Decision Support by Handling Experience Feedback of Crisis Situations

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Abstract: The medical services have a key role when the crisis endangers lives. The surprising events and the time pressure render the decisions more crucial and interventions become more complex. A lot of progress has been made about this issue, such as improving emergency services in hospitals and establishing cell crises, defining general and specific plans of intervention and ministerial circulars awareness to deal with most common threats. But, challenges of optimality, decisions speed, and interventions effectiveness are still present. These problems have, in general, three issues; communication, coordination and loss of information. We present in this paper our results related to the definition of structure and interfaces in order to handle experience of crisis management. The aim is to define a decision making environment based on the emergency experience feedback (Experience representation and use).

1 INTRODUCTION

The decision makers in emergency department team are faced with major crises; they manage big disorganizing and destabilizing situations. In order to preserve human life, they project during the short time of the emergency in the imperative to act quickly. Consequently, the decision is under an enormous stress. It can cause prolonged inhibition or impulsivity slowing the process of reasoning. Other effects are so damaging: the communication and coordination. Therefore, in order to avoid repeated mistakes and acting more appropriately, they need right information at the right moment; these pieces of information are related to the crisis context, experience feedback of previous situations and logistics management. We present in this study our first result aimed at representing emergency management situations based on experience feedback. Several dimensions are considered in this study: organization, communication decision making and problem solving activities.

As we are unable to prevent or anticipate disasters sufficiently, optimal management of such eventual situation is necessary. We have to think first about the means and methods of recognizing situations and provide training for stakeholders to ensure pertinent decisions and effective interventions. Crisis management consists in dealing with the complexity and the interdependency of systems (Birregah and Muller, 2012; Smith and Elliott, 2005; Lagadec, 1993) and especially with the combination of events. Some researchers define approaches and techniques in order to define criteria to help to assess the vulnerability of systems (Whybo, 2010), they define organizations and communications guidelines in order to avoid vulnerability and deal with the crisis with minor consequences.

Our study focuses on crisis management in medical contexts. In fact, medical services have a key role when the crisis endangers lives. The unexpected events and the time pressure render the decisions more crucial (Sommer, 2012) and intervention become more complex. A lot of progress has been made in this issue, such as improving emergency services in hospitals and the establishment of cell crises, definition of general and specific plans of intervention and ministerial circulars awareness to deal with most common threats (Couty, 2004). But, the problems of the optimality of decisions speed and effectiveness of interventions are still present. Those issues have, in general, three axis; communication, coordination and loss of information.

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2 RELATED WORKS

Several theories design decision support in the crisis. The authors propose several psychological aspects of crisis managers and the organizations that are faced with these situations (Turoff et al., 2004). The evaluation of proposals approaches provides rather inconclusive results. Other approaches that attempt to design a perfect system can be found in the works of French and Turoff (French and Turoff, 2007). These works attempt to study decision making process in crisis situation, as well as filling the gaps of the systems supposed manage it. Hale (Hale, 1997) and Carver (Carver and Turoff, 2007) offer a part of their architecture to communication aspect between actors, Caver aim to provide models for a perfect communication between human actors and software as a single team. Finally Kim (Kim et al., 2007) proposed the CIMS system for critical situations. This system is more focused on the problem of communication taking into account a number of small significant problems.

Other systems are focused on representing the operational, organizational and communicational levels (Smith and Elliott, 2005); these solutions are either general approach (Oomes, 2004) or rigorous techniques adapted to specific situations. (Sell and Braun, 2009) the most commonly used techniques and methods are based on modeling workflow (Schoenharl et al., 2006), GIS, multi-agent systems and rule-based systems (Johnson, 2000).

Recently, others intersecting works are introduced. These works propose another point of view using new techniques such as, case-based reasoning (Moehrle, 2012) and knowledge anthologies (Otim, 2006; Chakraborty et al., 2010). The limitation of these proposition is that they are either very small or they define many concepts that are not shared between other crisis situation; therefore they are not adapted to the dynamic aspect of this kind of situation.

