

Information Requirements for Context-Aware Multi-Agency Real-Time Coordination during Crisis Response

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ABSTRACT

Most information systems (IS) research into emergency management (EM) consists of case studies of prior disasters, social behavior research, and planning or preparedness research. This study fills a gap in EM and IS research as it aims to better understand the nature of coordination during crisis response; investigate the functions and capabilities of existing coordination systems; and identify the desired functions to manage multi-agency coordination response. Grounded theory is the methodology adopted for this study. Firsthand interview and observational data will be collected from agency command centers, ride-outs with police, fire, and emergency medical services (EMS) agencies, and from multi-agency training exercises. This study is expected to make a theoretical contribution to crisis response system design as it will develop a theory to better understand the information requirements for context-aware multi-agency real-time coordination responses to crises.

Keywords

Crisis response, multi-agency, coordination, grounded theory.

INTRODUCTION

When a crisis occurs, maintaining effective communication and coordination is an important challenge to managing an effective crisis response and minimizing damages or loss of life (Seeger, 2006). Larger scope disasters require more complex coordination efforts in order to deal with diverse technical, social, and organizational communication networks (Seeger, 2006).

The ability for diverse emergency responders such as police, fire, and emergency medical services (EMS) to communicate and coordinate is often called interoperability. Interoperability is the process of maximizing opportunities for the exchange and re-use of information, whether internally or externally, through the management of systems, procedures and the culture of an organization (Miller, 2000). Amongst the various emergency services, interoperability tends to focus on technical or hard interoperability which relies on technological factors such as hardware, communication protocols, storage, etc. for the exchange of information. However, other forms of interoperability, characterized as soft interoperability, such as semantic, human/political, inter-community, legal, and international operability (Miller, 2000) exist and may influence communication and coordination.

Coordination

Coordination (consisting of goals, activities, actors, and interdependencies) can be defined as the management of interdependencies between activities to achieve a goal (Malone & Crowston, 1990). Coordination has also been described as the fundamental task of the firm in order to maximize the efficiency gains from specialization (Grant, 1996). With Grant's perspective, transferring knowledge is not as efficient as integrating knowledge, thus making coordination a priority. An emergency response requiring the coordination of more than one type of agency (such as police, fire, or EMS) or multiple agencies of the same type (ie. fire fighters from multiple

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jurisdictions) is considered a multi-agency response for this study. Furthermore, this study adopts a working definition for multi-agency coordination (consisting of goals, activities, actors from multiple agencies, and interdependencies) as the management of interdependencies and integration of knowledge between activities and agencies in order to achieve a goal. Therefore, coordination behavior would be activities performed or information shared by responder agents in order to facilitate the completion of interdependent activities. For example, to rescue a trapped victim, coordination behavior may be firefighters using the jaws-of-life to free somebody from a vehicle so that paramedics may then transport the patient to a hospital.

An information system that facilitates the exchange of information between a responder and others to aid in crisis response is a crisis response coordination system. For example, many ambulances are equipped with vehicle locators which track their movement and transmit that information to a mapping system. This system allows dispatchers to see where all the ambulances are in a city and dispatch the EMS crew able to respond the quickest to a scene.

Context and Context-Awareness

Recently new information tools have been implemented to assist emergency responders in locating people calling for emergency assistance. Emergency responders in Canada used to be unable to accurately determine where a call came from when placed by mobile phone, but legislation forcing telephone companies to upgrade their cellular towers now allows emergency call centers to receive exact GPS locations of callers, technology permitting, or triangulated latitude and longitude of the device so that responders can locate callers. This ability to guide responders using automatically sensed location-based information is part of a growing area of information systems research called context-aware computing.

Context has been defined as the set of environmental states and settings that determines an application's behavior (active context) or characterizes the conditions in which an application event occurs (passive context) (Chen & Kotz, 2000). Context-awareness is the use of sensors or other information sources to measure environmental conditions and identify many low-level contexts (location, temperature, orientation, time, etc.) (Chen & Kotz, 2000). Context-aware applications combine environmental and low-level contexts using artificial intelligence to develop higher level complex contexts (Chen & Kotz, 2000). Context-aware computing utilizes both active and passive context-aware applications where active context-aware applications automatically adapt application behavior when new context is discovered; and passive context-aware applications adapt the presentation of information.

Objective

While on the front lines during a crisis response, it is often responders that interact directly with the environment and other agencies. Responders require as much relevant contextual information as possible in order to respond appropriately to a crisis. Responders also may report back additional contextual information to dispatchers or coordinators so additional response activities can be planned. Contextual information is an integral part of coordinating emergency responses.

