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Intelligent Systems or Standardization and Ontologies

Why do you think your paper is particularly suited to this track session?

Intelligent Systems-

One of the main focuses of implementation is to provide content and context aware routing for ICS consumers of data. The architecture would aim to provide the "right" data at the "right" level of detail to the "right" user at the "right" time. This focus is to use the current ICS context to automatically hypothesize what users will be interested in what information and at what level of detail and deliver it to them without significant user interaction. Although the system would allow for customization, this would create an environment where end users could stand up a unified command post and start serving immediately in a time of need without the need for complex configuration. As the incident expanded and the ICS structure grows, the system continues to evaluate the context of the ICS structure and updates user subscriptions to data feed appropriately. This allow for easy continuity of incident management, without IT department staff managing complex enterprise architecture in the incident command post.

Standardization & Ontologies-

Our preliminary results have led to the adoption of the EDXL Distribution Element (EDXL-DE) as our top-level loose coupler. The EDXL-DE standard was designed by OASIS as a generic loose coupler that can carry a variety of structured payloads, is designed with cross-domain routing in mind, and has seen adoption within the First Responder community. In addition to EDXL-DE, we will leverage the EDXL Hospital Availability (EDXL-HAVE) standard for transmission of hospital availability and status. We are working closely with the OASIS Emergency Management Technical Committee (EM-TC) on their current work with EDXL Situational Representation (EDXL-SR) to incorporate gaps in the data model that exist for field units to report information about a current event to ICS. EDXL-SR is primarily focused on ICS reports to document ICS operations, however we feel in light of our findings within the data model a message set can be developed for field unit reporting that would allow auto-creation of EDXL-SR reports for ICS. We will also be transferring our findings on the EMS specific activities for the EDXL Tracking of Emergency Patients (EDXL-TEP) to the EM-TC once this effort is transferred to OASIS for implementation.

- Type of paper. This may be either a full research paper, which will be double blind peer reviewed, or a shorter work in progress, or practitioner report or discussion, which will be reviewed for clarity, relevance and significance. *Delete as appropriate*

  Work in progress – review for clarity, relevance and significance; no more than 5 pages with figures & tables (~2500 words)

  Note that the designation of the paper and its reviewing will be indicated in the conference proceedings. We are not trying to create some concept of first and second quality papers. Rather we are aware that some report finished work which can be assessed in the sense of full peer review and contribution to research, while others offer ideas and thoughts which will stimulate discussion at ISCRAM conferences. The latter are vital if we are to make the conference valuable for *shaping* our subject and its impact on society.

- Contribution of your paper. Explain what your objectives are in writing this paper. What do you believe is the contribution that your paper is making? Feel free to lift text from your paper and repeat it here – that would mean that your paper is clear on its contribution and objectives! (~100 words)

IC.NET – A Self-Aware & Interoperable System for Incident Management

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ABSTRACT

During medium to large scale disaster responses that involve mutual aid from neighboring counties, states, or regions, Incident command relies on voice of radio communication along with pen and paper notes for situational awareness. This leads to cluttered radio chatter, necessitates the need for dedicated staff to transfer notes to a common operational picture, and can result in the unreliable transfer of information to and from the Incident Command Post.

IC.NET seeks to develop lightweight 'Loose Couplers' for First Responder units so that interoperability at the national level may be achieved. The First Responder Loose Coupler will look to work with and leverage existing standards to provide a messaging format that is lightweight, agile, simple to implement and rapidly deployable. In addition, this research will investigate ways to appropriately route messages to their proper destination using an interface that can be modified by the user without significant IT expertise.

Keywords

Emergency Preparedness and Response, DHS, FEMA, Loose Coupler, ICS, Incident Command System, NIMS, National Incident Management System, EMS, Emergency Medical Services, NORTHCOM, First Responder, Emergency Management

INTRODUCTION

During medium to large scale disaster responses that involve mutual aid from neighboring counties, states, or regions, Incident command relies on voice of radio communication along with pen and paper notes for situational awareness. This leads to cluttered radio chatter, necessitates the need for dedicated staff to transfer notes to a common operational picture, and can result in the unreliable transfer of information to and from the Incident Command Post.