3 CRISIS MANAGEMENT

Crisis management is a special type of collaborative approach in which the actors are subject to an uninterrupted stress. It requires succeeding because the consequences are important (human and economic losses). Crisis differs from an emergency situation by its destabilizing effects (Lagadec, 1993) "emergency plus destabilization," an emergency is an event for which intervention procedures are known specialties requirements are clearly identified, and roles and responsibilities are clearly divided.

A variety of approaches has been identified to deal with a crisis and can be classified in three categories (Smith and Elliott, 2005; Lagadec, 1993).

In the first category, we can note the model presented by Ian Mitroff and Pauchan Thierry, it is a model of identification, one of their axes identifies characteristics "internal" or "external" while the other highlight the dimensions "Technical / Economic" or "Human / Social / Organizational." The second category focuses more on a set of points that characterize the crisis as a result of events and behaviours. The eventual effects caused by this situation in terms of pressure on people supposed to manage it, its consequences on the environment and the difficulty of adopting adequate responses to many concerns. The last category includes approaches, called synthetic. It aims to give general definitions for the crisis in terms of threats to the objectives of stakeholders and critical choices facing the surprising events in the crisis situations.

The authors have identified a set of common phases in the management of crisis situations (Johnson, 2000; Lagadec, 1993; Oomes, 2004); to summarize, we can identify three major phases that can occur cyclically:

- Preparation: through the classification of situations, training and exercises, scripting events, identification of critical sites, structuring and computerization of library resources and the definition of roles and tasks for structuring feedback.
- Intervention / handling: The phases from alert to system stabilization. It consists in four basic steps:
- Identification of the situation.
- Logistics and implementation of emergency on site.
- The evacuation, reception and support of victims in institutional care.
- The drafting of the comprehensive review.
- Analysis/ Feedback: learning from real-life situations. This assessment is critical to improve the response strategy. It will therefore help us describe the types of situations more precisely and enrich the feedback structure.

Through these three phases, we found the importance of experience feedback in order to deal with crisis situations. In our work, we use knowledge engineering and management of knowledge to face the problems of the three phases described above.

In dealing with crisis, decision makers attempt to identify or anticipate potential events that can occur,

also the important moment, or incidents, that may trouble in an effort to develop actions and measures intended to avoid other incident to evolve into a current crisis (Smith and Elliott, 2005). These elements are attached to the crisis context that influences the initial followed reasoning and decision making strategies.

Until today, a lot of research work has been done about the influence of context during the reasoning and decision making process. A non-integral perception of the environment may lead to limited inferences. This process is strongly influenced by the information received through sensorial registers, as well as the memory capacity. In consequence, any useful information will interact with inferential processes during (Van der henst, 2002) premises processing. Tulving (1976) (Richard, 1998) was the first to draw attention to this phenomenon; he introduced the concept of specific encoding (the success of recovery depends on the proximity between encoding and recall context). An inefficiency context representation and perception may influence the actor's point of view and build inappropriate decisions.

Moreover, the analogy reasoning is an essential activity in dealing with crisis situation, which leads us to use the techniques defined by the CBR for recognition and representation of situations. The term analogy (Reed, 2011; Richard, 1998) is used in expression "reasoning by analogy" that is a general heuristic for assumptions forging. It refers to the form of reasoning that is involved in a task, used extensively in the psychometric tests. It also means the transfer of meaning from one domain to another. Moreover, it consists in reusing a known situation from other similar situations (Reed, 2011; Richard, 1998). The analogy is a central activity in the human life. We use it every day when faced with unknown situations. It allows dealing with the unknown from what is already known. Pedagogically, it is the most natural and the easiest way of reasoning.

According to Gentner and Toupin (1986), the analogy (Reed, 2011), is based on a general and calculated similarity between a source and a target. There are three kinds of similarities: attribute similarities, similarities between low-order relationships and between high-order relationships. To make the analogy, we need to match our current situation (called base) with another past situation (called target) based on the similarities of high rank. Commonly, in crisis situation the similarity among situations can be estimated using metrics and considering that cases are represented as attribute-value pairs (the number of victims, localization, accident type, homogeneity, etc). The other techniques can be used such as looking in semantic field of some indicators. Thus, we are interested in developing an algorithm that could provide results within a reasonable response time. It must also be suited to this kind of non-formal situations.

