Challenges for Decision Support in Urban Disaster Scenarios

Sergio F. Ochoa
Universidad de Chile, Chile

José A. Pino
Universidad de Chile, Chile

INTRODUCTION

An urgent challenge confronting society today is the vulnerability of urban areas to "eXtreme" Events (XEs) (Mileti, 1999; CWR, 2002; Godschalk, 2003). These hazardous situations include natural disasters such as earthquakes, hurricanes, and floods, as well as accidental and intentional disasters such as fires and terrorist attacks. At the global level, a total of 608 million people were affected by these disasters in 2002, out of which 24,500 died (IFRC, 2003). The economic damages to property and the environment were estimated at $27 billion dollars (IFRC, 2003). From January to October 2005, the number of people killed in disasters globally was estimated at 97,490 and the economical losses were approximately U.S. $159 billion (WHO, 2006). These significant human and economic costs emphasize the urgent need to reduce the vulnerability of urban areas to XEs (Mileti, 1999; CWR, 2002; Godschalk, 2003), improve the impact of relief team actions in these situations (NRC, 1999; NSTC, 2003), and the decision making process (Stewart, 2002; Mendonca, 2007).

When an XE affects an urban area, a variety of personnel and organizations with different expertise participate in the disaster relief process (*fire, police, health services, and government authorities)*. Typically, this process is composed of three phases: (a) the *preparedness* of first response plans for disasters, (b) the *response* process to reduce the impact of XEs, and (c) the *recovery* of the affected areas (Mileti, 1999; NSTC, 2003). Some countries have defined response plans specifying the role of each organization and the way the relief tasks have to be coordinated (FEMA, 1999). Additionally, these plans establish the superior authority in charge of coordinating the inter-organizational efforts.

Nevertheless, it is rare in practice to find a superior authority making macro-decisions and coordinating the inter-organization activities (Scalem, 2004). Typically, each organization has its own hierarchical structure and it establishes members' responsibilities, decision making levels, and protocols to coordinate its activities. The decision making process is local for each organization; thus, the decisions made by one of them can generate problems to other ones. The lack of cooperation and trust among these public and private agencies (Mileti, 1999; NCTA, 2004) and also the lack of coordination and information sharing (NRC, 1999; NCTA, 2004) often jeopardize the effectiveness of the mitigation process (Stewart, 2002).

Although this problem is complex, two important lessons have been learned from recent disasters: (a) the need to improve the collaboration among organizations in order to increase response effectiveness (NRC, 1999; Scalem, 2004) and (b) the use of IT solutions to support the coordination activities and the distributed decision-making processes (NRC, 2002; NSTC, 2003; Scalem, 2004). This article describes the challenges to face when carrying out distributed inter-organizational decision making and the technological requirements to be considered when supporting such process in urban disaster cases. The next section presents the key XE properties and the implications they have on the decision making process. The third section describes the decision making scenario in urban disasters. The fourth section describes the technological requirements for supporting this process. Finally, the fifth section presents the conclusions and further work.

CHARACTERIZING EXTREME EVENTS

Prior research has proposed six properties of extreme events that are important for decision making and decision support. These properties are: *rarity*, *uncertainty*, *high and broad consequences*, *complexity*, *time pressure*, and *multiple decision makers* (Stewart, 2002).

XEs are *rare.* Their low frequency of occurrence restricts the opportunities for preparation and learning from them. This rarity creates the need for diverse thinking, solutions, and skills. Furthermore, this rarity makes these events difficult of understand, model, and predict.

XEs are also *uncertain* because both its occurrence is unpredictable and its evolution is highly dynamic. The challenges to face and consequences of an XE are the joint product of an event, the affected community, and the organizations involved in preparation and response. Every disaster is different; therefore, disasters present varying challenges to decision making, for example, time availability and geographic scale.

When XEs affect urban areas they usually have *high and broad consequences*, leading to the need to manage interdependencies among a wide range of physical and social systems (Godschalk, 2003). The risks and the disaster evolution should be evaluated quickly and accurately. Thus, the decisions can be effective and on-time. Provided these processes involve several people and organizations, it may be appropriate to use tools to support interaction among these people and organizations.

Event *complexity* arises in part due to the severe consequences of XEs (CWR, 2002). It may also arise as a result of interdependencies among urban infrastructure systems (Godschalk, 2003). The complexity of the events requires the participation of experts in several areas (e.g., civil engineers, transportation/electrical engineers, and chemical experts) to support decision making.

Time pressure forces a convergence of planning and execution, so that opportunities for analysis are few (Stewart, 2002). It is therefore vital that accurate and timely information be gathered and delivered among the organizations participating in the disaster relief effort. Information supporting forecasting event impact and propagation is needed. This time pressure also creates a need for convergent thinking in order to generate a solution in a timely fashion.

Finally, we have to consider that *multiple decision makers* will be involved given the complexity and diversity of organizations participating in the relief activities. They may compete or negotiate while responding to the event. It may therefore be advisable to consider how decision support systems can support the management of shared resources and help people to converge soon to joint decisions.

All these XE properties add requirements and challenges to the decision making process. Communication, coordination, and information delivery become critical issues to make effective and on-time decisions in such scenario.

BACKGROUND

Typically, as soon as first responders are notified about the occurrence of an XE, they can start the response endeavor. The delay in the detection and notification of the XE, and the delay in starting the response process affect the consequences of the XE. For example, the physical infrastructure and lifelines systems that are affected by a fire could depend on the time spent by firefighters to detect the XE and initiate response actions. The number of survivors definitively depends on the elapsed time from the XE occurrence (Tadokoro, 2002). Therefore, the earlier the first response is, the higher is the probability to reduce the negative consequences of an XE. Early detection and fast alarm propagation play key roles as triggers for resistant activities and the decision making process. The inability to access information and the lack of standardization, coordination, and communication are all obstacles that need to be overcome in a disaster scenario in order to implement integral decision making accomplishment, and therefore effective relief actions (NRC, 1999).

Once the response process is triggered, the first actions are started by first responders, who are typically firefighters, police officers, and medical personnel. They make local decisions based on improvisations (Mendonca, 2007). While additional response groups are included to the relief endeavor, the most urgent need is having an ad-hoc inter-organizational structure able to establish responsibilities and decision making levels. Although proposals for this structure could be stated in some response plan, in practice it is the result of a self-organizing negotiation and even discussion process.

Typically, a critical response process should be carried out in this situation. This process involves multiple organizations and must be executed within the first 12 hours after the event occurrence. The time pressure also creates a need for convergent thinking in order to generate coordinated mitigation actions in a timely