It appears much of the existent information systems literature on crisis response coordination emphasizes the practical implementation of systems and ignores theoretical foundation or provides no new theory for further analysis and improvement of crisis response. This study aims to explore the nature of multi-agency crisis response at the local level of responders, and incorporate the growing field of context-aware computing to lay the foundation for a theory of context-aware multi-agency crisis response.

METHODOLOGY

Classic grounded theory is the methodology chosen for this study as it provides the scientific rigor necessary for new theory formation, the stated output of this study. The data used to help formulate a new theory will consist of observations of i) the coordination tasks performed during crisis response; ii) the coordination systems used; iii) the relationships between the tasks, people, and systems for coordination support; iv) the performance of coordination; and v) the relationships between tasks, people, systems and performance associated with context-aware multi-party coordination by emergency responders.

The traditional techniques for classical grounded theory include data collection and analysis, conceptualization and abstraction, identification of the core category, theoretical sampling and saturation, and theoretical coding. A survey of other existing theories will be performed and incorporated into the final proposed theory after a core category for the study has emerged in an attempt to limit any bias in research that may emerge from

incorporating prior theory too early into the process. It is anticipated that existing theories on crisis management and response, multi-party coordination, context and context-aware computing, and group decision support systems will inform the emergent theory.

In this study, initial data collection is to take place during embedded ride-outs with police, firefighter, and paramedic emergency responders. In addition, data collection will occur at emergency dispatch call-centers as an embedded observer. In these situations, data will be collected based on observations of employee tasks, interactions, communication, use of technology, and contextual information related to coordination. Furthermore, the use of open interviews with participants regarding their tasks, interactions, communication, use of technology, and perceptions of context will also be recorded. Open interview questions will evolve after an initial introductory interview followed by initial observations. Prior research, popular media such as newspapers, and other credible sources will also be used as sources for data. Data analysis follows each data collection opportunity. NVivo9 qualitative data analysis software will be used to aggregate common ideas and identify concepts and themes repeated in data collection. This analysis is necessary as it directs future information gathering such as interviews and observations through the incorporation of all emergent relevant issues (Corbin & Strauss, 1990). The sampling of gathered data is of i) the incidents, events, and happenings of the crisis response environment; ii) the conditions that facilitate, interrupt, or prevent the ability to respond to crises; iii) the manner in which response is observed; iv) the interactions between multiple parties during a response; and v) the resulting consequences of the response. Data will be stored using written notes and digital recordings where appropriate. As data is collected it is organized into concepts. The practice of *theoretical memoranda* will be used to explore relationships between concepts as they emerge by systematically recording patterns, thoughts, questions, relationships between interviews, emerged themes, and concepts and themes in literature (Martin & Turner, 1986; Corbin & Strauss, 1990; Giske & Artinian, 2007). As observations and data continue to be gathered, only the data directly relevant to those categories will be coded. The repeated presence (or absence) of concepts from data collection are incorporated into an evolving theory (Corbin & Strauss, 1990). Data collection will cease once theoretical saturation is achieved; a state in the research where no new categories or properties emerge from the collection of new data (Glaser & Strauss, 1967). Until that point, more samples are needed for comparison purposes (Corbin & Strauss, 1990). Theoretical coding will conclude the methodology where the concepts will be related around the core category and presented as a theory.

The participants in this study are police officers, fire fighters, paramedics, emergency call center coordinators, and any related supervisors who participate in local crisis response operations. These participants are located in various urban and rural communities in Southern Ontario, Canada. A combination of six different regions and four other local or provincial services have been targeted for participation with a goal of having 33 interview sessions, 21 ride-outs, and 21 call-center observation sessions divided amongst the various responder services. The number of participants is unknown and not relevant for this study as the number of incidents is more important in order to achieve theoretical saturation.

The recruitment for participation was initiated with known contacts. The known contacts permitted the use of their names to contact new leads which included police, fire, EMS, community emergency management coordinators (CEMCs) and contacts in related supporting agencies at the provincial level. Other participants were sought using the internet to gather contact information and then either telephoned or e-mailed in order to setup a meeting to discuss the study.

RESULTS

The results reported in this paper have been acquired from an initial 9 interviews, 2 ride-outs, and 3 observation sessions involving over two dozen participants. This data has been collected from call-takers and dispatchers for police and EMS, operations managers, supervisors and responders in EMS, a responder for fire services, CEMCs for a large city, sergeants in charge of a communication center for police, and a deputy chief in charge of EMS for a large city.

A sample of the areas discussed include interoperability standards, communications methods, and current context-aware technologies.

Interoperability Standards

Technology standards amongst all the services and departments do not exist with the exception of EMS. Each jurisdiction chooses its own radio, communication, and information systems. Even amongst the OPP the technology can vary as they are contracted to perform police services for various communities and their vehicles are outfitted differently according to the agreements in place with the communities.