Finally, crisis management is a cooperative activity. Therefore, we also study Computer-Supported Cooperative Work to process communication and coordination (Shmidt and Simone, 1996) in such situations.

4 OUR METHOD OF WORK

In an informal field like crisis, case-based analysis (Burke et al., 2000) seems to be the best approach, because the actors express their knowledge through a set of real-life situations. So, we use the techniques of case-based reasoning (CBR) (Kolodner, 1993) and especially the description of situations to define a structure of crisis representation taking into account the context of resolution. Similarly, the type of underlying reasoning in CBR systems can be based on an analogy of situations (Reed, 2011; Aich and Loriette, 2007), very useful in the recognition of crisis situations.

Moreover, in our work, we need to represent a feedback of these situations. This experience is generally owned by the actors of the emergency sector, as well as the documents and reports prepared or produced as a result of such intervention. Knowledge Engineering provides techniques to represent expertise in problem solving (Reed, 2011; Richard, 1998). These techniques allow highlighting key points as objectives or reasons for such actions of the experts. Several techniques of interview issued from knowledge management and engineering are used to communicate with experts in order to understand and represent rules and concepts used in crisis management experiences.

The cooperative aspect must be considered including coordination, communication and cooperative problem solving in order to specify several actors with different objectives who are involved in crisis management (Reed, 2011; Richard, 1998; Shmidt and Simone, 1996). In this project, we studied the dimensions of coordination and communication conducted by a single type of actor: the Emergency Department. Cooperative decision making in a crisis where other types of actors are involved (the prefecture, fire-fighters, police,) is not studied in this work.

To sum up, the different aspects considered in our work are (Sediri et al., 2013):

- Representation of the context of the situation: environmental information and available resources.
- Dynamic representation of the problem-solving considering the evolution of situation.
- Successes and failures pointed on each intervention as well as rules and concepts.
- Identification of the types of situations and criteria for recognition of these situations.
- Representation of the communication between the actors within the spatial dimension (various locations).
- Coordination in actions as well as human and material logistics.

Our results are based on several meetings with actors in the emergency department of the Troyes' hospital; the emergency doctors, assistants and the specialists who have experience in real crisis situation and training exercises. First interviews were general and helped to identify main problems and discover the domain, Next ones aimed at describing a specific situation like road accident, intervention on an infirmary establishment because of a fire alarm and a nuclear accident exercise.

5 ANALYSIS OF CRISIS SITUATIONS

The space (place) is a major dimension of crisis management; the representation of the organization of actors in relation to the space will help, in one hand, to clarify the type of existing communication and vision that each actor has of the situation. In the other hand it makes more clearly the manner in which we make sense of crisis events and issues around problems associated with managing the acute phases of a crisis, as well as dealing with its location, setting, victims destination and its aftermath. Three main places have been identified (Sediri et al., 2012; Matta et al., 2012):

- *The Crisis Cell*: the place of the control and the orchestration of the intervention, its most important roles are managing the material and human resources. The link with outside and the responsible of emergency department (the rear base) is done by the communication center.
- *Crisis Site:* The area affected by the event, it includes actors such as the first medical team and advanced medical and other professionals.
- *Emergencies/hospitals:* These services receive victims and their families and ensure their follow-up. The rear base, depending on the distance of crisis site and or available places and required specialties for each victim, achieves the choice of the orientation of the victims.

Several actors of emergency department are involved in crisis situation: doctors, first aids rescuers, assistants, secretaries etc. According to the work place and situation 's state, each actor is in contact with other professional of the domain such as police, state services, government delegates, etc (Figure 1). So, the communication and organization dimensions have to be considered to represent this type of situations.

