# Crisis Manager Portals for Homeland Security Event Response Decision Support and Training

# CREATE Report

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# Abstract

We focus primarily in this report on Crisis Manager Portals (CMPs) in CREATE, and the use of federated ontologies (inter-related information from various sources). It is a decision support application, where time is critical. We also propose the use of such portals for training various kinds of crisis decision makers. The Crisis Manager Portal supports important utilities related to make decisions in crisis situations such as collecting heterogeneous information, filtering the information, and displaying the filtered information. It of course also allows the crisis manager to make decisions, such as the deployment of attack response resources.

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# Acknowledgements

## 1. Goals of the Project

After a terrorist attack, with information abundance/overload and heterogeneity, it is not easy to focus on the task at hand and make effective decisions. Especially in a crisis situations, it is essential to make precise and fast decisions. The challenge in this project is to make best use of the information and help individuals who use the information to make decisions effectively.

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During the past year, we have focused on constructing key components of a CREATE CMP, stressing initially the events of fires, injuries, and associated problems caused by a terrorist shoot down of a large aircraft on approach to LAX, with the damage mainly on the USC campus.  In particular, we have emphasized three key problems:

1.  Constructing semantic descriptions of the crisis itself, and of the resources that can be used to respond to it.  These descriptions are termed ontologies.  We have constructed an ontology manager for creating, refining, and managing such ontologies (the system is named Ontronic).

2.  Creating techniques to providing for a CMP to produce customized interactive multimedia presentations using user models.   We stress here interactive, in the sense that the crisis manager may ask question and make decisions.

3.  Developing techniques to integrate and combine crisis status information from multiple sources using federated ontologies, i.e., ontologies that can be inter-related.


## 2. Research Approach

The goal of the Crisis Manager Portal is to develop a tool that better prepares people in and for (training) an emergency situation to react swiftly and efficiently to a disaster. To attain this goal, the semantic level information is a key to addressing the problem of information overload on the crisis managers.   And, there are two main kinds of knowledge that must be represented in this domain:

(1) Crisis management resource knowledge
- Human resources such as crisis workers and managers
- Environment resources such as fire trucks, ambulances, etc.

(2) Crisis scenario domain knowledge
- Crisis scene data analyzed for higher-level concepts, features, trends, patterns, etc.

With above knowledge, a crisis manager request can be used to generate interactive presentations back to the user to assist them in their tasks. We customize the information presentations based upon user models (profiles of types of crisis managers, and specific individuals).

In this project, we first designed higher-level ontologies as a structured data using Ontronic [1]. A prerequisite for this was Ontronic, which was developed for use in this project and another in earthquake management. We then researched information filtering to extract quality information from a plethora of heterogeneous information resulting from a terrorist attack. Finally, we developed user models to make interactive user-customized interactive presentations [2]. We detail this work below, and discuss our plans to complete the system more specifically explained below.

## 2.1. System Architecture

We propose a novel architecture for supporting Crisis Manager Portals, which is illustrated in Figure 1.
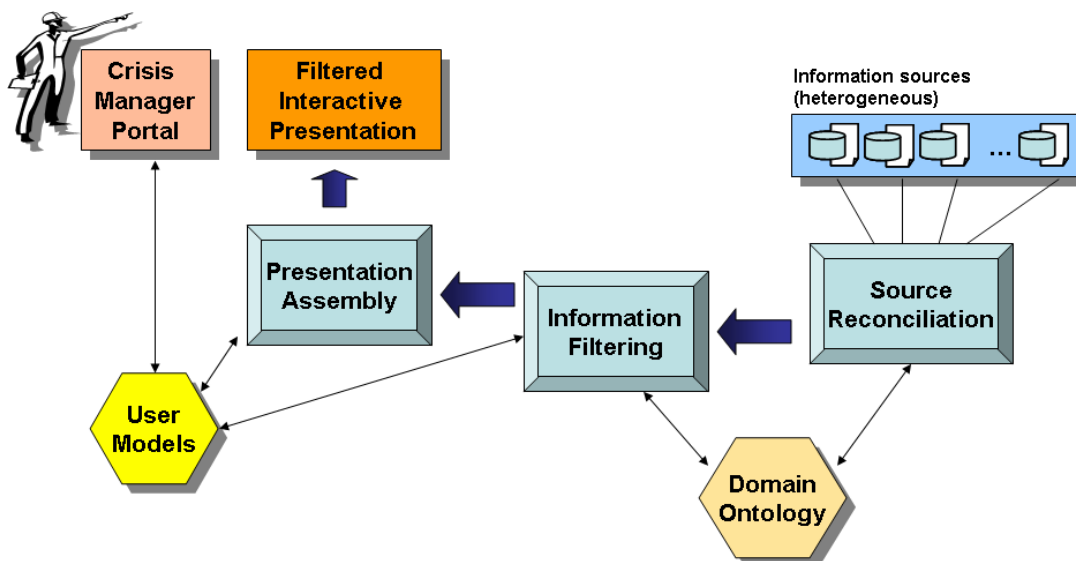
*Figure 1.  Crisis Manager Portal (CMP)*