Interoperability solutions do exist with current radio systems that allow all agencies to communicate, but they require the use of designated channels not normally monitored, or the use of extra radios to patch into a software solution integrating each agency's communication network. In addition, responders must use plain language and not agency-specific jargon so that everybody can understand what is being discussed.

Communication Methods

Intra-agency communication methods vary by purpose. For police and EMS the use of a telephone is primarily for management issues and to avoid filling the radio airwaves with non-emergency chatter. In addition, police highlighted the use of a cellular phone to take conversations offline as all landline calls and radio communication in a call center are recorded. The radio was for dispatch-responder communication only and idle chatter was minimal. The radio systems managed by dispatchers usually had neighboring jurisdictional agencies available so that they could be brought into a talk group if necessary, but this rarely occurs. Inter-agency communication was from dispatcher of one agency to a call-taker in another agency using the traditional emergency phone line. There was no mechanism to share data entered electronically between call-centers of two similar or different agencies.

Current Context-Aware Technologies

A few context-aware technologies are currently in place with the agencies studied. All ambulances in Ontario are equipped with location-based tracking via the Automated Vehicle Locator (AVL) system. While most fire and police services do not have a similar system, several departments are trialing similar technology. Many police radios have specific buttons that indicate whether officers are enroute, arrived at a scene, available, in court, want to clear a call, or require assistance. These buttons are integrated with the dispatch system and timestamp and update officers' status when pressed. Finally, call-takers for police receive location-based coordinates and caller identification when emergency calls hit their system.

DISCUSSION

Overall, participants have been very supportive of the research plan and very few barriers were presented. The few barriers presented included a new senior manager concerned about looking ill-prepared for a multi-agency training exercise, and a police service that did not feel the study provided enough of a direct value to their service to warrant participation.

The results presented above are a limited representation of results that were observed or discussed. The general impression received from the participants is that each agency does its job very well, but they do not necessarily coordinate or share information well. It was observed on several occasions that responders from the various agencies would barely speak two sentences to one another. They performed their individual tasks as expected while only speaking to their immediate colleagues. The only information shared between agencies that was observed was a question by police regarding which hospital the victim was being taken to by EMS. On one emergency medical call where all of the agencies responded, at least three police vehicles responded to the scene while EMS only responded with an ambulance and a supervisor. A context-aware system could have informed police dispatch that three vehicles were responding so one or two of them could be reassigned.

Early indicators are the factors influencing context-aware coordination appear to be more organizational and behavioral issues as opposed to technical. The issues range from costs, to responder perceptions of being monitored continuously, to concerns about reliability, and concerns about training on the equipment.

The ability to generalize this study from a specific region to a global setting depends on the alignment of attributes in the initial region to that of new locations. One technique to generalize results is to perform a multi-site study seeking a wide variety in shared attributes (Firestone, 1993). This is attempted in this study by collecting data from several regions in Ontario with both urban and rural settings, various economic conditions, various regional priorities, and studying the various agencies operating in the regions. In addition, the descriptions of agency contextual and operating environments in the complete study will allow the comparison to other regions around the globe to identify commonalities and suitable fit allowing the results to be suitably applied to the new location. This study is immediately expected to be applicable to most North American locations as several attributes such as infrastructure, cultural, and operating perspectives align between Canada and the United States.

The ability to apply the results of this study from smaller crises requiring multi-agency responses to larger disasters depends on the similarity of factors influencing coordination. A senior emergency planning participant

stated, "The only thing different between a small crisis and large disaster is the scale. The work is still the same." Initial observations indicate responder concerns exist about efficient communication via interoperability, adequate training, and fears of sharing sensitive information or looking bad if there is a problem. Many of these concerns resemble crisis response coordination concerns expressed in studies of larger disasters (Gheyntanhi, 2007; Quarantelli, 1997). This may indicate that the final results of this study should scale well to larger disasters.

CONCLUSION

This paper presents a study in progress to develop a theory for context-aware multi-agency coordination during crisis response. Grounded theory has proved to be a very suitable methodology thus far as it is able to adapt to the dynamic needs of the research involving participants with various responsibilities from different agencies of emergency response. The early results have identified the current uses of context-aware computing available to emergency responders and have identified a few early trends indicating contributing factors to multi-agency coordination. The final results of this study may be applicable to other areas around the globe and to disasters of larger scale due to the use of multiple sites to gather data, and due to the apparent similarities of concepts contributing to crisis response coordination. The concepts and categories that will ultimately contribute to a new theory for context-aware multi-agency coordination are yet to emerge but early conceptualization has begun.

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