A Prototype Multi-Modal Decision Support Architecture

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ABSTRACT

This paper presents the design of a decision support tool for crisis response applications. We propose a system to replace emergency contact calling trees with a multi-modal personnel contact architecture. This architecture consists of a centralized notification framework using existing enterprise e-mail, Web site, instant messaging, and voice over IP (VOIP) infrastructure. Response and audit data is collected and stored for analysis, and can be reviewed using a variety of methods in real time. Details of our prototype implementation are discussed. Specifically, we address multi-modal communication techniques and their benefits, enterprise deployment challenges, and opportunities for further research.

INTRODUCTION

In an emergency situation, an organization's leaders and managers need clear, accurate real-time information about the effect of the disaster upon human resources and the readiness status of the organization. Previous research at the MITRE Corporation has shown that one of the key IT elements for emergency response is the availability of decision support tools (Graves 2004). The MITRE Crisis Response System prototype provides real-time data for decision support, and offers a number of benefits over a typical emergency calling tree.

Standard emergency calling trees suffer from a number of drawbacks. Failure at any point in the calling tree can result in large numbers of personnel never being contacted and hamper efforts to assess organization readiness. Other attempts to contact employees in case of disaster may be additionally hampered by severed phone lines, unavailability of the Internet, or other forms of infrastructure damage. Employees may never even know that someone is trying to contact them. Sharma et al. explain that:

> *[Multi-modal interfaces] offer the potential for considerable flexibility, broad utility, and use by a larger and more diverse population than ever before. A particularly advantageous feature of multimodal interface design is its ability to support superior error handling, compared to unimodal recognition-based interfaces, in terms of both error avoidance and graceful recovery from errors. (Sharma 2004).*

We suggest that the chance of successfully contacting individual employees in an emergency situation would be higher via a multi-modal system than via a standard call tree. We believe this is due to the increased flexibility and usability of a system employing multi-modal communication, and the higher quality of information available for decision-making.

SCENARIO

John Smith, Director Strategic Site Management, has received an e-mail message on his BlackBerry notifying him that the National Oceanic and Atmospheric Administration (NOAA) National Weather Service has issued a tsunami bulletin for a region containing the company's overseas headquarters. John quickly learns that the company has been directly affected and activates the Crisis Response System.

Within minutes, operational readiness data is available to the organization's leadership and management teams. John can see which of the employees who directly report to him are missing at a glance. He can also drill down in greater detail by location, center, or organization to determine the effect upon the company more specifically. He can see all the prior messages that have been sent out though the system, and go back through the results of those emergency situations.

Anyone traveling or living within the area of the site receives a message via the Crisis Response Network. Employees are contacted via phone, instant messenger and e-mail and are able to acknowledge receipt of the message back to the system, ultimately confirming their location and safety. Team leader Tom Brown learns of the situation and logs into the system. The "Leadership View" provides data on the organization readiness at his departmental level as shown in Figure 1. Human resource statistics for each department are displayed as separate stacked bar graphs, along with the organization's overall status. The bar graphs demonstrate clearly which departments have been hit hardest by the disaster and aid in decision-making for resource allocation. Tom can see the status of employees in his department, and the details of what attempts have been made to contact those employees who have not yet responded. The management view shown in Figure 2 allows team leaders to obtain the greatest level of detail for a single team, enabling them to quickly identify missing team members and determine how employees have responded and at what time. Detailed logging

provides a history of responses that ultimately can be viewed by any person with access to the real-time updates. Managers can also mark employees as "found" if they contact the employee personally.

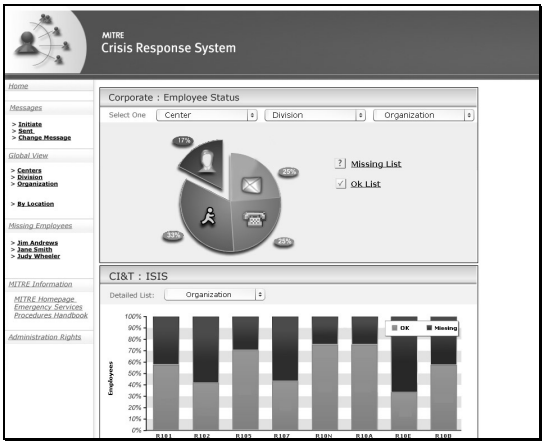

Figure 1. MITRE CRS: Leadership View

User Interface

The user interface for this system is designed to allow at-a-glance extraction of essential information, with three primary views for different management roles. If a secondary crisis arises, crisis managers can reactivate the system with a new message while still viewing response reports and contact data for previously recorded emergencies. The color scheme was chosen to be familiar to most users. Red, associated with danger, is used for employees whose status is unknown. Green has a strong emotional correspondence with safety so it is used to highlight employees who have responded.

