overload of information, wasting physical resources and valuable time which is needed to get through all of the information. Another approach is to leave the information search to the initiative of the actors which is also problematic because an actor cannot always be aware of what is available. New information is continuously created, therefore a standard query-return model of information retrieval will not suffice: team members cannot continuously query a database for information they need, especially if they do not know that the information exists. On the other hand, systems that filter and distribute information (Belkin & Croft, 1992; Yan & Garcia-Molina, 1999) based on user-supplied (static) profiles or long-standing queries are also inadequate. In a dynamic collaborative environment, team members are constantly completing tasks and beginning new ones, and changing roles. Meanwhile new actors are entering the process as others drop out. To deal with these issues, a system managing the information distribution must be able to adapt information to the actor's task, moreover be able to adapt when actors change roles, take on new tasks, and abandon old tasks.

We propose a trainable system for dynamic information distribution that takes into account the users' tasks and the state of their workflow. Such a system should determine which actor needs to know which information at what time and only

provide the actors with information that is relevant to their task at that moment. The system will provide and actively push important task-relevant information to actors that initially were unaware of this available information or were skipped in the information chain. Because the environment in which the system operates is dynamic, the system will not be able to rely on static user profiles. User input will be necessary to teach the system when certain types of information are relevant for certain tasks and actors. For this purpose, the system will be provided with user feedback on the relevance of the information distributed to the user through a 'training' process. The system will need to be trained off-line (i.e. before it is used in practice) by a few domain experts that can give relevance feedback to the system. This way the system can learn to even better assess the relevance of certain information for the tasks of actors. We expect that using such a trainable system will reduce information overload and provide better information distribution to actors that collaborate in fast-changing dynamic environments and will lead to more effective actor collaboration.

RELATED WORK

Previous research conducted in the area of information management addresses the problems with conventional information filtering methods in situations that are highly 'dynamic' (Atoji et al., 2004; Wolverton, 1999). Especially in fast-changing environments there is no time for the user to change the profile, i.e. change the representation of his/her own information needs, or for the system to learn a new profile from the user's interactions with the system (e.g., pattern learning (Stevens, 1992)). Furthermore, users will not know about the possibility of the (future) existence of certain information, so he or she is unlikely to tailor a profile to detect the relevance of information when it is finally created.
Recently, researchers have proposed an information filtering system specifically designed for emergency management focusing on information overload of control room operators in dynamic emergency situations (Atoji et al., 2004). This system is able to display information according to causal relations found by qualitative simulation and thereby contributing to faster understanding of an emergency situation. The method used in this approach provides a good way to reduce the information load to the operator in emergency management situations, since it presents relevant information with causal relations, leading to a faster understanding of the emergency situation by the operators. In this case, the focus lies on the information flood to a central control room operator instead of the information flow between all collaborative actors in a crisis situation.
Sevay and Tsatsouilis (2002) propose a related system that deals with changing information needs of users in dynamic environments. Their 'Anticipator' system uses agents to maintain a dynamic profile of user's information needs based on changes in the environment. The used method enables an adaptive anticipation to the information needs of the user in a dynamic environment. It does not however anticipate on any future information needs of the users.
Research by Waern (2004) has shown why it is sometimes necessary to partially automate and partially use direct user involvement to profiling. Other work on information distribution systems specifically for crisis management is for instance the Virtual Crisis Management Centre (VCMC) (Otten et al, 2004). This work has focused on the development of a support system to structure communication and information exchange for a special crisis team that is active for environmental disasters. The VCMC allows members to share data in real-time, discuss information and can be used as the common platform for emergency organisations. We believe that our proposed trainable information distribution system can be used as an add-on to such existing information sharing systems.

GOALS AND APPROACH

In dynamic environments such as crisis response and management situations, it is essential to be able to anticipate the information needs users. Building information distribution systems that can adapt to changing information needs and anticipate future information needs would be very useful. To be able to 'push' information, a system would have to know what information will be needed by a given user at a given time, how frequently this information needs to be delivered and how to adapt to the dynamic changes in the environment (and information needs). The approach we take to this issue is to start from existing methods used for recommending (Mooney & Roy, 2000) and workflow modelling (Sierhuis, 2001) and to extend these using the following principles:

- A description of user activities will be used to guide information distribution
- Acquiring and filtering information on the basis of relevance for the user activities
- The use of machine learning methods to automatically construct context-specific task profiles
- The use of Human-Computer Interaction methods to develop an interface for information presentation and system training.

