Emergency-Management Situational-Awareness Prototype (EMSAP)

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Abstract

This paper describes the architecture and requirements of an integrated system that is needed to support command and control for the interoperability-capability focus area. The architecture is designed to enhance situational awareness during emergencies such as earthquakes, volcanic eruptions, wild fires, floods, tsunamis, mud slides, storms, tornadoes, hurricanes, extreme heat, extreme cold, massive disease outbreaks, wars, terrorist attacks, power outages, cyber-attacks on utility grids and civil unrest. A net-centric approach that emphasizes cognitive aspects, such as cognitive-information operations, in decision support ensures information superiority by networking sensors and human-factors monitoring. This enables decision makers to achieve shared awareness. Linking knowledgeable entities effectively leads to increased speed of command and a higher tempo of operations with a degree of self-synchronization. The resulting system will decrease cognitive overload and improve cognitive monitoring by providing a more systematic and less labor-intensive method to manage information from and for first responders at the local, tribal, state, and federal levels.

Keywords: Cognition, Command and Control (C^2); Decision Support; Net-Centric Services; Integration; Situation Awareness[†]

I. Introduction

An integrated system is needed to support command-and-control interoperability emergency management. The purpose of the architecture is to en-

hance situational awareness during emergencies such as earthquakes, volcanic eruptions, wild fires, floods, tsunamis, mud slides, storms, tornadoes, hurricanes, extreme heat, extreme cold, massive disease outbreaks, wars, terrorist attacks, power outages, cyber-attacks on utility grids and civil unrest. The architecture is designed to function with a net-centric approach that emphasizes the cognitive aspects of decision support, and ensures information superiority and mission success by networking sensors and human-factors monitoring.

The interoperability of current decision-support command-and-control systems across multiple government agencies is, at best, ad hoc across the military and homeland-security domains [1]. The goal of the architecture described here is to address and correct these deficiencies. Several components for a national strategy need to be addressed to solve the problem with imperatives for implementation of an integrated system that is sustainable both in terms of the technology and life-cycle logistical support. The following imperatives [1], [14] serve as components of a functionally integrated, service-centric [17] emergency-management C^2 system.

- National Incident Management System (NIMS) and National Response Framework (NRF) for first responders in governments and private agencies.
- Outreach centers for technology transfer, including C^4 ISR systems, Chemical, Biological, Radiological, Nuclear (CBRNE) defense [2], [6]; and human factors.
- Science and Technology (S&T) assistance for architecture, data management, Cognitive Information Operations (CIO) [5], acquisition, sustainment.

This paper describes an architectural approach to support the Departments of Defense (DoD) and DHS with a particular emphasis on CIO, thereby improving interoperability and providing additional capability to various users communities.

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II. Background

Many of the components specified in the architectural design of this integrated system already are deployed and in use for various defense and DHS purposes. Thus, the integration involves not only mature systems that continue to prove their utility at a relatively high level of technological readiness, but future components now under development.

CIO needs to be integrated into emergency management in a more explicit manner. Originally, CIO was envisioned as a systematic way to understand and predict adversarial actions in asymmetric- and irregular-warfare environments. However, in disaster-relief situations, depending on the cause of the disaster, a clearly defined adversary is not always evident. Those in adversarial roles include but are not limited to terrorists in the case of man-made disasters, and opportunists who exploit for personal gain the chaotic conditions present in the aftermath of any disaster. To apply CIO to emergency management, we must understand how the adversary thinks, as thoughts precede all actions [5]. More timely and accurate information sharing can improve CIO. Moreover, CIO and the timely reporting of CIO-related events can enhance the overall disaster-relief mission.

Efficient Disaster Management (DM) consists of more than just the use of interoperable C² components. It includes but is not limited to support for CIO and the dissemination of CIO-related information throughout the area of operation. First responders in various levels of government collaborate with private industry and private-relief organizations to implement systems and hardware working toward the goal to improve substantially the user-focused disaster-management resources.

III. Cognition and Emergency Management

Several aspects of cognition are important for situational awareness in emergency-management and disaster-relief situations.

- Sharing of information acquired during CIO contributes to overall situation awareness.
 - Ingroup-outgroup bias detection through language analysis [5].
 - Deception regarding group bias, e.g. falsely appearing to be a member of a group, or false denial of group membership.
 - Deception in general [10]
- Communication of cognitive states
 - Normal mental conditions
 - Cognition under stress [13]
 - Fatigue, lack of sleep, and exhaustion
 - Noise and thermal extremes
 - Task urgency and time pressures
 - Hypervigilance, rapid attention shifting

- Feeling of isolation due to scarcity of human and material resources.
- Mental impairment due to environmental hazards, e.g. CBRNE-related factors.
- Information overload can result not only when too much data must be analyzed quickly, but also when these data are not self consistent and are inconsistent with other observations.

EMSAP can help share information in reporting the results of CIO. For example, natural disasters, such as earthquakes, volcanic eruptions, and floods, cause widespread destruction of infrastructure and result in massive evacuation of personnel. Under these conditions, looting historically has been a problem. CIO is likely to be conducted while protecting vital infrastructure and deterring looters. During such a CIO, deception detection could become important when an individual posing as a store owner, actually wants entry for the purpose of looting.

Stress channels the attention to reduce focus on peripheral information and tasks and increase focus on main tasks [13]. Although selective attention can improve under stress [7], in general, stress degrades judgment and decision making [13]. Therefore, a commander or coordinator may want more information on the relative stress levels of personnel. A feature of the proposed standard Common Decision-Exchange Protocol (CDEP) [15] designed to track uncertainty in the decision-making process can be modified to support tracking and reporting of the cognitive state of various participants and groups in relief efforts. If a commander or disaster-management coordinator is aware of the cognitive state of first responders and other relief personnel throughout the extended area of operation, the coordinator can allocate resources and make other decisions more efficiently.