Further, during shift changes at Incident Command and other supervising facilities outgoing staff need to brief incoming staff from their pen and paper notes, resulting in delay of command and lack of full knowledge of current operations at the incident. This model also results in information being shared only on an ad-hoc basis to potential third and fourth responders such as FEMA, DHS, National Guard, and NORTHCOM.

Currently, most First Responder units have a Mobile Data Terminal (MDT) with the necessary software that connects to their Region's Computer Aided Dispatch (CAD) system. Unfortunately, these software systems are not interoperable from region-to-region, even if purchased from the same software vendor. In addition to lack of interoperability among First Responder CAD and digital messaging systems, First Responders are using a variety of devices producing field sensor data that is often not being transmitted in real-time, or are transmitted using unique applications on isolated machines serving isolated entities within the Incident Command Structure.

Reviewing Statement: <to be completed by the editors> This paper has been fully double blind peer reviewed./This paper represents work in progress, an issue for discussion, a case study, best practice or other matters of interest and has been reviewed for clarity, relevance and significance.

IC.NET seeks to develop a lightweight 'Loose Couplers' for First Responder units so that interoperability at the national level may be achieved. The First Responder Loose Couplers will look to work with and leverage existing standards to provide a messaging format that is lightweight, agile, simple to implement and rapidly deployable. In addition, this research will investigate ways to appropriately route messages to their proper destination using an interface that can be modified by the user without significant IT expertise.

This project will consists of research in the First Responder domain space, including existing data standards, Local, State, and Federal needs for data interoperability. Based on this research the authors will develop the base loose coupler and extensions for Emergency Medical Services (EMS) including EMS field sensor data. We also have developed and leveraged visualization and tasking software and integration with existing CAD and Incident Command Software to demonstrate the advantages, flexibility, and rapid deployment capability of the IC.NET system. We plan on participating in field exercises with First Responders to demonstrate the capabilities to stakeholders at the Regional, State, and Federal levels to motivate the adoption of this system by the end users and this transition this research to the field.

RESEARCH GOALS

This research seeks to first analyze and document the First Responder Domain by developing a data model for the First Responder Domain. For the purposes of the initial phase of this research we are focused on the use cases surrounding EMS operations, the appropriate ICS structure to manage EMS resources, and other EMS stakeholders such as Medical Control Hospitals and other regional hospitals. Therefore, after development of the general data model for the Emergency Medical Services (EMS) sub-domain, we will then analyze and document data exchanges in the EMS sub-domain, examining use-cases for incident management for EMS operations. From these common data exchange patterns we can extrapolate both the minimal required information to be sent "over the wire" as well as a comprehensive set of optional information that could be transmitted. From these data requirements we will develop architectural requirements for information sharing systems for the First Responder Domain and design an information sharing system based on these architectural requirements.

When developing our data requirements, we aim to expose data for National Interoperability, integrate with field sensor data, as well as work with and leverage existing standards, such as the OASIS EDXL family of standards. Therefore, after specifying our data requirements, a side by side analysis will be conducted with existing standards to determine where these standards could be used for this set of use cases. Because this work is focused at "boots on the ground", some requirements apply to any solution proposed for this area. Any interoperability solution should be lightweight, agile, simple to implement, and rapidly deployable in order to support the dynamic environment of practicing first responders. Additionally it should be extendable to support unanticipated users, units, roles, or data.

IC.NET aims to serve as a proof of concept and feasibility study for lightweight information exchange and is currently developing a prototype to serve as a proof of concept. We feel that this effort works towards a system that is practical for field deployment, provides accurate and timely information focused on the ICS structure in order to offer an unambiguous view of data based on user's role in ICS. IC.NET will be rapid to deploy, easy to perform administrative tasks without IT expertise and connects field EMS units, ICS, and hospitals.

