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# EVResponse - Moving Beyond Traditional Emergency Response Notification

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## ABSTRACT

Federal, state and local governmental agencies have been investing considerably in emergency response management systems to assist crisis management officers in the assessment, mitigation and response to emergency situations. In crisis management contexts, the timeliness of a response may be determined with reference to a fixed instant in the form of an absolute action threshold. This establishes the last possible point in time where any sort of solution is available. Once an action threshold is passed, a crisis is no longer containable; whatever adverse consequences a problem portends are thereafter inescapable. In this paper, we describe a special GIS-based response management system, EVResponse that combines GIS capabilities with web based voice translation technologies such as VoiceXML to effectively coordinate the pre, current and post crisis management activities. VoiceXML provides open standards based methodology to facilitate the integration and communication of emergency response systems with existing disaster planning systems. The EVResponse application uses web services to provide real-time reporting capabilities to both decision makers and first response units.

## Keywords

Geographic Information Systems, Emergency Response Management Systems, EVResponse, Voice Technology, Decision Support Systems, VoiceXML

## INTRODUCTION

Federal, state and local governmental agencies have wide range of responsibilities in managing and responding to various natural disasters such as hurricane and tsunami, and un-natural emergency situations such as bioterrorism attacks and toxic spills. Complexity associated with the handling of emergencies that typically cover wide geographic areas dictate the need for powerful computer software to enable effective and quick dissipation of timely notification to the affected areas. Geographic Information Systems (GIS) based applications allow the referencing and analysis of spatial data and is heavily used by decision makers to provide critical crisis specific support. In this regard, several GIS based emergency response systems have been developed to assist governmental agencies to analyze, manage and respond to crisis (Fuhrmann et al., 2003; Gunes & Kovel, 2000; Keenan, 1997; Mennecke, Crossland, & Dangemond, 1994; Stone, 2004). Emergency Response Management usually revolve around the activities immediately prior to, during and post crisis, and focus mainly on saving lives and minimizing damages to property (Gunes & Kovel, 2000). In crisis management contexts, the timeliness of a response may be determined with reference to a fixed instant in the form of an absolute action threshold. This establishes the last possible point in time where any sort of solution is available. Once an action threshold is passed, a crisis is no longer containable; whatever adverse consequences a problem portends are thereafter inescapable. Timeliness and access to real-time updates of the situational factors in the affected zone play a critical role in ensuring effective crisis management decisions.

An effective emergency response system should at a minimum have the following functionalities. It should support the efforts to mitigate the impact of disaster, enhance preparedness and assist in responding to disasters with follow up and recovery plans. GIS based applications are valuable tools that help decision makers deal with emergency management and respond in a timely fashion. Such tools should ideally help to accurately plot the geographic location of the disaster based on user inputs, notify first responders and provide detailed information about the crisis to the emergency response planners. Furthermore, the application should have reporting features to help incident tracking and reporting for post crisis analysis and

risk assessment. Post crisis analysis is core activity undertaken by emergency management teams so that historical incident data can be used to improve strategies to handle future crisis that are similar in nature.

Although existing emergency response systems incorporate many of the above features, they still lack in robustness to reach out to the common mass effectively and convey critical life saving and property conservation messages (Gunes & Kovel, 2000; Stone, 2004). Currently most emergency response systems in place are unidirectional that channel pre-recorded messages to the community with no real means to interact or analyze responses returned from the people affected. In addition, most existing systems require extensive human intervention to communicate evacuation plans and notifications to the communities most likely to be affected by the crisis. Since notifications are best communicated via telephones, the communication process is slow, time consuming and places high demand on the personnel. The situational complexity is usually made worse due to the immediate unpredictability of the effects of the crisis as well as the inability to provide comprehensive spatial information (operational – such as spatial prediction of the coverage area following a toxic aerosol leak and, tactical – such as cordon traffic from a particular direction) to the first response teams in a real-time manner.

In this paper we present EVResponse, a GIS-based decision support system for emergency response management that takes advantage of the functional benefits of VoiceXML. The EVResponse application also uses a combination of other diverse Internet-based technologies (such as XML standards, web services) and combine it with GIS mapping data to provide decision makers with comprehensive information specific to the crisis situation in a dynamic and timely fashion. GeoResponse uses web services to let other application access relevant data as well as provide easy accessible web-based reports to agencies and managers. Multi-device, multi modal support ensure that location specific emergency plans and evacuation notifications can be directed to newer, more popular Connected Device Configuration (CDC) devices such as PDAs, web enabled mobile phones, MMS pagers and other smart devices. Responses and valuable information from the people can also be captured and made available to the emergency response team.