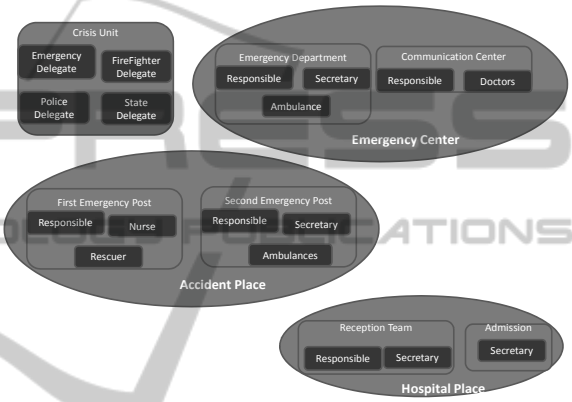

Figure 1: Actors' organization seen from the space dimension.

For better configuration of the actor tasks, the time dimension is very important in crisis management not only in terms of life preserving as a final objective. But it has also a major importance on each episode during the intervention. It must be considered so as to provide (Sediri et al., 2012) to decision makers an empirical and control environment in which they can have an overview of what happens in terms of tasks and actions duration, what must be done or what should be done immediately etc.

Experts identify different types of situations to represent and we work with them for acquiring experience and definition of common structures (Sediri et al., 2012) to represent this experience. They are looking forward to promote the reuse of this experience and acquiring a future one Thus, we propose a structure that include, chronologically, actor tasks and faced problems during an intervention (Figure 2).

The aim of this structure is to represent the different communication links established during the crisis intervention and nature of its exchange. In

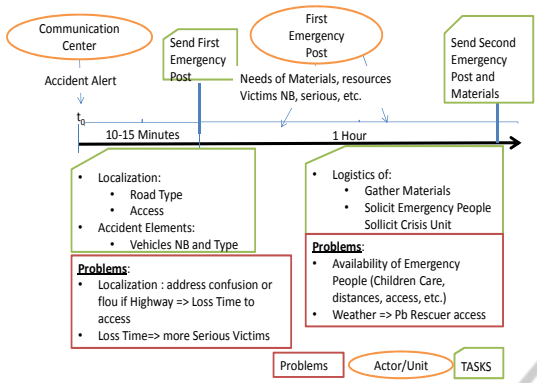

Figure 2: The responsible of emergency department tasks and faced problems on a time line.

addition we represent the experiences; they help representing several tasks and associated problems as well as consequences of the non-respect by the tasks of its attended duration and its recommendations.

6 DECISION SUPPORT SYSTEM

We develop several techniques in order to handle problem solving and experience memorization. We promote the use of experience feedback to support learning and decision-making. As first solutions, we offer to represent the experience feedback using on one hand experience-based and situation representation methods and on the other hand knowledge engineering methods, in order to define the specifications of a system as a decision making support environment. We also aim at studying scenario representation to promote learning from this type of situations.

To guide decision makers in crisis situations we can act at two levels. The first one concerns the perception of the context as an important element in reasoning process (Van der henst, 2002) by providing additional and useful data with less ambiguity about context using the quick and automatic research in GIS system and situation bases. The second one concern guiding the process of decision making (Van der henst, 2002; Reed, 2011; Richard, 1998) as a cognitive process. We aim at guiding the reasoning process during each phase of the crisis using available cases in the situation base.

Information processing in dynamic situations can be distinguished by a number of dimensions from decision making in the normally used static task environments. First, because the environment changes, time is an inherent dimension of the decision making process. Second, strategies can be used that benefit from feedback. Third, time pressure can be defined from the evolving situation itself rather than by some external criterion (Kerstholt, 1994).

Cognitive psychology is assumed to contribute significantly to the improvement of analytical issues and the quality of solutions offered in decision support and problem solving. This could be achieved by methods and tools for firstly making the analysis of decision maker's query; secondly, providing high quality methodologies and systems evaluations. It can thus define gaps to be narrowed. Finally, it provides the knowledge and methods needed to evaluate the proposed solutions.

Mental activities are a part of cognitive activities (Van der henst, 2002; Reed, 2011; Richard, 1998). They are located between sensorial and action programming activities. It helps building an understanding of the situation, developing new knowledge and making decisions. Considering information processing types, we can distinguish three broad categories of mental activities (Reed, 2011): The understanding which consists in constructing a situation interpretation, the reasoning that is looking for links between information collected via inferences using knowledge eventually stored in the memory, then finally all the control mechanisms of mental activity.