DOMAIN OVERVIEW

Defining the Emergency Management Domain

The entire scope of disaster management includes all First Responder Units (Fire, Police, EMS, Infrastructure, SAR, etc.), the complete ICS as defined in the NIMS, and all supervising facilities needed to support ICS (Hospitals for the EMS use cases). The principle functions of emergency management include identifying events that require response, tasking existing resources to events, tracking events to completion, determining additional resource needs, maintaining a chain of command, and disseminating information to field resources and other ICS stakeholders. In order to define the emergency response we have divided a large disaster response into four phases of response including: local or first responders, regional or second responders, state or third responders, and federal or forth responders. After breaking down the phases of response we analyzed each phase with the following key considerations for each:

- Who are the participants at each level?
- What activities generate information to be shared?
- Where do standards or information gaps exist?

- What are the implications for the IC.NET architecture?

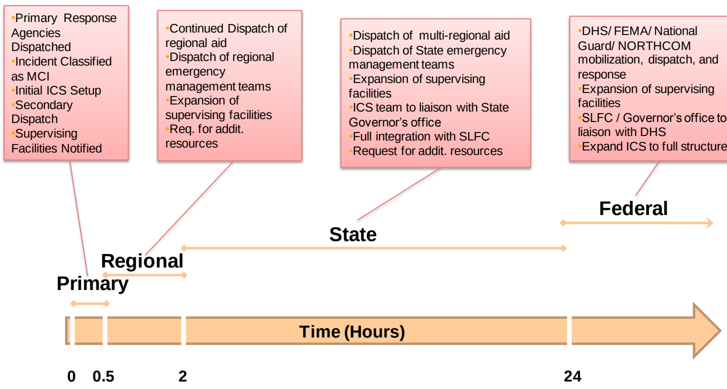

Figure 1 - Incident Response Timeline

Figure 1 represents an overview of our breakdown of the timeline of an Incident Response encompassing the four phases of an emergency response. Key actions are highlighted at each phase of the response to address the key considerations for each phase and the implications to the IC.NET architecture.

The Incident Command System

The Incident Command System as defined by FEMA is a standardized on-scene emergency management construct derived to ensure the safety of responders and others, the achievement of tactical objectives, the efficient use of resources. It is an integrated organizational structure to handle the complexities of incident(s) without the hindrance of jurisdictional boundaries. The command structure represents a top down modular design dependent on the size, complexity and hazard environment caused by the incident that includes facilities, equipment, personnel, procedures and communications. One of the advantages of this standardized command structure with clearly defined roles is that the current state or context of the ICS structure can be used for message routing. One of the main focuses of implementation is to provide content and context aware routing for ICS consumers of data. The architecture would aim to provide the "right" data at the "right" level of detail to the "right" user at the "right" time. This focus is to use the current ICS context to automatically hypothesize what users will be interested in what information and at what level of detail and deliver it to them without significant user interaction. Although the system would allow for customization, this would create an environment where end users could stand up a unified command post and start serving immediately in a time of need without the need for complex configuration. As the incident expanded and the ICS structure grows, the system continues to evaluate the context of the ICS structure and updates user subscriptions to data feed appropriately. This allow for easy continuity of incident management, without IT department staff managing complex enterprise architecture in the incident command post.

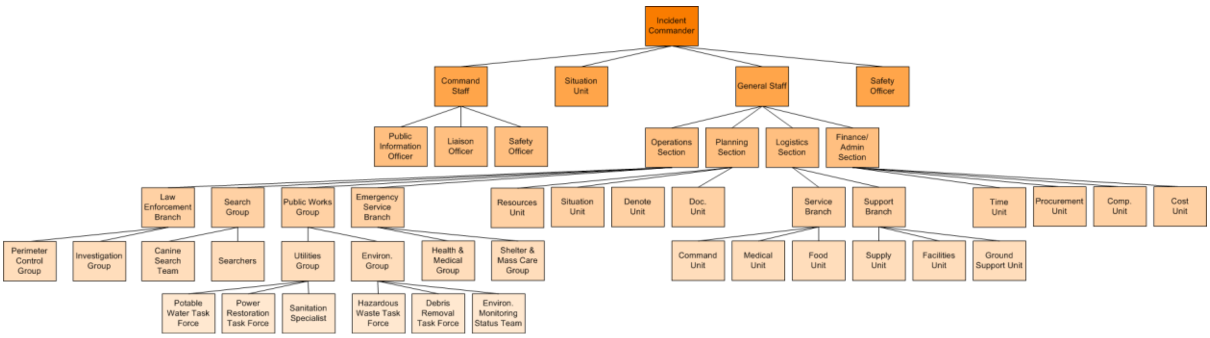

Figure 2 - Incident Command Organization Tree

Figure 2 represents the ICS organization tree for the command structure of ICS. We utilize this standardized command structure is our design to implement dynamic message routing to appropriate recipients.