The paper is presented as follows. We first provide a brief background of the application of GIS software in emergency management systems and present a preview of the capabilities of VoiceXML and web services that can be employed to enhance the power of a GIS-based emergency response system. We then describe the detailed architecture of the EVResponse system, followed by a real world example to demonstrate the architecture. In the third section we highlight the architectural benefits of EVResponse that make it superior to other existing systems. The paper concludes by summarizing the strengths of the architecture and the limitations that can open interesting new avenues for research in the future.

## BACKGROUND

Crisis management requires the collaboration and coordination of different groups (fire marshals, paramedics, first response teams, Environmental Protection Agency personnel, etc.) working together to disseminate information and provide diverse services to people in and around areas where crisis has occurred. Handling the situation is further complicated by the fact that the responding personnel are rarely housed at the same locational facility. In addition, there is an urgency with which the communities in the disaster zone have to be contacted. All these factors amplify the need for an efficient automated communication and management system to initiate the response process with minimal user intervention.

Integration of mapping data through GIS provide decision makers and emergency management personnel with powerful capabilities to make informed decisions, and share knowledge with others based on visualization and interpretation of spatial data (ESRI). IT investments, especially emergency response systems can gain an upper edge by combining spatial maps with crisis specific information to provide better decision making and analysis tools to quickly respond to a crisis situation. GIS extend the capabilities of traditional database systems in that they enclose spatially-referenced information (cartographic coordinates, layers, etc.) as well as textual data (attributes and aspatial data) making them powerful tools for advanced modeling, designing and planning, and imaging capabilities for spatial analysis (Chrisman, 1997; Sugumaran & Sugumaran, 2003). As such GIS have wide range of application in organizations typically providing decision support (Pick, Viswanathan, & Hettrick, 2000). In fact GIS applications are taking on prominent roles in business as well as in governmental agencies (Fuhrmann et al., 2003; Grimshaw, 1999; Pick et al., 2000). GIS thus serves as an effective decision support tool due to its ability to visually display data in the form of maps (Speier & Swink, 1998).

Mennecke et al. summarize the characteristics of GIS and the growing interest of GIS to both academics and practitioners when they write that:

Geographic information systems (GIS) represent a class of decision support tools that are attracting increasing interest in both the academic and practitioner communities. GIS technology offers a way to integrate spatial data (e.g., maps, floor plans, virtual space) with databases containing textual, analytical, and graphical data. The resulting information set contains data that are referenced to geographically-accurate locations in space and can be used for complex spatial analyses by decision makers. GIS have been used for many years in the natural resources, forestry, and environmental industries. GIS are now increasingly being

used for a number of business and management functions such as logistics, site management, facility management, marketing, public policy and planning (Mennecke et al., 1994, p. 506).

Other researchers have extensively discussed the use of GIS for emergency management.