When fully developed, the Crisis Manager Portal will support three main phases of decision-making, shown in light blue in the figure and described below:

- Source reconciliation
  - Collect all related data from heterogeneous information sources (e.g. phone calls, email, system logs, sensor data)
  - Construct a federation of ontologies to handle the semantic meta-data for each kind of knowledge

- Information filtering
  - Extract useful information from domain ontology
  - Selectively weed out the irrelevant information based on user models

- Presentation assembly
  - With filtered information, create an interactive user-customized presentation using user models
  - Help users get significant information, provide feedback, and make decisions

## 2.2    Creation of Crisis and Response Resource Ontologies and the Ontronic Ontology Manager

The Crisis Manager Portal involves ontologies that are structured data to filter important and quality information quickly. Ontologies present an explicit model for structuring concepts and interrelationships between them [3, 4]. We developed Ontronic, which is a general purpose ontology-based metadata management system to create ontologies in crisis domain. Ontronic provides general functionalities to manage ontology-based meta data [1].

### 2.2.1  Ontronic

We propose a novel model for developing ontologies, which is named CIOM. CIOM is the design of a higher-level ontology model that will enable the ontology developers to naturally and directly incorporate the semantics of ontologies into its meanings. In order to apply CIOM in applications that utilize domain-specific knowledge, we introduce Ontronic; this provides general functionality for the engineering, discovery, management, and presentation of ontology-based metadata incorporated with CIOM. In addition,

Ontronic establishes a platform that is necessary to support the Semantic Web technologies for crisis management for terrorist attacks.

Ontronic provides general functionality to manage ontology-based metadata. In order to access a large-scale and growing amount of heterogeneous terrorist attack management data, an ontology-based semantic metadata management system is required to support effective information retrieval and search for data of interest to crisis managers and the ability to interoperate such diverse datasets with various models and simulation codes.

The process of ontology design, which describes a fundamental method of constructing ontologies in Ontronic, consists mainly of three layers as follows:

- Domain layer: A conceptualization that captures a hared knowledge of the given domain.
- Semantic layer: An explicit ontology model based on CIOM is generated from the conceptualization of the given domain. Such a model has a collection of concepts, interrelationships and the constraints.
- Metadata layer: A formal description for the above model is produced to be machine understandable.

In the domain layer, ontology developers usually conduct an information requirements analysis and express the results of their analysis in terms of the semantic model. The gap between the semantic level of the domain and ontologies can be bridged by CIOM in the semantic layer. In other words, in comparison with the model theory of the contemporary ontology languages, CIOM can be used as a higher-level semantic model in which the ontology developers design ontologies. Consequently, a collection of metadata, which is represented as various kinds of ontology languages such as DAML+OIL and OWL, can be generated from ontologies that are already produced in the previous layer.

Differentiated from the contemporary ontology tools, we approach the construction of crisis management ontologies by incorporating CIOM. Generated ontologies based on CIOM can be translated into various kinds of the current ontology languages such as OWL and DAML+OIL. Thus, by deploying CIOM, Ontronic is capable of increasing the level of semantic interoperability.

