Using Semantic Web Technologies to Support Enhanced Situation Awareness

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Abstract

The AKTiveSA project is using Semantic Web technologies to support information fusion and enhanced situation awareness in a simulated humanitarian relief scenario. We have developed an application that shows how situation awareness can be supported during humanitarian relief situations; often occurring alongside military conflict. Semantic Web technologies provide new opportunities for harvesting information from numerous, disparate and often heterogeneous information sources and can be used to better support complex knowledge fusion.

1 Introduction

Humanitarian relief is an increasingly pressing topic - there is the need for more advanced knowledge resources, so that resource spread, meteorological information and a whole plethora of information can be considered in order to provide the most effective relief [Choudhury, 2005]. Most notably, the temporal development of events is becoming critical to the success of modern operations. The term that is central to the majority of recent discussions is 'situation awareness'; this was well defined by Endsley [1988]:

> "… the perception of elements in the environment with a volume of space and time, the comprehension of their meaning and the projection of their status in the near future."

These days, the problem lies in filtering and aggregating these vast resources in order to find the most relevant and pertinent information. In this project we aim to show how the Semantic Web initiative[1], and its developing technologies, can address the problem of information overload, by providing a more expressive context-orientated medium for information filtering and triage. Central to our argument is that semantic technologies are invaluable to the knowledge-based fusion of physically disparate and semantically heterogeneous information.

2 System Functionality

The prototype software, shown in Figure 1, has six functions that are built upon semantic technologies. Greater detail about the system can be found in [Smart et al, 2005] and is presented briefly in Sections 3, 4 and 5.

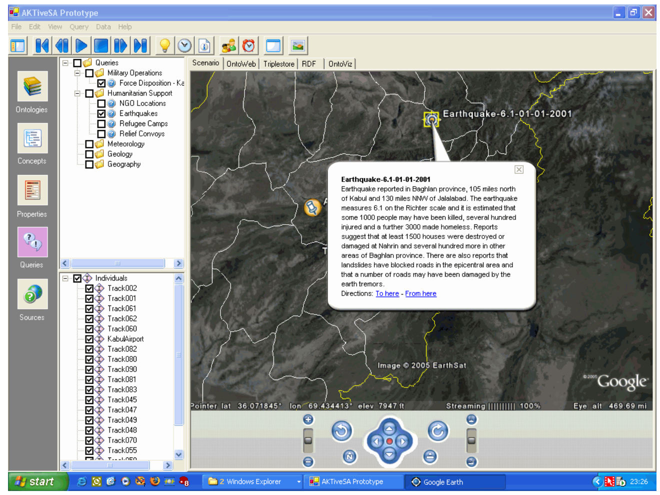

Figure 1: Interface of Prototype Software showing Semantic Information Overlaid onto the Google Earth Visualisation.

2.1 Information Retrieval

This functionality is concerned with both active and passive forms of harvesting information. One may wish to actively gather information from heterogeneous information sources such as news feeds, web pages and even tactical data-links; intelligent screen-scraping mechanisms exist in projects such as MIT's Piggy-Bank[2] and can be easily supplemented by users. Semantically stored, this information has greater context and relevant information can be discovered through developing semantic browsers; the interface is discussed later in the paper. Passively, one may receive email notifications or updates from external agent software; with semantic mark-ups, this information can be automatically processed.

2.2 Information Triage

Information triage is as important to information retrieval. Semantic annotations allow information to be accessed, filtered and sorted automatically by agents and the central system. Further, this information can be filtered according to the profile of the end user. Those making important decisions can, therefore, receive different information to those in the field or even those performing continued research.

2.3 Information Fusion

This is concerned with the dimensionality of all the information available. Not only is the content important, but the validity of the source, the accuracy of its content and its provenance are all important when making decisions. Through semantic encoding, this information can be ac-

[1] http://www.wc.org/2001/sw, W3C Semantic Web Website

[2] http://simile.mit.edu/piggy-bank, SIMILE | Piggy Bank

cessed and represented by the system, as it is provided to the end user; semantic inference allows the system to allocate such meta-data based upon stored context about a source.

2.4 Knowledge Processing

Aside from interactions that the user is concerned with and aware of, the system should initiate its own action in certain situations. An example of this is inference. For example, with knowledge about an earthquake and its size, the system can automatically estimate the size of response required and even initiate contact humanitarian relief agencies.

2.5 Information Dissemination

As mentioned above, an important measure of the system is its ability to coordinate with external agencies that will be involved with the humanitarian relief effort. This entails the timely notification to those involved with the support effort as well as the facilitation of communication links between cooperating agencies. This process will occur through the system's interoperation with external agents and would not be possible without the system's semantic understanding of each agent and its role within the system.

2.6 Interaction and Visualisation

Visualisation capabilities are clearly important in terms of enabling improved situation awareness. The problem of information overload must be considered as the system presents information to users. Similarly, the user's platform for presentation must also be considered.