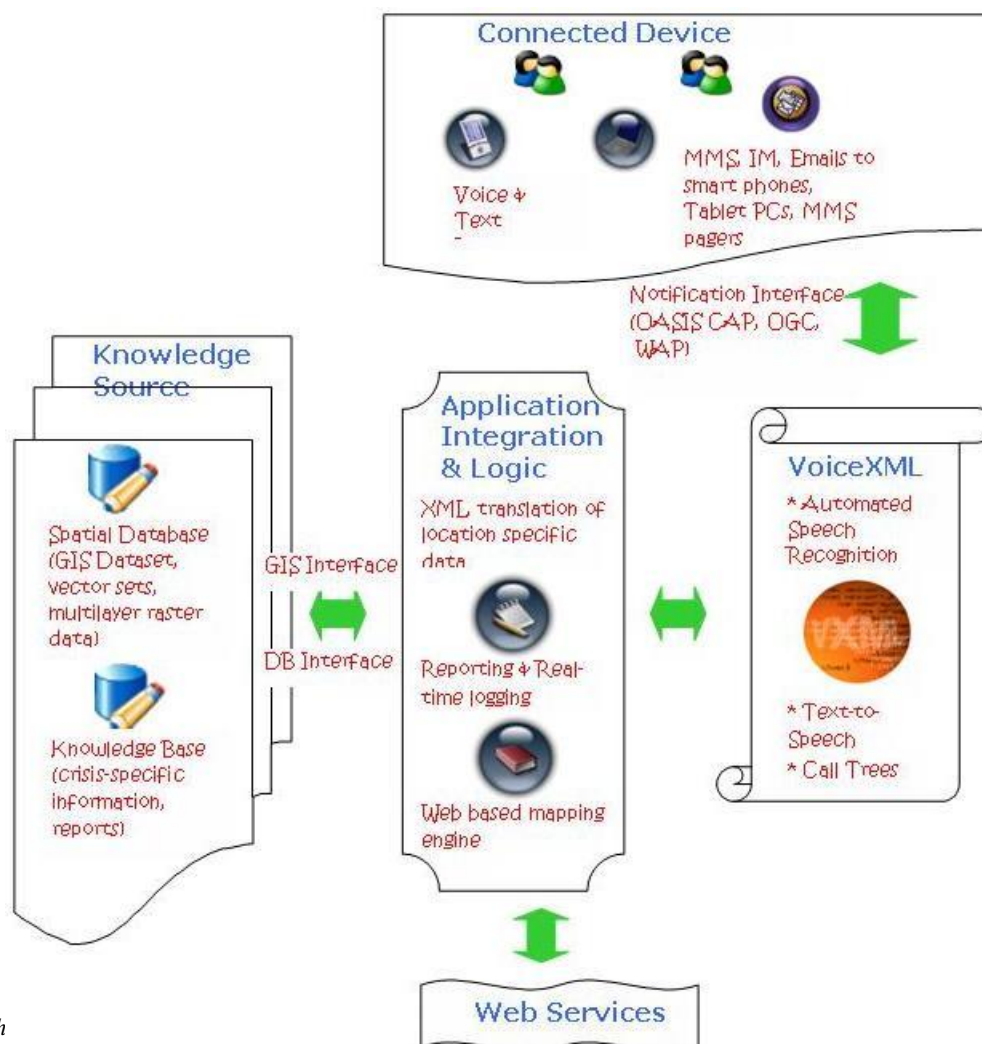
GIS provide critical support for decision makers during emergencies. Emergency management is a collaborative effort requiring coordination among federal, state and specialists local in planning, logistics, etc. Thus, GIS should provide access to geospatial information quickly and support collaborative work between domain experts (Fuhrmann et al., 2003)

This technology has the ability to capture data by digitizing, scanning, digital imagery, or aerial photography; to store the data; to manipulate the data; to form data queries; to analyze the data; and most importantly to visualize the data (Gunes & Kovel, 2000, p. 137).

Current emergency response systems are unidirectional with limited interaction capabilities and require extensive human intervention for managing the different phases of the crisis lifecycle. New standards of VoiceXML 2.0 provide a robust approach to interpret actual spoken syllables and synthesize speech into markup specifications that can easily be transported via simple transfer protocols like HTTP. Incorporating VoiceXML into GIS based emergency response system offers the potential to develop highly powerful yet simple means for addressing the shortcoming of existing disaster response management systems.

### THE EVRESPONSE ARCHITECTURE AND EXAMPLE

It is implicit that information needed to handle a crisis situation has added value when combined with persistent and spatial data. Persistent data can be made available through the use of wireless technologies and small profile devices. Spatial data can be made persistent using GIS based mapping software, and VoiceXML is an efficient means of communicating notifications and customized messages (such as evacuation routes, emergency planning tips, etc.) using automated speech recognition, Text-to-Speech conversion and Call trees features. The EVResponse architecture is shown in figure 1. It consists of four main components - Knowledge Source, Application Integration and Logic layer, VoiceXML Component and Connected Device Configuration (CDC) profile Interface.