### 2.2.2 Ontologies for the Example Terrorist Attack

In the initial system we have constructed, the Crisis Manager Portal has two kinds of ontologies, as follows:

- Crisis management resources
    - Human resources

- - Fire officers
    - Police officers
    - Medical assistants
  - Environment resources

- Crisis scenario domain
  - Crisis starting time
  - Crisis end time
  - Location
  - Causes
  - Causalities' information
    - Name
    - Age
    - Sex
    - Degree of injury
  - Required resources
    - Human resources
    - Equipment resources

Using domain ontologies, we generate a history archive of events that take place within a given geo-spatial time frame. We also can monitor decisions and actions taken during an event and review these decisions for future scenarios. And then we are able to learn from the previous similar encounters. Lastly, we are going to mine histories for novel/ problematical patterns using the domain ontology. Figures 2a and 2b show examples from the ontologies we have constructed.
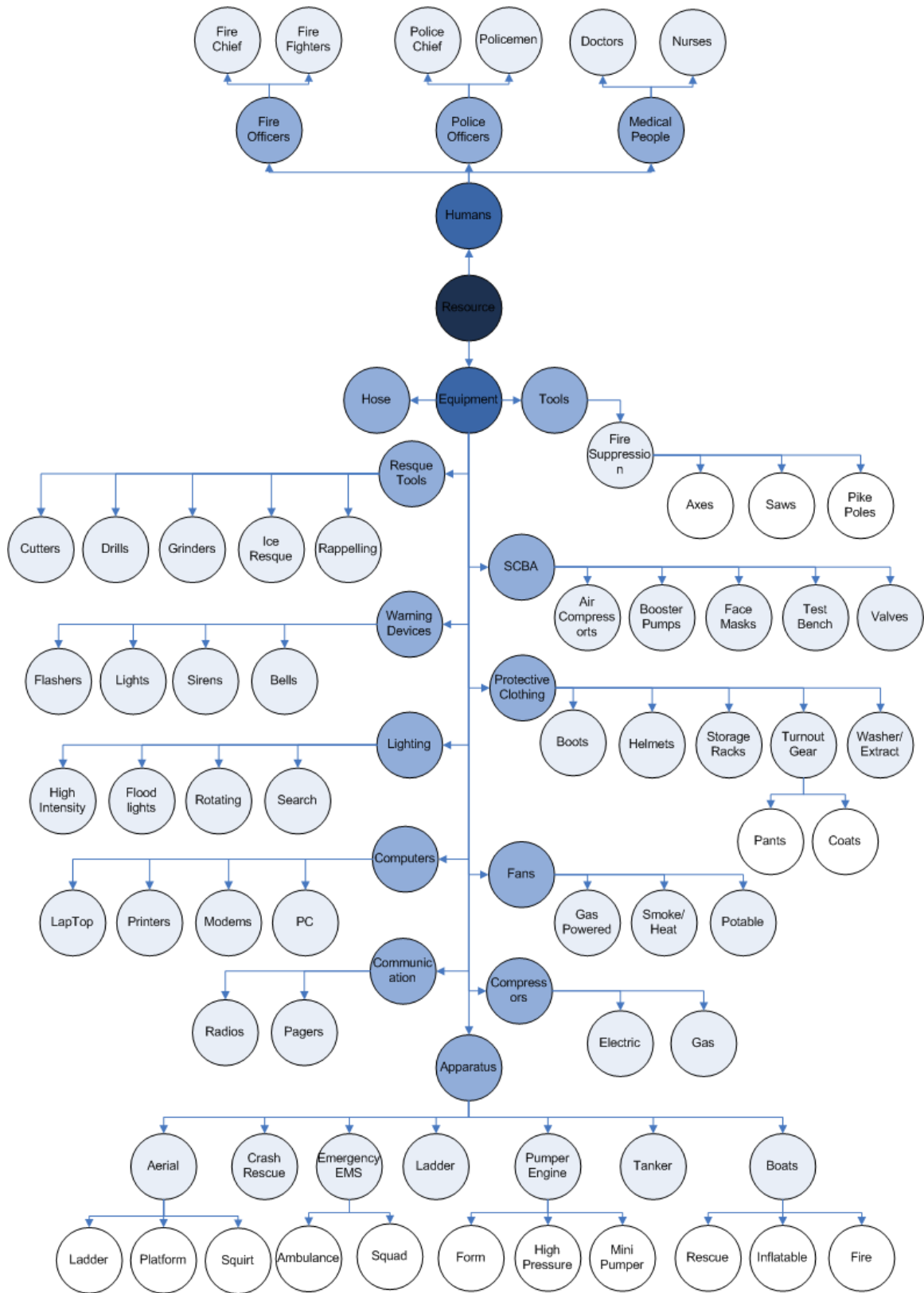
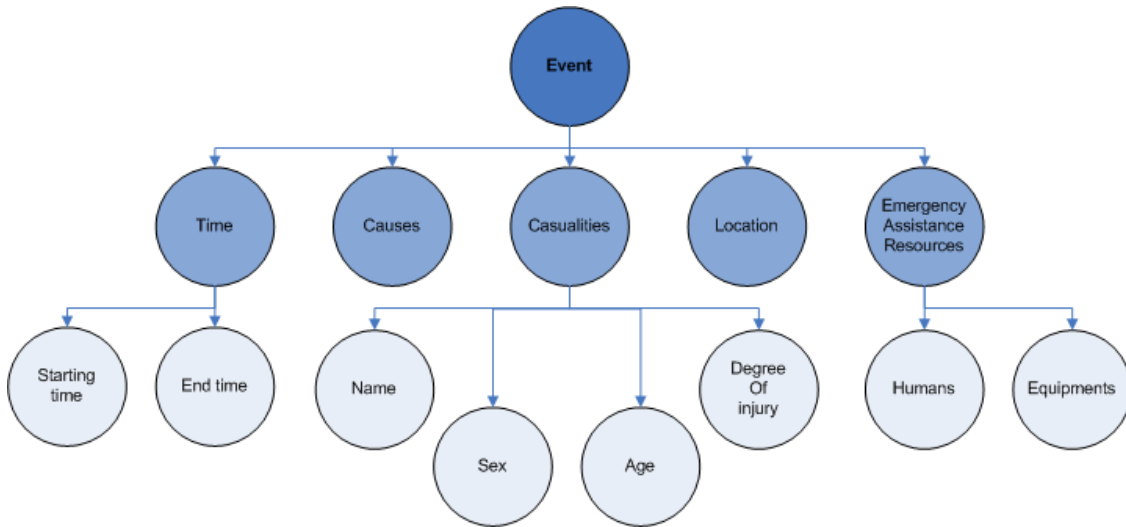*Figure 2a. Example from Ontology for Crisis Management Resources*