3 Scenario

In example of the above terms, we consider a flood scenario triggered by earthquake damage to a damn. For information retrieval, sources such as NEIC may provide automatic notification of the earthquake size and location; further information about the flood may be drawn from semantically annotated news reports. Information fusion provides automatic filtering of unrelated sources and can connect related information such as water level and death count. Triage would then prioritise these sources based upon aspects like relevant content and associated trust. Knowledge processing would allow the system to develop basic procedures and organise potential resources for a response; the homeless would require both shelter and blankets. Dissemination services allow third parties, like civil relief agencies, with whom the sharing of newly inferred information is extremely important. Device-appropriate visualisations can then be provided for various users; rescue units in the field may be using a small mobile device, whereas agency headquarters may monitor the developing events over multiple large displays.

4 Use of Technology

4.1 Knowledge Stores

This system comprises a very substantial knowledge base, built upon a number of ontologies; we already have over 1500 classes, 100 properties and 500 individuals. Each of these is currently in development and is being refined in accordance with our growing understanding of the knowledge infrastructure of the problem domain. OWL ontologies have been used to describe this information space [Antoniou and Harmelen, 2003], whilst 3Store has been used to store the RDF information [Harris and Gibbins, 2003]; this storage system uses an RDQL interface for information retrieval and semantic querying. At this time there are 169,000 stored instance triples. Inferential reasoning over this information is being provided by JESS [Friedman-Hill, 1997].

4.2 End User Software

The existing demo co-opts the visualization capabilities provided by Google Earth[3]. The system can make inferences over the existing knowledge base as new information is included. As a result, temporal predictions can be made of the unfolding of events; Google Earth provides a spatial visualisation for the event, including these changes over time.

Detailed investigation into the user interface is just beginning, and many forms of exploration and data visualisations are being considered. Currently, a hierarchical browser for exploring the ontologies has been included. However, both mSpace, a columnar approach, and Haystack, a faceted approach, provide lightweight but high levels of access to semantic information[4]. In conjunction, other multi-platform implementation options are being considered.

5 Conclusions

Whilst this project is in the early stages of development it is showing how semantic technologies can be applied to support situation awareness in an area of pressing need.

References

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[3] http://earth.google.com – Google Earth

[4] http://echo.ischool.utexas.edu/~anuj13/semweb_UI.htm - User Interfaces for Semantic Web Applications

Explanation of Demonstration

An early prototype of an application will be presented, demonstrating the humanitarian relief scenario briefly discussed in the short paper above; a screen shot is also shown above. The core capabilities labelled within the paper are each exampled through the demonstration, along with four key interactive capabilities within the development of such a scenario:

1) The opportunistic exploitation of military assets, for example, the ability of military agents to advertise their current status, capabilities and requirements in order to allow for cross-force integration and self-synchronization. This capability is highly relevant to future capability requirements as documented in the UK Government's HLOC[5]. The specific aspect of the scenario relevant to this capability concerns the coordination of strategic air assets and land components with respect to reconnaissance activities.

2) Support for anti-fratricide measures and avoidance of blue-on-blue engagements via increased situation awareness about the disposition of military assets Situation awareness in this case will be promoted by the ability of diverse military agencies to share information in support of the formation of a CROP (Common Relevant Operational Picture).

3) The ability to monitor the movement of neutral entities, such as relief convoys and refugees, so as to avoid inadvertent military attacks and minimize collateral damage. This capability is particularly relevant during the pre-deployment (the acquisition and assimilation of aid supplies) and the deployment (the transport of supplies to affected region and the distribution of humanitarian aid) phases of a humanitarian aid operation. It is also important in terms of avoiding attacks on refugees, which might otherwise have politically aversive repercussions and undermine the struggle for 'hearts and minds'.

4) The ability to plan the relief effort in terms of identifying requisite humanitarian aid resources (i.e. those specifically required to deal with the flood crisis), identifying the source of the supplies (i.e. the agencies, organizations or countries responsible for the provision of supplies), deciding what transport routes are appropriate for the transportation of aid supplies and the constraints that apply to such transport options (e.g. the viability of roads in terms of structural integrity and security).

[5] UK Joint High Level Operational Concept: An Analysis of the Components of the UK Defense Capability Framework, Joint Doctrine and Concepts Centre (2005), Ministry of Defense, UK.

In terms of our prototype, the demonstration also illustrates: our access to the semantic information through visualizing the ontology and its structure; the exampling inclusion of the Google Earth visualisation – utilising its altitude and resolution capabilities; and the development of semantic queries.

The advent of Semantic Web technologies has facilitated the realisation of the capabilities discussed above. We thus see such technologies as a key enabler with respect to enhanced situation awareness in joint civil-military operations. The use of these technologies is highlighted within the demonstration.