**Figure 1. EVResponse System Architecture****Knowledge Source:**

The two main sources of knowledge needed to support the system are spatial database (GIS dataset, vector and raster data for multilayering) and knowledge base (crisis specific information, historic data, reports, community and response team contact data). Spatial data is available from various third party professional geographic mapping companies. The GIS mapping layer is built on this spatial data infrastructure (SDI) enabling easy and rapid access to pre-pruned geographic data. The knowledge base stores detailed information of past crisis situations as well as those actions required to handle unique crisis scenario as defined by various governmental crisis planning and evacuation planning agencies. The knowledge base also contains contact information of the response personnel and the community. As CDC devices become more prolific among the general public, the contact database will be sufficiently extensive to store multi-device data associated with each individual (instead of just home/office/cell phone numbers).

**Application Integration and Logic:**

The Application Integration Logic Layer provides the following functions. Intelligence built in this layer will allow the system to match new cases to prior cases based on similarities and present the decision maker with the accurate response protocol to be followed. It also maintains the Document Object Model (DOM) translation logic to parse location specific GIS data into descriptive XML documents. This layer also includes a web based mapping engine to translate the GIS data into dynamic maps deliverable as web pages. Web service ‘ties’ for sharing geospatial information with other applications as well as reporting and real-time logging functions are managed in this layer. Interaction with this layer is mainly via a web interface that allows authorized decision makers to generate reports for each crisis situation. For example, one crucial emergency response metric is the response notification time, the time it takes to notify the community of an incident and the required precautionary measures to be taken. The reporting and logging module within this layer offers the ability to generate post crisis reports that will enable involved agencies to proactively strategize actions and continuously rate the effectiveness of the overall notification response strategy used.

**VoiceXML Parser:**

New W3C specifications of VoiceXML 2.0 describe standards that allow Text-to-Speech (TTS) conversion as well as Automatic Speech Recognition (ASR). The standards also allow interpretation of spoken syllables and synthesize speech into markup tags for easy formatting and transport. VoiceXML can offer highly interactive features for web based applications through the use of audio dialogs. By integrating VoiceXML into the architecture, messages are no longer limited to plain broadcast text formats. VoiceXML enables the creation of flexible and powerful ‘Voice Forms’ that enable two-way communication between the sender and the recipient. ‘Voice Forms’ authored using VoiceXML 2.0 can interface with any ANSI SQL standard based database (e.g., Oracle, DB2 or SQL Server) for storing the form and field responses from the user. Using VoiceXML allows the ‘Voice Forms’ to support recorded audio wav files in addition to primary data types such as text strings, date, time and numeric. The recipient’s responses can be automatically collected and stored to a database or as XML DOM trees. This information can be used to trigger related actions or use as inputs to other applications. This is in striking contrast to traditional emergency response systems that are not interactive, highly limited, restrictive and require human intervention to collect responses and trigger actions based on responses.

**Notification Interface:**

The notification interface for data transfer to the connected devices utilizes open standards based (OASIS and Open GIS Consortium, OGC) Common Alerting Protocol (CAP). CAP is an open, non-proprietary data interchange format standard commonly used to disseminate warnings and reports to information management and warning systems. EVResponse architecture adopts the open standards based protocol so that the system can support various forms of operational warning systems independently developed and deployed throughout the nation.

**Web Services:**

The use of web services allow for easy integration with other stand alone applications or services that governmental and control agencies currently have in place or would implement as part of future emergency response expansion and improvement plans. For example, the web service tiers in EVResponse architecture can be used to provide access to reports,

maps and customized notifications independent of operating systems, platforms and remote applications dependencies. Additionally, all relevant listings of the system capabilities, contact and feature information can be exposed to collaborating agencies in a seamless manner. This will become more prevalent as more and more emergency response teams move towards unifying their systems using web technologies. Some example of web service tiers (accessible through client side stubs) and their corresponding response component are given below:

```

getMap(areaCoordinates) .....utilizing OGC communication standards
getActorNotificationTree(CallTreeXML).....utilizing VoiceXML parameters
get AcidSpillResponseNotification(CAP, VXML).....utilizing CAP & VoiceXML parameters
getCapabilities(query string) .....utilizing ODBC & OGC communication standards
getContacts(fireMarshall) ..... utilizing ODBC & OGC communication standards