Figure 2. MITRE CRS: Management View

Should an employee not respond to any system alerts, the system will prioritize those "missing" employees by placing their information at the top of the display. The display could order them further by seniority, or alphabetically. All accounted-for employees appear lower on the display, with the method by which those employees were contacted.

PROTOTYPE ARCHITECTURE

The MITRE Crisis Response System consists of two servers operating in tandem. The Personnel Status Server is responsible for managing requests for employee status information and determining which employees still need to be contacted. Detailed logs are kept of both successful and failed contact attempts; these logs are accessible in real time as well as afterwards for review. The Communications Server manages and tracks contact attempts, and handles all inbound and outbound communications with employees. The system is platform independent, and runs in a Java Servlet container. Employee status data is available via a dynamic Web site, accessible with any browser. The multimodality of the system provides redundancy in the employee contact process and the platform-independence of Java Servlets provides flexibility; primary concerns in information system design for crisis response (Mahinda, Whitworth 2004).

Activation

The system is activated via an Internet-based form. Once activated, it creates a list of which employees need to be contacted. Employee contact information is mined from existing company data stores such as LDAP or Active Directory employee databases, as well as other existing electronic sources. These data sources can be configured to meet the needs of the company doing the deployment. Although a Web-based activation interface was implemented as part of this prototype, there is no practical reason that the multi-modal nature of this system could not be extended to allow managers to start the system via instant messaging, e-mail, or even a phone call. A message could easily be selected via a touch tone phone from a preconfigured set. As the quality of voice recognition technologies improves, the system could eventually allow for natural language interaction via the telephone.

Staff Contact

The communications server contacts staff members via telephone, instant messaging, and e-mail. Phone calls begin with work extensions, but eventually move on to cellular phone numbers and other possible contact points. In our prototype implementation, employees could specify which phone numbers should be tried first. Instant messages and e-mails are sent almost immediately, and can be answered at any time. The use of wireless "text messages" over narrowband PCM could offer significant advantages in emergency situations, as suggested by Kapsales; the system is able to utilize text messaging via the e-mail interface provided by wireless providers (Kapsales 2004). Successful contact via any single communications mode will update the employee's status on the Personnel Status Server, and all contact attempts to that employee will cease.

Cherry suggests that the "presence" data available about users in most instant messaging programs has been a key factor in its corporate adoption (Cherry 2002). If someone tries to contact an instant messaging client, managers could currently check whether an away message was returned in the logs. It could eventually be possible to parse that presence data to provide additional information about employee status without needing a team leader to read it. Others suggest that presence data will be integrated into additional software products besides instant messaging clients in the future; as this trend continues, presence data could eventually play a much larger role in the system (Vaughan-Nichols 2003).

In our prototypical implementation, the communications server used CallXML and a hardware call manager to interface with the Voice over IP system. A commercial Java API was used to interface with the various instant messaging protocols. Outgoing e-mail was sent from a standard SMTP account on the corporate mail server, and incoming e-mail was stored in an IMAP folder for later reference. A similar model to what is implemented in the prototype would be sufficient for most large scale deployment scenarios, with the exception of the Voice over IP system. In a large scale deployment scenario, we would suggest outsourcing core communications such as telephony call management. Doing so would avert a significant infrastructure investment needed to accommodate a large number of concurrent calls.

FINAL COMMENTS

While the system prototype uses multimodal techniques to contact employees, the real-time status information is currently only available to crisis managers through a Web interface. Voice over IP and instant messaging interfaces to the status data would provide another layer of accessibility for crisis responders in the case of an actual disaster. The MITRE Crisis Response System was designed to fit the needs of a single organization, and to assist in decision making while reacting to the crisis. The architecture could be restructured to serve the needs of multiple organizations, providing a crisis response system that could be shared between agencies or even physical locations. In the future, we predict that similar crisis response systems will be offered on a per-contact/event subscription service.

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