*Figure 2b.  Example from Crisis Scenario Domain Ontology*

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Below we show sample screenshots from the Ontronic implementation of the crisis management resources and crisis scenario, in Figures 3a and 3b, respectively.
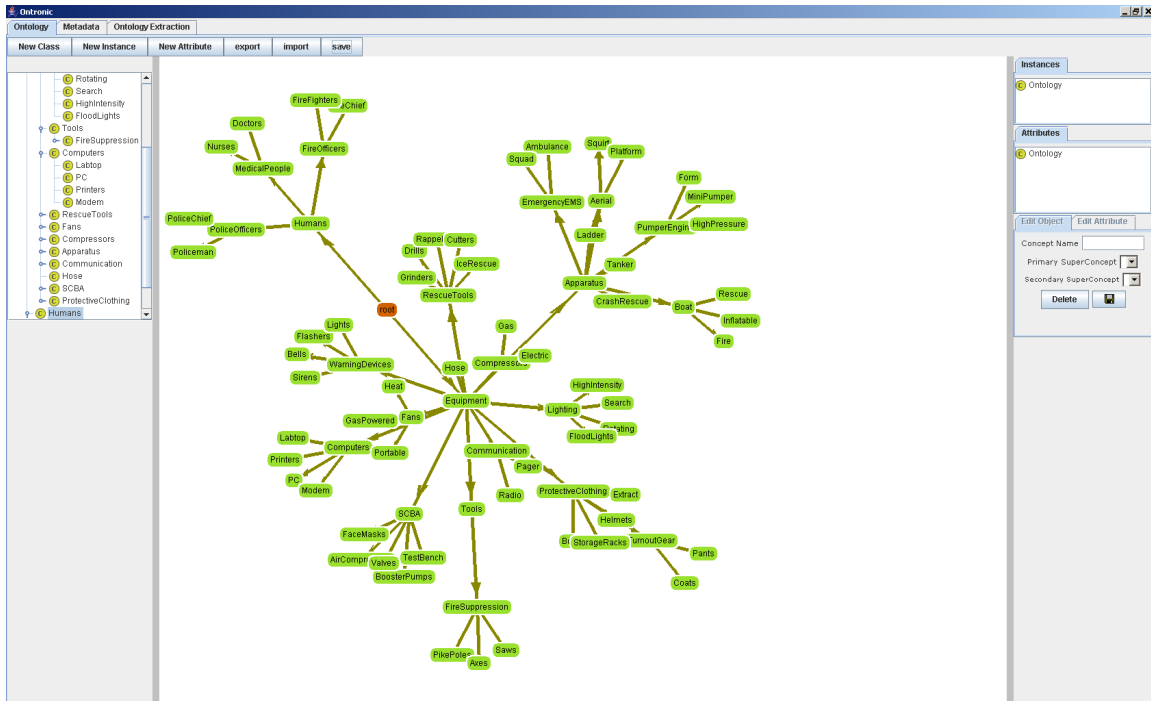