EMS Specific Activities

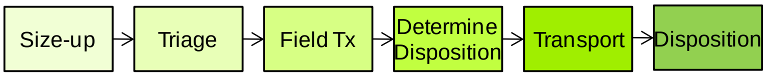

Figure 3 - EMS Operations Timeline

Figure 3 illustrates the EMS Operations timeline of field EMS providers during a disaster response. EMS activities and their interactions with ICS and ICS stakeholders is the use case that we chose to break down for our initial phase of prototyping. During scene size-up the scene is evaluated for potential hazards, approximate number of patients, presence of hazardous materials (HAZMAT), and the need for patient decontamination. For the first phase of this research we are not including decontamination or HAZMAT operations in our use cases. Once size-up is completed, triage takes place which includes rapid (less than thirty seconds per patient) assessment and categorization of patients based on the type and severity of their injuries. This process is supervised by the triage officer. Number and category of patients is reported to ICS and the Medical Control Hospital. Normally triaged patients are given no treatment other than airway positioning and major bleeding control, are categorizes into 3 priorities or dead. In addition to patients, there are also individuals that can be categorized as an "affected person". These individuals are not injured but are affected by disaster and may require transport or evacuation from the area. The use cases will include affected persons in order to track their egress from the scene. Patients are then treated in the field at either a treatment area or field hospital. This process is supervised by treatment officer who also collaborates with ICS and Medical Control. During treatment a decision is made if the patient is to be transported to a field hospital, a traditional hospital, or released. Patient destination decision is made by collaborating with the Transport Officer, Medical Control Hospital based on patient condition / priority, hospital availability, and patient wishes. Patients are then transported by Ambulance to receiving facility. Unit and patient data is recorded by Transport Officer and patient information is sent to the receiving facility. Finally the patient is transferred to receiving facility, and the transport officer is informed of the patient disposition.

USE CASE ANALYSIS

From our data model analysis, we constructed two use cases to extract a common set of data exchange patterns. The two use cases were a day to day EMS operations (a "typical" EMS call) and a Mass Casualty Incident (with ICS implemented). From these two use cases we have extracted the following common set of activities: Creating / Updating an Incident, and EMS activities including Triage, Treatment, and Transport. Bound within creation or updating of an incident are individual events within a larger incident, units assigned to each event, points of interest, areas of interest, situational representation, and current ICS structure. EMS activities include triage records, hospital status, pre-hospital care reports, and patient information.

Field sensor data to be captured in these use cases include geo-tagged images from smartphone devices, vital signs, summary data from field ECG monitors, triage tag information, and field chat data.

PRELIMINARY RESULTS

Our preliminary results have led to the adoption of the EDXL Distribution Element (EDXL-DE) as our top-level loose coupler. The EDXL-DE standard was designed by OASIS as a generic loose coupler that can carry a variety of structured payloads, is designed with cross-domain routing in mind, and has seen adoption within the First Responder community. In addition to EDXL-DE, we will leverage the EDXL Hospital Availability (EDXL-HAVE) standard for transmission of hospital availability and status. We are working closely with the OASIS Emergency Management Technical Committee (EM-TC) on their current work with EDXL Situational Representation (EDXL-SR) to incorporate gaps in the data model that exist for field units to report information about a current event to ICS. EDXL-SR is primarily focused on ICS reports to document ICS operations, however we feel in light of our findings within the data model a message set can be developed for field unit reporting that would allow auto-creation of EDXL-SR reports for ICS. We will also be transferring our findings on the EMS specific activities for the EDXL Tracking of Emergency Patients (EDXL-TEP) to the EM-TC once this effort is transferred to OASIS for implementation.