```

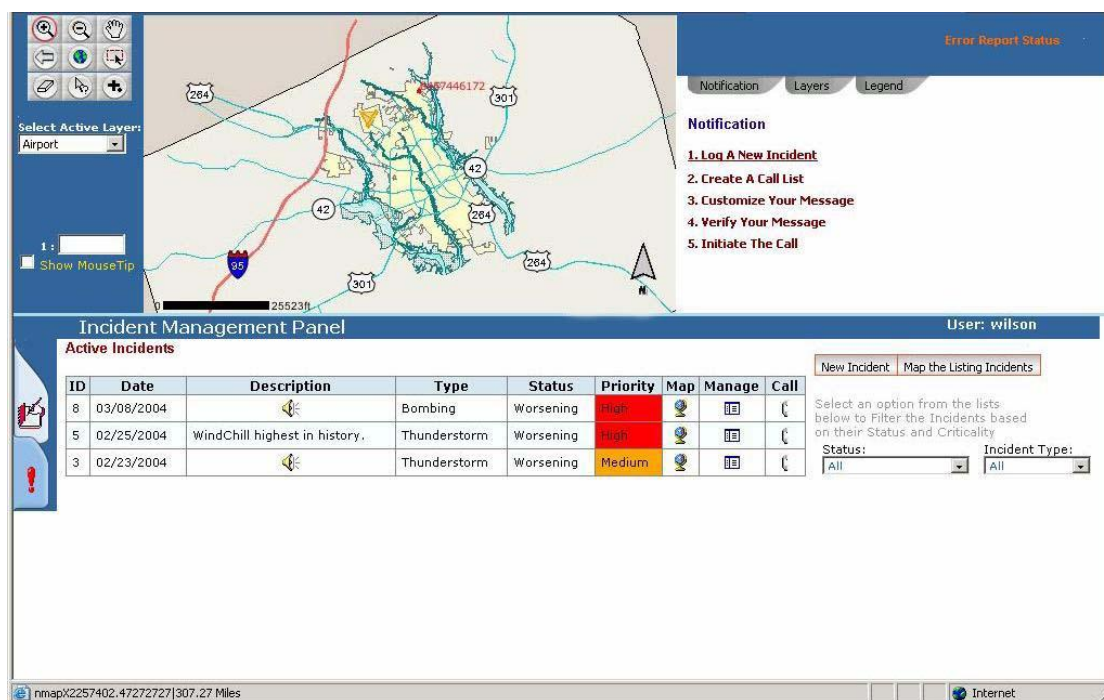
#### **Connected Device Configuration (CDC) Interface:**

The Connected Device Configuration (CDC) defines the base of application programming catered to highly portable but resource-constrained devices such as smart phones, multimedia messaging service (MMS) pagers, personal digital assistants (PDAs) and tablet PCs. XML and Extensible HTML (XHTML) content can be transmitted to wireless enabled CDC devices using Wireless Application Protocol (WAP). CDC interface allows EVResponse to propagate profile specific information by supporting a wide variety of CDC profile that is currently proliferating the communication devices market. The application layer maintains the algorithm to identify the correct user-agent (browser type and version) on the device and consequently render the data in the right format so that the content is clearly presented to the targeted device profile. With the ever growing popularity of CDC devices among the public, it is only sensible to provide an interface that can communicate with PDAs, SMS pagers and other smart devices, especially since these devices have replaced the traditional land-line based telephones as the preferred way to stay connected.

#### **An example scenario:**

Consider a scenario where an apparent toxic chemical agent leak has been reported to the Environmental Protection Agency (EPA). The officer on duty initiates emergency response by verifying the authenticity of the report. This is done by contacting other governmental agencies and conducting spatial analysis to identify the location of the crisis and disaster prone neighborhoods. With web based access to the underlying system, the officer can input a new incident, interact with the GIS map to access an incident area and study the surrounding, create an evacuation region and generate an incident specific notification message. The officer can also lookup phone numbers of all identified households and businesses, trigger dial outs and deliver notification messages with options to collect and store responses.

The web based GIS mapping engine helps the officer to specify anchors on the map to start the emergency response planning. Once the officer specifies the type of crisis and all known relevant information in the EVResponse Interface, the data integrator module of the Logic layer can generate what it recognizes as the doctrinally-proper or administratively-approved response decision. The officer can query the knowledge base (for sub-plans, contact information of response teams, etc) or the spatial dataset (for call region geo-references, demographic information, identify susceptible or danger zones) or both for specific data or reference points. The officer can then activate the geocoding of the call region to be immediately notified based on the significance of the crisis. The application logic layer uses the geo-spatial dataset and the call region data to generate a call list for the emergency response. The notification message pertinent to the crisis is automatically made available to the officer. The officer has the option to customize the message or approve the narrative. The notification message is translated by the XML translator in conjunction with the VoiceXML parser to convert the text message to speech.