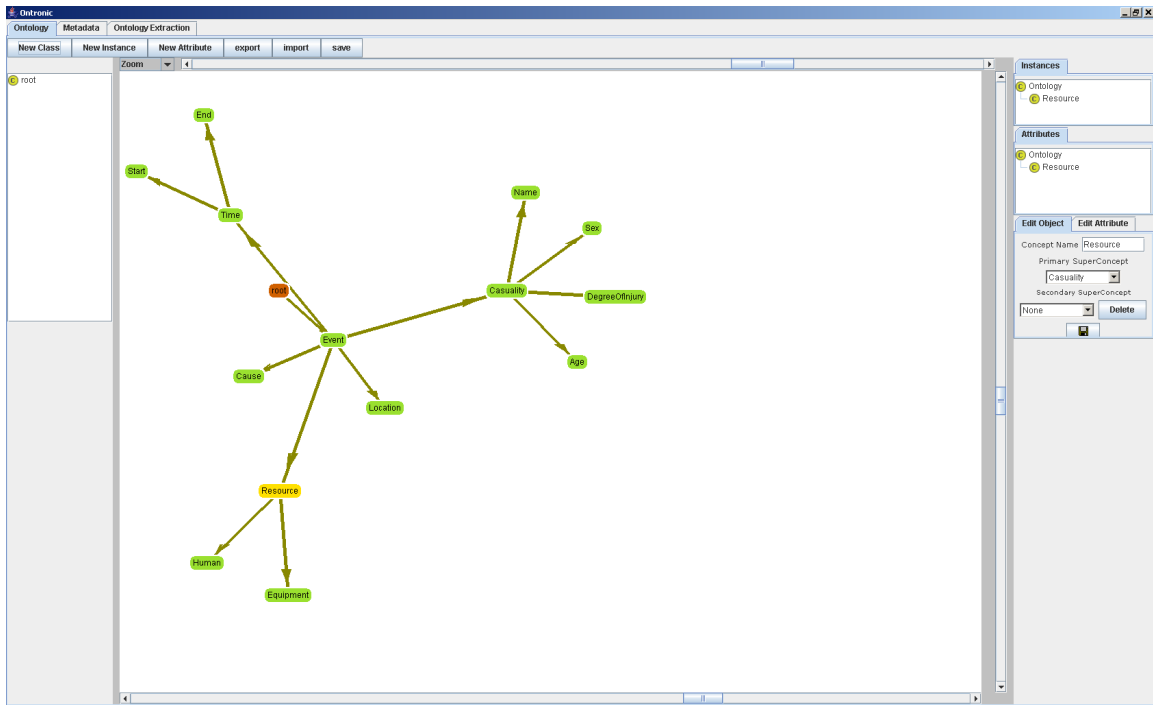*Figure 3a.  Ontronic Screenshot for Crisis Management Resources*

*Figure 3b. Ontronic Screenshot for Crisis Management Scenario*

## 2.3.  Filtered Interactive Presentation with User Models

The user-customized information presentation subsystem is a core part of the Presentation Assembly module that is illustrated in Figure 1.   As delineated in figure 1, the Presentation Assembly module is to generate a filtered interactive presentation by utilizing user models including user profile/history, and information filtering.  The goal of a user model is to accurately capture and represent a user's intent. User modeling techniques have been exploited to help users, including analysts, and to improve their performance since the late 80s [5].   The information filtering module generates information that fills in presentation types, which lay out the appropriate presentation style depending on the user's role and the situation.   Note that presentation types are generic, written in a manner such that they can be "filled in" with combinations of information elements (objects) [2].  The basic idea behind this is to generate and deliver user-customized semantic information for helping a spectrum of kinds of incident commanders.