With a preliminary messaging structure defined we are developing a backend message handling system. This message handling system will both route messages to the appropriate clients as well as handle message orchestration by escalating "stale" messages among Incident Command. Routing is accomplished by implementing a Service Oriented Architecture (SOA) style of design with a mechanism to route messages based on their XML content and context of the ICS structure. Services will allow client to publish and subscribe messages into the SOA. The system will route messages based on dynamic routing rules. These rules are auto-generated by the system based on the ICS structure logged onto the system or they may be manually entered by client applications. This provides both ease of use for non-technical end-users who will most likely use a pre-defined set of user interface widgets based on their role along with the flexibility of being able to support unforeseen circumstances which will often arise during large scale and long term emergency response.

Message orchestration allows important messages to be handled in a timely manner without overwhelming IC staff. Rule-Based message re-routing/escalation allows messages sitting in a queue to be re-transmitted to other able ICS staff to be addressed. Message orchestration also creates an infrastructure in the system for message passing among ICS staff for enhanced collaboration.

The system also provides message archiving for incidents. This allows secondary responders and above to be brought "up to speed" without diverting attention from ICS staff who are still managing an incident. It also allow responders from the Local to the Federal level to preform incident/team debriefing as well as incident analysis to determine what went right and what went wrong during an incident.

To facilitate digital input of field image data we are working to create phone-agnostic software that can be integrated into field MDTs. This would allow first responders' cellular phones to connect to the field MDT to transmit their geo-tagged images into the IC.NET system. Triage data will be captured digitally by utilizing similar phone based applications combined with camera based bar-code scanning or by capturing providers' handwriting by digital pen. ECG monitor data captured through communication between the field ECG monitor and the MDT computer.

Finally, to leverage the message handling system we are developing a web-based user interface that will be composed of a set of "widgets" that will be implemented with real-time publish/subscribe capabilities of messages on the network. The user interface will be pre-fabricated with capability sets for anticipated users. Anticipated users are based on the ICS structure defined by FEMA. In addition users will be able to add/remove/create capabilities during incident evolution based on the services available in the SOA in conjunction with message routing rules. This allows users to create command "context" that is determined by what ICS staff and management facilities are logged into the system. This context allows the backend message handling infrastructure to pass messages with an appropriate level of detail to the end users based on their role and the breadth of the total ICS roles on the network. This results in users only getting the type of information with an appropriate level of detail needed to do their job and make their decision. This will cut down on information overload as well as reduce time for ICS users to filter through unnecessary or over-complex data. To implement the user interface component we plan to leverage the existing work of the Warfighter Widgets MOIE by implementing their common widget language and infrastructure, leaving us only to have to create the actual ICS widgets for our demo. This web interface is only meant to illustrate the utility of utilizing data standards combined with the underlying messaging architecture. The intent of this research is to highlight that any interface

CONCLUSIONS

IC.NET is a work in progress prototype designed to bring focus on the need for interoperable systems and data standards for CAD and MDT software. This work has developed a data model for the First Responder Domain, extracted common data exchange patterns for two EMS use cases, married existing data standards where applicable, and identified gaps in the data model. By combining these loose couplers with a dynamic and intelligent message routing system that is both content and context aware, we have created an environment that captures comprehensive field data and routes it to the appropriate parties within ICS and their stakeholders.

REFERENCES

1. Brady, T. (2003). Emergency Management: Capability Analysis of Critical Incident Response. *Proceedings of the 2003 Winter Simulation Conference.*
2. Chen, R. et. al. (2008). Coordination in Emergency Response Management. *Communications of the ACM*, 51(5), 66-73
3. Chipman, R. et. al. (2008). *Network Based Information Sharing Between Emergency Operations Center*. IEEE Xplore.
4. Emergency Interoperability Consortium [EIC] (2009). *The Emergency Interoperability Consortium.* Retrieved from the EIC Web site: http://www.eic.org/

