Tackling a DISASTER using semantic technologies

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Abstract. In the event of a disaster, coordination of emergency responders is challenging due to the diversity of support systems in use. Work is now being done to tackle the problem leveraging semantic technologies. The chosen approach focuses on the interoperability between Emergency Management Systems (EMSs) via data mediation and a reference ontology. This paper introduces the DISASTER FP7 project and outlines its main activities planned for the upcoming years.

Keywords: emergency management systems, ontology, data mediation, ontology modularization, data sharing

1 Introduction

Near 100,000 people died in Europe in the first decade of this century due to natural and industrial disasters [6]. Transport accidents and terrorism also add casualities to this figure. Moreover, material losses ascend to 150 billion Euro from natural disasters alone in the same decade. Disasters such as L'Aquila, Eyjafjallajökull, Prestige and Chernobyl will remain carved in the collective European consciousness.

In the current era, developed countries have a number of bodies that respond to emergencies in order to minimize casualities and economic loss. First responders include fire brigades, police, hospitals and military forces. An effective response depends on their ability to quickly take decisions based on accurate and reliable data. Emergency Management Systems (EMS) are information tools supporting resolutive actions against the clock.

Nowadays Europe showcases a well-spread heterogeneity of EMSs depending on the stakeholder "color" (emergency jargon to identify first responders) and the administrative division (city, region, etc.) where they operate. Political boundaries and compartimentation of functional competences are a hindrance

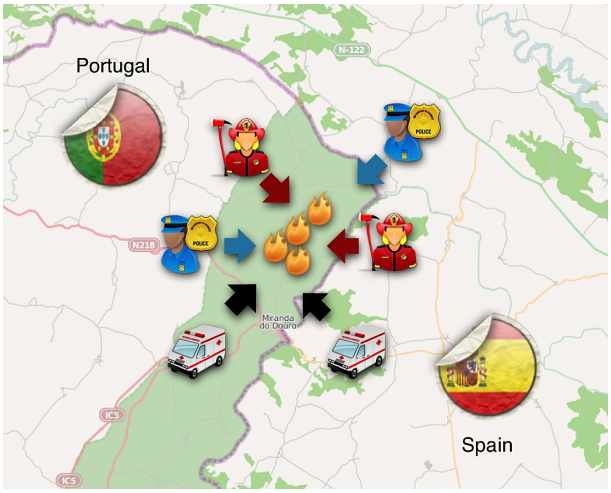

Fig. 1. First responders of different "colors" react to a forest fire on the border between two European countries.

for fluid communication and information exchange between EMSs. This fragmentation has evolved with time for cultural and historic reasons, and it is an unavoidable part of the European reality. The complexity of some emergency situations requires the participation of a variety of first responders who depend crucially on their ability to effectively exchange data (Figure 1).

2 Requirements for effective operational data exchange

At the event of a disaster many entities are involved. Some may be affected by the disaster, others may need to take contigence actions, while others may be accidental watchers of the incident. Thus, each entity can provide a partial version of the total picture. The objective is to make the most complete picture available to decision makers by putting together the partial pictures coming from the different parts involved. Due to the decentralization of the information scenario a number of conditions must be fulfilled:

- It must be possible to gather and to manage heterogeneous information from many available sources. This information includes an appropriate description of the disaster event in terms of both quality and quantity. In addition, the description of the scenario must be enriched with contextual and environmental data, e.g., infrastructures, populated areas, weather forecast... This harvest process often faces challenges due to the incompleteness and incorrectness of the data.
- The description of the scenario must be shared and agreed by the stakeholders in real time. A common picture facilitates team coordination and

synchronization of response operations, for instance, to know in real time which areas have been already evacuated.
- Information overload must be prevented. Decisions are difficult to make when dealing with an overwhelming volume of heterogeneous data. Filtering information in terms of relevance is crucial. Moreover, the concept of relevance is subjective: each actor is interested in a different subset of the information.
- Information pieces must be referenced with respect to both geographical and temporal coordinates. To gain an insight of the situation, it helps to have map interfaces and events displayed in sequence.
- Message oriented communications among different responders must be effective regardless of cultural and technical differences. Due to the diversity at each end of the channel, many problems arise including divergences of communication protocols, data formats or information models. In addition to the core message, the sender may decide to include additional information that enriches the message and increases its usefulness to the receiver.
- When integrating information from various sources and communication breakdown occurs, previously exchanged information might still be valuable. Not all data has the same expiration date: topographic information will still be valid, whereas current positioning of units deployed is dynamic and potentially untrustable afterwards.

