Semantic-based Incident Management System

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1 Introduction

Incident management plays a critical role in many application domains including Homeland Security. An Incident Management System (IMS) needs to effectively expedite the rapid engagement of first responders at state and local levels to facilitate agile and effective responses to emergency incidents that may pose an immediate security threat to human life and/or the flow of commerce. Data feeds to IMS may include different sensors including radiological, biological and chemical, videos from surveillance cameras. Current IMS faces two major challenges: (1) Since the number of incoming alerts is overwhelming, IMS needs to customize the dissemination of alerts and relevant information on a need-to-know basis, to relevant agencies and individuals. (2) There is a need to interpret the data and alerts generated from different agencies' systems (e.g., local transportation authority, police department) to make meaningful and informed decisions.

We present a Semantic Incident Management System (SIMS) that has the following desirable features: 1) dynamically discover and customize information, relevant resources, reports, models, based on the semantics and location of the alert; 2) automatically manifest the modality and format of the information based on the recipient's role and device (PDA, Laptop, Cell phone, etc.), and 3) automatically compose the alert components and models through Semantic Web and Semantic Web Services.

2. Our Approach and Architecture

SIMS achieves automatic filtering of information and data using an incident knowledge base represented as the semantic graph (Incident Ontology). The semantic graph captures the concepts of different incident types and their relationships among different incidents. The information resources such as textual description of incidents, audio and video clips from the incident scene are described with the semantic concepts in the ontology. Web services are also described using the Incident Ontology. To achieve complex information service, composite Webs services are composed of individual services using matching making algorithm. The customization and dissemination consider the roles of each agency and responder in IM and their device characteristics. SIMS adheres to the National Incident Management System (NIMS) and the National Response Plan (NRP) protocols. Incident Ontology and Webs services are implemented with Ontology Web Language for Services (OWL-S) and the customized alert message with multimedia information components is implemented with the Common Alerting Protocol (CAP).

Figure 1 shows the overall architecture and components of SIMS.

- **Alert Profile Update & Alert Generation Data mining:** These two modules capture the incident/alert profile from the situation reports or detected from automatic data mining components from the sensor network data [Janeja et.al]. Alert profiles include alert types, location, severity, casualties, etc.
- **Semantic Filtering for Incident Information Discovery:** The necessary resources, services and information for handling the incident are automatically discovered. This module uses Incident Ontology and incident relationships to discover resources. Each of the resources is described using concepts and relationships defined in the ontology. For instance, the semantic description of the resources takes into consideration the alert profile such as the type of incidents (e.g. fire, radiological or chemical), severity, human casualty levels, etc. Individual agencies are also considered as resources, and they are described with the semantic concepts from the incident ontology. Thus the types of the incidents may determine which agencies need to be involved and which resources are needed.

- **Service Discovery and Service Composition**: Some of the information resources are not static, for instance, the map of coordinate (x, y) needs to be generated using a map generation software. Thus the Web services are described as a part of information resource. In order to plan an evacuation, a host of information is required. First the evacuation plan should identify a hazardous material spreading modeling tool to assess where may be most severely affected, and a map of potential evacuation sites and hospitals are needed around the incident site. Thus decision on the evacuation plan may require a complex set of information and service resources composed together, e.g. hazard spread modeling with wind directions from the weather forecasting service. Then the plan will require determining the number of volunteers based on the size of evacuation. This requires the volunteer lookup service. The Semantic Web services and Service composition modules are to discover available services and compose them for complex information needs. These services are also described in terms of incident ontology to be discovered with semantic concepts.
- **Customization with Role Filtering:** The alert information and services discovered from the semantic filtering stage now can be disseminated to each agency and responders. However, not all the semantically related incident information is needed for all the agencies. The role filtering of the alert message is based on the jurisdiction policies, agency policies and the role policies. The fire department and medical organization's information needs are different and responder's role may further restrict information based on the need-to-know access authorization.
- **Display Customization with Personal Preference and Device Filtering:** This module adapts the alert content components with spatial layout and rendering format based on the recipient's devices characteristics (e.g. monitor size, Operating System), and the recipient's preferences (e.g. audio instead of text) [GAA05].

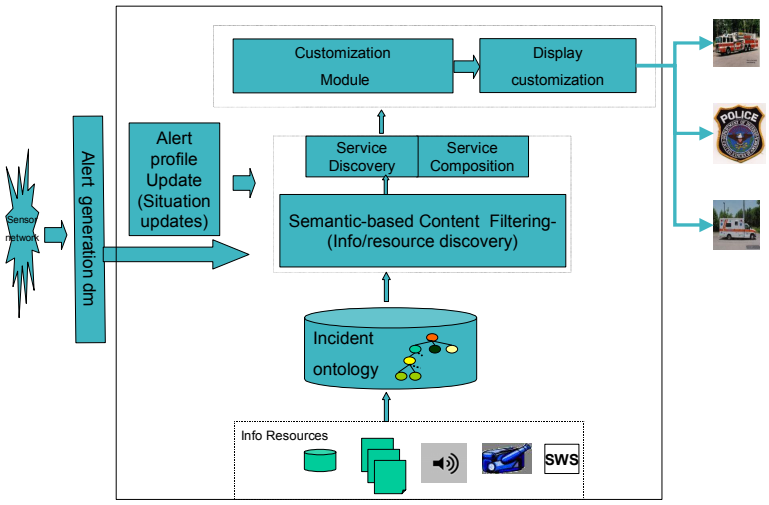

Figure 1 SIMS Architecture

We are developing a prototype SIMS for Emergency Management Office of New York – New Jersey Port Authority, which allows multimedia alert message to be customized according to the semantics, and according to the roles and policies, user device properties as well as user preferences. The alert messages are encapsulated in CAP (Common Alerting Protocol) compliant XML format that can be easily shared and disseminated to any device. Web services discovery and composition are implemented with WSDL and OWL-S using SAP's Auto-ID Infrastructure.

References

[Janeja et. al] V. Janeja, V. Atluri, A. Gomaa, N. Adam, C. Bornhoevd and T. Lin., "DM-AMS: Employing Data Mining Techniques Alert Management", NSF National Conference on Digital Government, 2005. Atlanta, Georgia

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