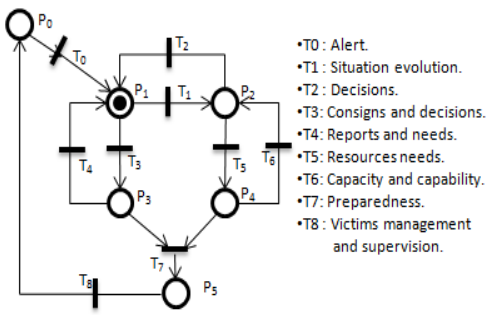

Figure 3: Petri network of crisis management -- P: Actors/unit – T: event/tasks/exchanges (P0: the stable system .-P1: Communication Center. -P2: Emergency department.-P3: Intervention Teams. P4: hospitals. -P5: Victims' evacuation).

For better understanding of the intervention and decision making steps, we may represent emergency department crisis management as a set of couples of states and events figure 3) using a basic Petri network (Aich and Loriette, 2007). Each state of the system match a crisis stage, it is represented by a place of Petri network (figure 4):

- Type: It's a sort of index referencing a complete or episode of a crisis situation. It indicates the main class (category) of current situation. (E.g. road-accident, fire, etc). Providing this index help the system to do research by keyword, it allows recognition and rebuilding of such situation through previous situations and keeping the link with central event of crisis.
- Actor/ role: is the concerned person or unit in each system state (crisis stage).
- Time: is the moment to do an action by the concerned actor according to place's type.
- Data: is the available data for concerned actor in each moment, this information are related to the characteristics of crisis situations, localization, weather and victims.
- Action: is the action to execute considering previous elements.
- Place: is the actor location.

The event (transition) is defined as the result of the action processing. It lends the next state the new information.

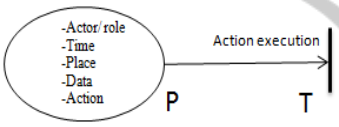

Figure 4: Petri network's State and transition of crisis situation.

The starting point of our proposition is based on the exchanges, the events and the tasks. All these elements are important to determine the following tasks to do or the decisions to make. Their definition on situation structure (figure 1) helped us to identify a set of system states, transitions and conditions between them. Representation of these elements inside the same structure for all actors is difficult. Indeed. A concrete structure is relatively complex considering the time and the space dimensions (Figure 1 and Figure 2), it make its interpretation difficult. While the transcription of a Petri network allowed us to see these elements in the form of a state / transition graph (figure 3) more simply and, especially better defined. Transitions represent the interactions between actors and events that can change the system state and parts. The places (state) represent the major interactions between the system parts.

We use several techniques in order to identify a representation structure of an accident. In fact, works on situations representations give (Schreiber et al., 1994) techniques to represent a situation as states and events. CBR (Kolodner, 1993), (Burke et al., 2000) proposes to define the context as well as the solution of a problem. It also provides processes for case retrieval and adaptation. Otherwise, Knowledge engineering (Matta et al., 2002; Chebel Moreloo, 2008; Cablé et al., 2011) techniques help to extract and formalize expertise as strategies (Dieng, 1998), plans, and concepts.

An efficient decision support environment has to take into consideration the characteristics of crisis situations (Turoff et al., 2004), the status of people supposed using it and, space and time dimensions. To sum up, firstly the provided information has to be precise; the decision maker in crisis situation has no tolerance or time to spend for things unrelated to the management of crisis. Secondly, the context must be understood and the experience reused; learning and understanding what happened before, during, and after the crisis is extremely important for the improvement of the system capacities. Thirdly, everything in a crisis is an exception, thus less generalization is recommended. Finally, the information exchange and its validity in timeliness is required, in fact the crises require for many hundreds of individuals with different roles to be able to exchange information which is critical to those who may risk lives and resources, these information must the most up-to-date and notified by alerts.

