An Agent based Approach to Situational Awareness

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Situational awareness is a key component is many emerging scenarios of command and control – C4IST systems in the defense forces, Incident Management in Homeland Security, Disaster Management and Relief operations in face of natural disasters, Cyber Physical Systems are some example applications that have gained prominence in recent years. A key common denominator of such systems is that there are a variety of distributed sensors/sources of information, each seeing only parts of the event, and each prone to its own errors/biases. Yet the commander and the warfighter/responder need a common situational picture that fuses these disparate inputs. Moreover, wireless networks, especially ad-hoc networks (MANETs, VANETs, CPS Sensor networks) that connect the component of many of these systems are highly susceptible to attacks. We argue that an agent based framework provides good underpinnings for constructing such proactive systems.

We use the UICDS system being developed by DHS as an example in our subsequent discussion. The aim of UICDS is to allow emergency responders to capture important incident-related information, analyze captured information, more effectively disseminate mission critical information to emergency responders, present decision guidance options for emergency response community, effectively coordinate efforts of emergency responders, and store incident related information for analysis.

As has been well demonstrated by a large body of work in agent based systems, they provide a good distributed communication substrate with well developed approaches such as the FIPA protocols that allow disparate agents to interoperate. There are several interesting issues in creating this substrate for the emerging situation aware systems. One is the use of new communication protocols and tools such as XMPP and inter-process communications in a cloud computing environment. Another is the integration of specialized agent communication languages and infrastructures with more conventional standards such as SOAP and REST APIs. A third is the exploitation of emerging standards for interoperability in rule-based systems, including SWRL (Semantic Web Rule Language) and RIF (Rule Interchange Formalism). The use of RIF will permit translation to any of several commonly used rule formalisms, such as Jess.

Intelligent Agents built on top of core UICDS communication services provide a range of additional, smarter capabilities that can potentially enhance the abilities of the federal,

state, and local organizations to carry out protection, response, and recovery related tasks. We use the term intelligent agents (IA) somewhat loosely and intend it to include a range of techniques that include both automated and semi-automated approaches. In particular, some of the IA technologies that are likely to be appropriate for situation aware systems include the following:

- Multiagent system techniques for coordination and collaboration, e.g., for negotiation and for argumentation to resolve conflicting assumptions or information, and for assignment and coordination of available support resources. We have recently shown how the BGP protocol, which undergirds much of the modern internet, can be made resilient to attacks using this approach.

- Context agents that integrate information from multiple sources (including other agents) to provide an overall context for individual incidents or a set of incidents occurring in or impacting a region. In particular, such agents can handle streaming knowledge (not just data) and make inferences to satisfy standing queries on the fly.

- Information integration agents that select, integrate and fuse relevant information from different data sources (including other agents) into a timeline or geo-political view. They can also make (individual and/or group) informed decisions about when/whether alerts must be issued and which/whether users must be notified.

- Information extraction agents that can extract semantic information from the text in incident reports, notifications and related news sources, including named entities (references to people, places and organizations) as well as simple relations between them and events in which they participate.

- Multiagent system techniques for proactive policy monitoring, governance, and enactment. The agents capture the rich and complex policies involved in the interaction of federal, state, and local organizations with hierarchies of largely autonomous, heterogeneous members (individuals or other organizations).

- Planning, scheduling, and automatic workflow enactment approaches for automatic/dynamic creation/adjustment of response plans, revision and inspection to ensure compliance with standards, and learning plans and outcomes to further suggest improvements.

- Game theoretic approaches to provide a framework to take costs, benefits, and entities into consideration, including individual reactions, and suggest courses of action.