The aforementioned conditions match some of the research topics tackled by the Semantic Web, e.g., information quality, data and model sharing, or data enrichment. These matchings suggest that a potential solution to the EMS interoperability problem may reuse the findings from the Semantic Web community. Moreover, the work on Semantic Web has demonstrated the value of adopting open standards to reuse vocabularies and exchange data between decoupled systems in the absence of a central authority.

3 A novel approach to disasters

DISASTER (Data Interoperability Solutions at STakeholders Emergencies Reaction) is a collaborative European project including software vendors, research organizations and specialists in emergency response. The goal of DISASTER is to ease communication among existing EMSs considering the requirements aforementioned.

DISASTER project respects EMSs diversity in Europe. No "one size fits all" central EMS or unique exchange language is proposed. Instead, DISASTER relies on a shared reference ontology as well as on mediation techniques. As depicted on Figure 2, semantic technologies will make possible for any EMS to exchange information and to query external sources including Geographical Information Systems and the Linked Open Data cloud, and of course, other EMSs.

When it comes to mutual understanding, the first step is to agree on shared baseline knowledge. Under our approach, this knowledge is modelled with ontologies. Ontologies have been proved to solve common understanding problems [2].

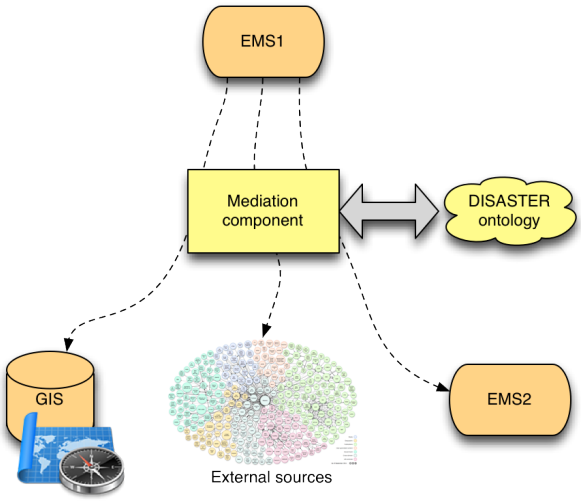

Fig. 2. DISASTER proposes data mediation based on a reference ontology to enable data exchange between existing EMSs and other systems.

Moreover, the use of ontologies to specify knowledge in the domain of emergencies have already been discussed in a number of studies [1, 3]. Despite this body of previous work, in 2011 the European Commission identified the need to develop an ontology shared by all stakeholders (FP7 research topic SEC-2011.5.3-2).

4 Prospective work

DISASTER has commenced in February 2012 and will run until 2015. The project has started by gathering requirements about different aspects: from first responders operative requirements to linguistic and cultural requirements.

DISASTER proposes data mediation to tackle communication problems among EMSs. Efforts are planned to bring to practice the theoretical results of the research community on data mediation. Actual interoperability among EMSs poses a number of challenges regarding several dimensions of the problem: communication protocols, data models and data formats. A workable solution typically involves all these aspects.

The main result of the project will be the DISASTER ontology. The creation of this ontology will follow a modular approach: the core module will be based on upper level ontologies such as DOLCE [4] or SUMO [5]. This core will be complemented with transversal modules giving support for representation of temporal and spatial descriptions. These vertical modules are vital to express contextual information, and offer a chance to plug-in existing domain ontologies and taxonomies. Finally, vertical modules will extend the base functionality to different domains at the levels of both disaster description and stakeholder

resources. Although a modular design brings a number of difficulties at design time, this methodology allows further extension to fit specific scenarios in the future. It is expected that at the end of the DISASTER project, a stable version of the ontology (as universal as possible) will be produced, leaving it feasible to store a local copy for each emergency system. By means of this ontology, mediation can take place in order to consume external data before any connection breakdown and under offline circumstances.

The ontology will serve to combine heterogeneous information coming from diverse sources. The project will study how to coherently assemble an agreed disaster scenario description. Moreover, map-based visualization paradigms will be explored to merge context information with operational data and user-oriented mechanisms will be defined to filter relevant subsets of information. Devices supporting on site operations should be taken into account. Responders are often equipped with mobile devices providing access to the information. However, connectivity issues must be addressed as connection cannot be ensured.

Finally, in order to ensure the DISASTER solution is grounded on reality, validation will be carried out. At this early stage of the project the details of the final project scenario are still a draft. However, one of the possibilities involves a (simulated) disaster at a large international European airport with a transnational component featuring stakeholders of different kinds and nationalities.

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