Chapter 14
Integrating Scenario-Based Reasoning into a Multi-Criteria Decision Support System for Emergency Management

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ABSTRACT

Multi-criteria decision analysis (MCDA) is a technique for decision making among multiple alternatives for action providing transparent and coherent decision support for complex situations with conflicting objectives. Managing longer term decisions for environmental incidents is an application domain in which MCDA has proved useful. Yet a difficulty in applying MCDA is when uncertainties abound. Contrarily, scenario-based reasoning is a method allowing for the assessment of multiple possible future developments of the situation. In this way, the use of scenarios is a transparent and easily understandable way to integrate uncertainties into the reasoning process. We propose a mechanism to integrate scenarios. Our theoretical framework can be operationalised by decision support systems relying on both automated systems and human experts. These facilitate the assessment of consequences within a scenario, and may propose new scenarios. We illustrate this mechanism taking the decision making in emergency management after a train crash with potential release of chlorine as an example.

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INTRODUCTION AND BACKGROUND

While natural hazards like floods or earthquakes have disrupted society since ancient times, nowadays both, natural as well as man-made emergencies threaten society, economy and environment with devastating consequences. The spread of high-risk technologies (e.g., nuclear power plants, chemical refineries) exacerbates the situation (Perrow, 1984).

Decision making situations in emergency management are usually characterised by multiple objectives, participation of multiple actors with conflicting interests, competences and knowledge, and uncertain or lacking information (see e.g. French & Geldermann, 2005). As time plays often a critical role, the need for timely, coherent and effective decision support arises. Furthermore, emergency response is usually a collaborative effort of many actors. That is why the need for acceptance on all levels of hierarchy which play a role in the implementation of counter- or remediation measures – directly or indirectly – arises. This need encompasses for example the population affected who has to comply and respond to the measures as well as the heads of all emergency management agencies involved.

Furthermore, the experts, stakeholders and decision makers who have to find a consensus before implementing a decision are often geographically dispersed. In these cases, it can be necessary to use an ICT system – as bringing all actors involved together face to face would require a substantial amount of time and resources.

In situations with multiple objectives, multicriteria decision analysis (MCDA) is often chosen as basis for decision support systems (see French, 1996), for its coherent support in complex situations. MCDA’s popularity is mainly due to the intuitive and transparent evaluation of ‘alternatives for action’ (termed ‘alternatives’ in this chapter) it offers.

Additionally, MCDA facilitates the communication of the results to stakeholders and other emergency management authorities. First, experts and decision makers may want to explain the justification of their decision to the public and thus to promote acceptance and trust. Secondly, stakeholders are more and more actively involved in the emergency management. With the rise of the new communication technologies like mobile phones and the internet, the public has not only to comply with the decisions made, but it is as well a source of information (Shim et. al., 2002). Therefore communication with the public becomes more and more important in emergency management.

Despite all the advantages described, the applicability of MCDA in emergency management is limited. Most importantly the use of MCDA can become cumbersome when uncertainties prevail. But uncertainties due to a lack of information, time pressure prohibiting the collection of further information and high uncertainty characterize most emergency management situations (Barker & Haimes, 2009; Bertsch, 2008; Cooke & Goossens, 2004). To facilitate reasoning under severe uncertainty, we integrate scenarios – possible, coherent and internally fully consistent descriptions of the situation and its future development – into the decision making framework.

This chapter starts with a presentation of deterministic state-of-the-art MCDA systems. Then, MCDA techniques for reasoning under uncertainty are discussed and their major drawbacks are described (e.g., the fact that they do not allow for handling situations which can develop in fundamentally different ways). To cope with highly varying situations, scenarios can be used (see e.g. Durbach & Stewart, 2003). Therefore, the next section of this chapter deals with scenario-based reasoning (SBR) approaches.

As MCDA is deficient in case of fundamentally changing situations and SBR does not evaluate alternatives, we then propose integrating scenarios into MCDA. A scenario selection technique based on the evaluation is developed in the next section. Then, the possibilities to analyse alternatives under...
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