Cognitive overload in DM can be reduced, but not eliminated entirely, by the sustainment of integrated, interoperable, and enhanced C² systems.

IV. EMSAP Sustainment

Sustainment requirements include the following.

- Maintenance of components necessary for migration to a net-centric environment and integration of common services.
- Development & demonstration of a C² Systems test strategy residing at the City and State Emergency Operations Centers that operate in an unclassified environment, and implementation of a test bed associated with vendor and government products available.
- Promotion and support of Service-Oriented Architecture (SOA) [17].
- Support for emerging services and sustainment of hardware and software interfaces.

- Configuration management of data, common- component software and hardware interfaces, and the sustainment of a DHS S&T resource repository with linkage to existing user-specific repositories and artifacts.
- Tracking the changing requirements associated with each agency's use of components and related interfaces will require extensive coordination and translation. Interfacing software for each mission-oriented capability will require changes.

Fig. 1. Existing capabilities focused on emergency-management requirements [14]

Fig. 2. Envisioned integrated-architectural framework of EMSAP using SOA-based technologies

V. Architecture for Cognitive Support

Fig. 1 illustrates how to build relationships between requirements and existing state-of-the-art technology solutions for first responders by providing:

- Technology development & transition
- Technology assistance & outreach centers
- Information reuse
- Technology & systems integration
- Modeling & simulation center for first responders.

For example, C^2 requirements include information sharing, collaboration, command, control, and situational awareness, as depicted in Fig. 1. Tools and technologies such as Chat [8] [11] support these and other military requirements. Chat can prove as valuable an asset for situation updates in future emergency management as it has for military communications.

Prior to chat technology, military personnel used radio as the primary means of tactical communication. This was very stressful and inefficient. The use of multiple radios for voice communications in a confined C^2 space with many users produced an acoustical environment characterized by interrupted and/or garbled transmissions, static, interference, and an ever increasing volume of background noise as users would shout to be heard.

In contrast, chat communication has become the primary and often the singular means of communication in situation updates on intermittent and discontinuous networks, superseding radio communications with text-only descriptions [8]. Chat is popular because it improves the speed, clarity, and certainty of tactical communications, and because it provides a record for later reference and analysis that can be valuable from legal, strategic, and training perspectives. Chat supports the cross-domain operations and information sharing even without a common-operational picture [8].

The use of chat enhances the cognitive environment because it is quiet and enables users to focus on clear thinking rather than loud screaming. Therefore, chat users enjoy a significant reduction in stress, uncertainty, and fatigue that lead to cognitive failure and eventually, errors. Moreover, the use of visual icons can enhance the efficiency of chat, also increasing cognitive efficiency [8] [9].

Fig. 2 depicts the integrated-architectural framework of EMSAP using SOA-based technologies, including DoD and DHS component systems and services for first responders at all levels of government. The envisioned integrated architecture includes the next step toward semantic interoperability for federal, state, and local emergency-response personnel. Semantic interoperability clearly addresses and enhances the cognitive do-

main. However, semantic-information integration has been the most challenging level of integration to achieve [3] [4] [16].

The architecture described in Fig. 2 features an integrated Universal Core (UCORE) semantic layer [12] and Integrated Public Alert and Warning System (IPAWS) as the heart of the semantic gateway to process alerts for emergency personnel from multiple echelons. The semantic gateway provides message aggregation and mediation. UCORE provides a general metadata foundation, fundamental components of an upper ontology, and an important step toward a comprehensive ontology of cognition for information sharing and understanding across multiple message domains [12].

VI. Future Directions

An expanded discussion of the way forward can be found in [14]. Moreover, the following developments are necessary for a completely integrated C^2 emergency-management system for first responders.

- Existing DHS S&T programs need to be leveraged to provide funding to extend DoD open source C^2 technology related to the following programs. The systems under development in these programs need to be integrated.
 - Situational Awareness Geospatial Enterprise NORTHCOM Common Operational Picture
 - Open architecture for city, state, and regional pilot program.
 - San Diego local government and beyond, e.g. Fire department and water district.
- Future standards, protocols and systems need to be researched, developed, and integrated with existing systems to produce a comprehensive C^2 system [16]. For example, commanders, coordinators of first-responder teams and other emergency personnel will have the option to track states of uncertainty in decision making when a CDEP [15] is integrated into the integrated-architectural framework of EMSAP.

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Appendix I. Acronym Glossary

AT/FP-Anti-Terrorism/Force Protection
CANES-Consolidated Afloat Network & Enterprise Services
CASM-Communication Assets Survey & Mapping
DM/OPEN-Disaster Management message broker offering non-proprietary interfaces
EAS-Emergency Alert System
FEMA-Federal Emergency Management Agency
IA- Information Assurance
ICBRNE-Integrated Chemical Biological Radiological, Nuclear, Explosive (Program)
ICTAP-Integrated Communications Technical Assistance Program
IWS- Integrated Warfare Systems
JCDX- Joint Cross Domain Exchange
JPSC2-Joint Protection & Surveillance Command & Control
M&S-Modeling & Simulation
NCES-Net-Centric Core Enterprise Services
NOAA-National Oceanic & Atmospheric Administration
PAAS-Personnel Accountability & Assessment System
SKIPAL-Strategic Knowledge Integration Personalized Assistant that Learns
SMS-Sensor-Management System
UICDS-Unified Incident Command & Decision-Support System
WAAN-Wide Area Alert Network