TITLE

Title: Semantic Reasoning for Intelligent Emergency Response Applications

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SIGNIFICANCE AND RELEVANCE OF TOPIC

Track: Intelligent Systems

The paper presents the practical design of an Emergency Response ontology which supports the development of intelligent emergency response applications. This formal emergency response definition enables to interpret the meaning and adequately filter the relevant information out of the huge amount of heterogeneous data provided about an emergency situation. The ontology is divided into several application-independent ontologies which are extended by emergency response specific ontologies.

ABSTRACT

Emergency responders, such as fire fighters, regularly face large amounts of data generated by a diverse set of sensors and devices. These need to be processed in a timely manner in order to form astute decisions during a disaster. An emerging trend (Strang and Linnho-Popien, 2004) in such settings is the development of context-aware decision support systems able to provide an accurate and concise view of the situation at hand. Relevant information, captured from various devices and sensors, should be pushed pro-actively and presented in a user-specific and context-aware way (Tsiporkova, Tourwé, González-Deleito and Hristoskova, 2012) supporting the situational awareness of the actors involved.

Current emergency response research focuses on crisis simulation environments (http://indigo.diginext.fr/) and decision support systems (Coates, Hawe, Wilson and Crouch, 2011; Lijnse, Jansen and Plasmeijer, 2012). However these emergency management systems are built on top of crisis databases which provide limited information processing and reasoning. In our approach, semantic technologies are adopted, enabling the formal definition of the domain concepts and their properties in an emergency response ontology. This supports intelligent reasoning on the available data inferring valuable insights on the current context.

The reasoning framework proposed in this poster seamlessly integrates this domain-specific semantic model into a decision support system for emergency response by the fire department in the context of the ASTUTE project (www.astute-project.eu). The novelty of the described approach is twofold. First, the overall architecture consists of the seamless combination of a semantic reasoner and an event-based system. Incoming real-time data from devices and sensor measurements during an emergency is updated into a semantic domain model. The reasoner automatically derives new knowledge from a formal definition of an emergency response model. Based on the inferred context the event-based system triggers events and alarms forwarded to the right units. Second, the developed semantic model is defined by means of several generic, High-Level, ontologies which can be used to describe concepts used within various context-aware application domains and Low-Level ontologies which extend them with emergency response specific features.

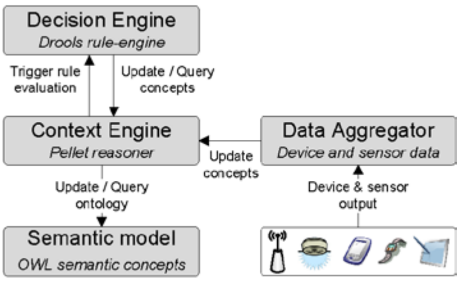

Figure 1: Reasoning framework layers: illustration of the importance of the semantic model within the application.

Figure 1 presents an overview of ASTUTE reasoning framework architectural layers. The *Semantic model* contains the Emergency Response Ontology. The main purpose of the *Context Engine* is semantic reasoning on the domain model by using Pellet (http://clarkparsia.com/pellet/). Pellet infers new data, which generates knowledge flow into the system. The *Context Engine* also encapsulates the translation of semantic concepts into Java Beans. These objects are queried by the *Decision Engine* which utilizes the event-based Drools Rule Engine (http://www.jboss.org/drools/). This translation enables the transparent use of an actual semantic model by Drools resulting in triggering rules on the created objects in a timely manner. The *Decision Engine* captures application knowledge in the form of rules in order to determine which information needs to be sent to whom at what moment. It relies on the *Context Engine* for delivering the interpreted raw context data. Finally, the *Data Aggregator* is responsible for capturing data from devices and sensors and formatting it as defined by the *Semantic model* using the encapsulated concepts from the *Context Engine*.

The Emergency Response Ontology was developed by ontology engineers in close collaboration with project stakeholders such as industry professionals who have a long track record of developing ICT solutions for emergency management. This close collaboration ensures that the information in the ontology accurately and completely reflects the daily work practices of the domain experts. Within ASTUTE 8 *High-Level* ontologies and 6 *Low-Level* ontologies were developed. How these ontologies are related to each other and which existing ontologies they are based on or import is visualized in Figure 2.

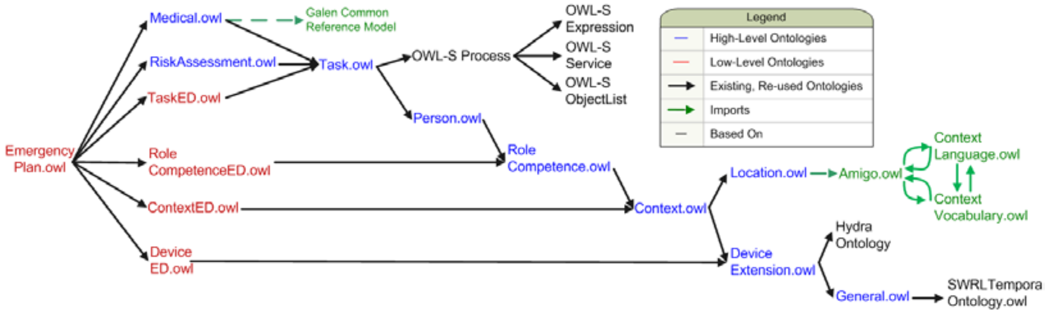

Figure 2: Import schema of the Emergency response Ontology.

The *General High-Level Ontology* describes classes, relations and axioms that are generic across all knowledge domains. The *Device Extension High-Level Ontology* describes concepts and properties related to devices. For the actual definition of devices, the Hydra ontology (www.hydramiddleware.eu/) was imported. The *Location High-Level Ontology* provides a formal description of locations including type of buildings, rooms, floors, etc. It is based on the Amigo (Valle, Ramparany and Vercouter, 2005) ontology. The *Context High-Level Ontology* defines additional context information not captured by the previously described ontologies, e.g. physical assets such as vehicles and equipment. The *Person High-Level Ontology* defines the profile information of people. The *Role & Competence High-Level Ontology* defines the roles and competences of people in order to determine which tasks they are able to. The *Task High-Level Ontology* models the process workflows executed during an emergency situation. It extends OWL-S (http://www.w3.org/Submission/OWL-S/), which is an ontology for describing Semantic Web Services and allows describing how processes can be mapped based on their inputs and outputs, which conditions need to be fulfilled to execute the process and which effects the execution has on the environment and the context. The *Medical High-Level Ontology* models the medical knowledge, which is relevant for the emergency response domain and is based on the Galen Common Reference Model (http://www.opengalen.org/index.html). The *Device, Context, Role & Competence and Task Emergency Demonstrator Low-Level Ontologies* extend the respective High-Level ontologies with concepts, axioms and relations specific for the emergency response domain. The *Risk Assessment Low-Level Ontology* models the various risks which are associated with particular locations or physical assets. Finally, the *Emergency Plan Low-Level Ontology* combines the concepts from all the ontologies to define the specific emergency incident and corresponding scenario. In this ontology, depending on the specific scenario, the required team having specific roles and competences is assigned.

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