5. Federal Emergency Management Agency [FEMA] (2009). *About the National Incident Management System (NIMS).* Retrieved from the FEMA Web site: http://www.fema.gov/emergency/nims/AboutNIMS.shtm
6. FEMA (2009). *Disaster Management Interoperability Services – Open Platform for Emergency Networks (OPEN).* Retrieved from the Disaster Help Web site: http://www.disasterhelp.gov/disastermanagement/open/index.shtm
7. FEMA (2008). *Incident Command System (ICS), Review Materials.* Retrieved from the FEMA Independent Study Web site: http://training.fema.gov/EMIWeb/IS/ICSResource/assets/reviewMaterials.pdf
8. FEMA (2008). *IS-100 Introduction to Incident Command System ICS-100 Instructor & Student Guide.* Retrieved from the FEMA Independent Study Web site: http://training.fema.gov/EMIWeb/IS/is100alst.asp
9. FEMA (2008). *IS-200 ICS for Single Resources and Initial Action Incidents ICS-200 Instructor & Student Guide.* Retrieved from the FEMA Independent Study Web site: http://training.fema.gov/EMIWeb/IS/is200alst.asp
10. FEMA (2009). *IS-700 NIMS An Introduction Instructor & Student Guide.* Retrieved from the FEMA Independent Study Web site: http://training.fema.gov/EMIWeb/IS/is700alst.asp
11. Leonard, H. B. and Howitt, A. M., *Against Desperate Peril: High Performance in Emergency Preparation and Response*, forthcoming in *Communicable Crisis*, edited by D. E. Gibbons. Leonard and Howitt, professors at Harvard's Kennedy School of Government, have researched the characteristics of novel crises and have distinguished sudden crises from emergent crises.
12. Organization for the Advancement of Structured Information Standards (OASIS) (2006). *Emergency Data Exchange Language Distribution Element (EDXL-DE) 1.0 OASIS Standard.* Retrieved from the OASIS Web site: http://docs.oasis-open.org/emergency/edxl-de/v1.0/EDXL-DE_Spec_v1.0.pdf
13. OASIS (2008). *Emergency Data Exchange Language Hospital Availability Exchange (EDXL-HAVE) 1.0 Public Review Draft.* Retrieved from the OASIS Web site: http://docs.oasis-open.org/emergency/edxl-have/pr05/emergency_edxl_have-1.0-spec-pr05.pdf
14. OASIS (2009). Emergency Data Exchange Language (EDXL) Requirements Statement and draft Messaging Specification for the Situation Reporting Messaging Standard (EDXL-SitRep). Retrieved from the OASIS Web site: http://www.oasis-open.org/apps/org/workgroup/emergency-msg/download.php/32999/EDXL-SitRep-Rqmts-MsgSpec020209.pdf
15. OASIS (2009). *The Distribution Element:The Basic Steps to Package and Address Your Emergency Information.* Retrieved from the OASIS Web site: http://www.oasis-open.org/apps/org/workgroup/emergency/download.php/34264/EDXL-DE-Basics-WhitePaper-18Aug09-r2.doc
16. FEMA (2008). *IS-800 National Response Framework, An Introduction Instructor & Student Guide.* Retrieved from the FEMA Independent Study Web site: http://training.fema.gov/EMIWeb/IS/is800blst.asp
17. FEMA (2008). *National Incident Management System.* Retrieved from the FEMA Web site: http://www.fema.gov/emergency/nims/
18. FEMA (2009). *National Incident Management System Supporting Technology Evaluation Program.* Retrieved from the NIMS-STEP Web site: https://www.nimsstep.org/Default.asp
19. FEMA (2008). *National Response Framework.* Retrieved from the FEMA Web site: http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf
20. Jain, S. et. al. (2007). Towards Standards for Integrated Gaming And Simulation For Incident Management. *SCSC.*
21. Truong, H. et. al. (2009). On Modeling, Collecting and Utilizing Context Information for Disaster Responses in Pervasive Environments. *CASTA '09.*
22. United States Department of Homeland Security [DHS] (2009). Emergency Data Exchange Language (EDXL) Project Initiation Document (PID) For the Tracking of Emergency Victims (EDXL-TEP) Messaging Standard PHASE I - Tracking of Emergency Patients (EDXL-TEP). Retrieved from the Evotec inc. Web site: http://www.evotecinc.com/TEP/index.php?dir=&file=EDXL-TEP%20Project%20Initiation%20Document%20%28PID%29%20v4%201.pdf
23. Bledsoe, Porter, Cherry. (2006). Paramedic Care Principles & Practices: Special Considerations Operations. Second Edition. Upper Saddle River, NJ: Pearson Education.