The maps of emergency interventions represent an essential tool; they show main information such as the locations, the networks of streams and rivers, and the locations of man-made features such as trails, roads, towns, boundaries, and buildings. They also show what the crisis site is like and distances between useful crisis management stakeholders. All of these are important considerations in emergency planning. It make easier to decide where to go and where to position things. Therefore, our system is fitted with interactive maps allowing actors to zoom to a custom scale for a detailed view of a specific area of interest associated to several information. These information concern essentially localization of risk places, Human / materials resources, emergency, rescuers means and services information. So, we identified a number of risk places and their characteristics in the AUBE's State. Further, used GIS should allow defending more position and information on maps.

The environments integrate multiple data sources (figure 5); the main one is our situation databases which contextualize requested information. It allows the data processing to use efficiently other data sources.

The emergency department database contains

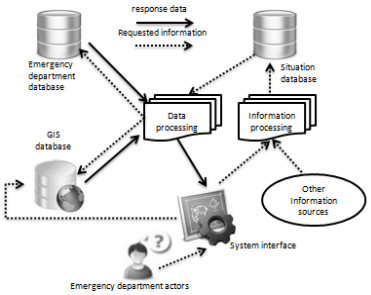

Figure 5: System data and information sources.

information about emergency department (human resources, equipments, procedures, hospitals, etc). The GIS database contains personalized geographical information about risks and vulnerable places and much other personalized information.

7 HUMAN MACHINE INTERFACE

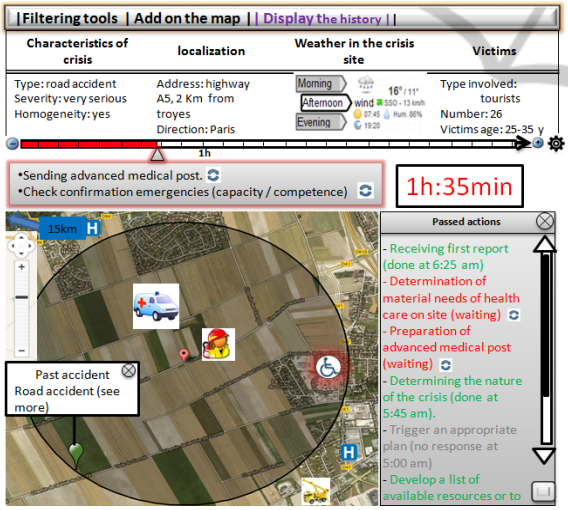

Figure 6: Emergency Responsible Interface Board.

We have proposed a human machine interface that helps to handle the experience of emergency actors (Sediri et al., 2013).

The main part of this interface is the map which is an important tool for emergency department. Several functionalities are offered by our proposition, the top panel "Fig. 6" that help to follow the evolution of the situations, the map and top menu GIS that help to locate accident, around risk sites, rescue materials resources, Hospitals, etc., a street view system that help to show the road configuration, and a communication Interface that help to send and collect information from and to other actors. All these parts are interrelated (figure 5).

8 CONCLUSIONS

We show in this paper, our results on analyzing crisis management. Our approach aims mainly at identifying the experience feedback and representing it (Sediri et al., 2013) the aim of this study is to define a decision making environment for crisis management, related to emergency activity. Future work aim is to provide specification of the interface of the system to promote decision support for each role conceding the objectives of stakeholders in the main project. Finally, we will focus on the definition of experience traceability module for our system. We use several approaches in order to represent this experience:

- We use GIS as base of the machine interface, it's the main part system for emergency department that represent their experience feedback.
- Crisis situations are a collaborative activity, so organization, coordination and communication dimensions have to be described.
- Situations have to be represented in this experience, so the dynamic dimension considering events has to be defined. We use time thread, which is an important aspect in crisis management for this purpose.
- Experience feedback has to be shown, so we use knowledge engineering techniques (interviews based on tasks, concepts and problem solving) in order to represent at each step tasks, related problems, success/fails keys, and related consequences

Our purpose in the future work is to define the model of the knowledge traceability. We aim also with involved ergonomist analyzing the emergency activity in order to define an adapted interface that helps to use the emergency experience.

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