To adaptively acquire, filter and distribute information between actors the system must be aware of the work context of the actors. This work context can be modelled using a role-task framework. In this framework roles of actors are identified and a set of tasks is associated to each role. The dynamically changing environment with interrupts, role change and parallelism makes this a complex issue. The system cannot operate with a fixed model of work processes but must continually revise its model of the current state of the workflow. Acquisition, filtering and distribution of information must be based on this adaptive model. The model consists of at least two components:

- a real world component that adequately describes the relevant roles and tasks in the domain under consideration
- a modelling language/environment that enables the dynamic simulation of the model

For the purpose of our research we believe that a dynamic workflow model of workflow-task contexts can be used to describe tasks and objects used in the tasks. Previous research has shown the feasibility of a dynamic model of workflow, including roles, tasks, and interrupts (Sierhuis, 2001). Another part of our research will focus on designing, developing and testing the system for adaptive workflow modelling and adaptation and user workflow load monitoring. Furthermore we focus on the Human-Computer Interaction aspects in greater detail at the interaction level between the user(s) and such systems.
It is difficult to specify in advance under which conditions new information will be relevant for a specific actor. For structured information this is more likely than for unstructured information (e.g. speech-to-text information) because of the ability of a system to understand the meaning of the message. We will therefore use relevance feedback from users that is generated through review sessions where users train the distribution component to determine relevance.
An additional advantage of our approach is that it can be easily extended from retrieving information from a database to finding relevant information in a more open source environment such as a local network or even the world-wide web. We currently base ourselves on the assumption to build a trainable information distribution system that is trained off-line by a few domain experts before operating in real situations. The proposed interaction model involves training of the system by the actors involved. This can be done through simulation of previous crisis situations or by offering feedback after operation in simulated scenarios. By analysing and giving feedback on the information flow in the simulated environment, the system is able learn which information is relevant for whom at which given moment. Subsequently, when the information distribution system is used in real situations it should deliver only relevant information to the right user at the right time on the basis of what it has learned. User-acceptance of this approach is clearly a risk factor because the training process makes the users responsible for the performance of the distribution component. As part of this study we will therefore apply a user-centred design process and research the human system interaction of the learning module that underlies the training procedure. The study aims to develop a working prototype of an adaptive information distribution system based on partially automated profiling which takes into account affective issues such as trust and perceived risk.

INFORMATION RELEVANCE

Assessing the task-relevance of new information requires some degree of understanding of the meaning of the message. A growing body of research addresses the problem of learning to classify documents and of detecting topics of documents (Sebastiani, 2002). From a collection of documents (or fragments) that are labelled as relevant/irrelevant, a system with machine learning methods can learn to classify new documents accordingly. Methods for topic detection search for words and sentences that are characteristic for a document relative to other documents. In our project we want to extend these methods in such a way that they take predefined descriptions of tasks into account. This means that, in addition to classifying examples of documents for user relevance (Figure 1), a description of the task, workflow information, and activities in the context are available that can be used to learn and determine much faster than using only the classified documents (Figure 2).

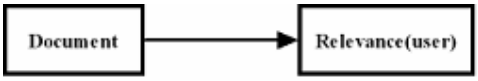

Figure 1. Only topic detection to determine relevance

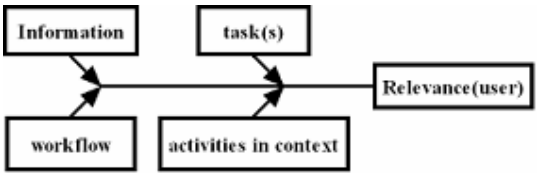

Figure 2. Multiple factors that determine relevance

SYSTEM REQUIREMENTS

The following combination of elements is needed for system development:

- An information system that stores and maintains information about the situation and actors
- A workflow modelling tool that includes descriptions of activities in structured and unstructured form
- A learning system for information filtering that includes the state of the workflow and the relevance assessment
- A load assessment tool (monitoring the information load to the user)
- A dynamic task allocation tool that operates on information from the dynamic workflow model
- An information flow review tool that helps users to review the history of the information flow and to provide relevant feedback.

DISCUSSION

Management of the information flow, i.e. representing the right information to the right person at the right time, in fast-changing environments is of great importance. It is very difficult to keep an overview of all ongoing activities and information within the entire environment. Moreover, distributing all information to all actors is not feasible and leaving information search to the initiative of the actors is also problematic because it requires time and skills. Our trainable information distribution system will provide task-relevant information to all collaborating actors. Furthermore, the technology that we develop is likely to have a wider applicability than only crisis response and management, since it can be molded (trained) for a specific domain. Some domain experts can train it beforehand by giving feedback to the system on simulated information flows from past situations. Our research focuses on a complex problem that deals with selecting and distributing information for collaborating users as a function of their tasks, the state of their workflows and context relevance of information. Several other research projects have proposed approaches to information distribution in dynamic settings. However they did not address the full complexity of information flow in such settings. We believe that our innovative approach will lead to better information management and therefore better effective collaboration between all actors in dynamic environments. Furthermore, the application of our research in crisis management can be seen as an add-on to existing information sharing and distribution systems for crisis management (Otten et al, 2004).

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