The current human interface of the DEFACTO system is called Omni-Viewer; it provides global and local views of situation by utilizing 2D and 3D views, respectively (Figure 3) [6].  Although the Omni-viewer visualizes the situation to help an incident commander, it cannot deliver semantics of the situation for different types/roles of incident commanders.

For example, if there is a disaster in the Los Angeles area, several authorities are involved for the disaster rescue mission such as Los Angeles Fire Department (LAFD), Los Angeles Police Department (LAPD), and Paramedics. Since each organization plays a different role in the situation, the user interface must be customized to provide appropriate information. In addition to customization, the user interface needs to be dynamically updated based on time/event change. Furthermore, the interaction and collaboration facilities are required to support collaboration among authorities.
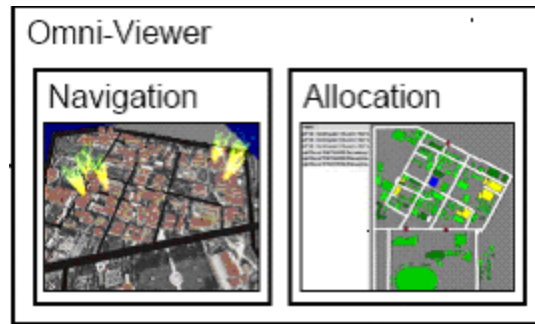


*Figure 3. Omni-Viewer*

To provide a user-customized presentation, we need two kinds of constraint information. The first is related to the user profile/knowledge level. The different presentations are created for a different user roles and user knowledge levels. Although basic presentation is the same as the Omni-viewer, different kinds of status reports and such are added to the Omni-viewer. For example, building information such as height, chemical materials in the building, and so forth is informed for the FD's incident commander. For the PD's incident commander, other building information such as number of workers, points to block the road, and so forth are presented. The presentation includes general information for a new training commander, but the general information is omitted for an experienced trainee.

The second kind of constraint involved is to support various communication devices including standard PC monitors, laptops, PDAs, and mobile phones. The basic constraints involved here are time, space, and user navigation. These basic constraints are used to generate presentations of the same information using different document formats.

The dynamic update is based on time/event change. The presentation must accommodate the change of disaster status. For example, the information filtering module dynamically invokes the presentation assembly module to generate and deliver a newly updated status report, and the commander is informed of a critical item that just appeared.

In the case of terrorist attack, collaboration among multiple authorities is a key to minimize the loss and maximize the recovery procedure effectiveness. In our design, we propose an interaction/collaboration tool for effective, efficient and powerful

methodology to communicate between not only incident commanders but also human and the machine to determine the best next step. The tool will present involved incident commanders, their current status reports and dialog boxes to communicate among humans. Once an incident commander decides the next step, that information feeds into the system to generate a status report for the next move.

## 3. Other Relevant Work Being Conducted and How this Project is Different

Most contemporary crisis management systems typically use unstructured data or semi-structured data that lacks specification of the semantic meaning of data. Differentiated from the contemporary systems, we use ontologies. Ontologies can represent the semantic meaning of data and help to filter worthy information rapidly. Further, the Crisis Manager Portal provides user-customized presentations. It can create various presentations from the same information according to user models while other systems provide one fixed user interface.

## 4. Plans for the Future Work

We will be engaging these tasks in the near future:

- Semantic information integration on the federated ontologies

  We will investigate the matching methodologies among the federated ontologies. The goal is to combine information semantically from the incoming heterogeneous information sources and streams. we will focus on designing an efficient algorithm to calculate similarily among multiple concepts with high matching accuracy. Based on the proposed algorithm, we will provide a machanism to identify the best mappings from the local ontologies.

- Learning system for information filtering

  The vision of ontology learning includes a number of complementary disciplines that feed on different types of unstructured and structured data to support semiautomatic, cooperative ontology engineering. We will investigate contemporary ontology-learning technologies including ontology import, extraction, pruning, refinement, and evaluation, giving the ontology engineer coordinated tools for ontology modeling. Besides the general framework and architecture, an efficient ontology-learning environment, such as ontology learning from heterogeneous information sources, is required. Toward this end, we will further extend Ontronic to support a semi-automatic ontology extraction mechanism incorporating ontology learning techniques.

- Terrorist attack types

  We will apply and test our system with other terrorist attack types, such as a chemical attack. This should require building new ontologies, but not a new

system. Our goal is to be general, and then operate for various types of attack consequence management via ontologies for those types.

# References

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