**Figure 2. Status monitoring through spatial analysis (pre, current and post response).**

Call trees are developed by the Application Integration and logic layer and also trigger the automated notification process to dial end user telephones or send message to other CDC devices registered under the user. The creation of call trees allow sequential attempts to contact a person using all available device registration information stored in the knowledge source. For example, the system will automatically attempt to call the cell phone number followed by the office number or send an MMS to the smart phone, in case no response was received by calling the home phone number. The officer can access detailed reports on calls made, successful and unsuccessful calls, and other activities associated with the notification creation and delivery process. The use of VoiceXML allows translations from text to speech that can be transmitted to voice devices as well as receive and map response from the person. Acknowledgement of receipt of notice from the person can be translated back to XML and stored in the database for analysis or forwarded to response teams already in action.

Figure 2 is the EVResponse interface showing the map of an affected area, the real-time status of the situation based on inputs from the field. The use of a web interface allows the officer in charge to monitor the progress of the incident in real-time through any connected device such as a tablet PC or a web enabled smart phone.





**Figure 3. Event reporting and response evaluation**

Figure 3 shows a sample call list that will be generated by EVResponse once the officer has authorized the appropriate sub-plan to deal with the crisis and the decision to contact the community has been reached.

## BENEFITS OF EVRESPONSE

In this section we discuss the key benefits of the proposed architecture. EVResponse provides a flexible notification system customizable to meet the needs of diverse crisis scenarios. For instance, the response notification needed to protect people against a threatening nuclear calamity would be different from what is needed to warn the community about a toxic chemical agent spill. The use of VoiceXML provides fast translation of text to speech and can use Speech Synthesis Markup Language (SSML) to render the synthesized speech to the user, while incorporating actual characteristics of spoken instructions given by the application to the end-user, such as pitch, speed or volume (NewsForge, 2004). All this can be accomplished by the use of simple internet browser based Voice Forms. VoiceXML also enables the capture of user responses using Automated Speech Recognitions (ASM) which can then be stored to the database in textual format or as XML DOM trees. Interactive dialog with the recipient through VoiceXML based technology interface helps in identifying those who might be in need of additional assistance. Furthermore, use of open standards based technology (XML, VoiceXML, GIS data specs) enhances interoperability and reduces future expansion and system integration costs.

Integration of web services into the architecture offers tremendous benefits. It allows easy discovery of other external geographic datasets which in turn offers significant labor saving potentials. As the web presence of governmental agencies become more pronounced in the future, dynamic interaction between disparate systems (GIS and non-GIS) will become easier through the use of web services.

Accurate identification of the location of the disaster and mapping of the communities that need to be contacted and notified about the disaster is highly critical since delays in initiating response process could make every action taken to address crisis unfruitful. Using GIS as a core component of the EVResponse system provides the ability to accurately identify these geographic locations through a browser interface. Creating call trees using VoiceXML seems to be the plausible solution to initiate multiple alerts with minimal human intervention and trigger dispatch of emergency management teams to the crisis locations.

Use of web service tiers provide an HTTP based transport interface that other agencies can use to access reports and historic data in a collaborative decision making environment. Decision makers from different departments irrespective of their geographical location can perform trend analysis to help them rate and evaluate the effectiveness of the response along predetermined evaluation metrics. This invaluable ability to access real-time dynamic data from multiple sources using web services will also help officers perform situational analysis and thereby leverage existing GIS investments across different local, state and federal agencies. It also helps to create an iterative environment focused on improving the existing crisis management strategies to handle similar situations more effectively in the future.

Appendix A provides a comparative analysis of the proposed architecture and traditional systems.



## CONCLUSION

Emergency response management is a collaborative effort requiring coordination among several local, state and federal agencies as well as specialists in crisis planning and response logistics. GIS provides useful geospatial information in this environment. In addition, in a crisis management context, the timeliness, correctness and clarity of response notification and the speed with which the notification is communicated to the people, households and businesses are critical determinants that influence the adversity of the consequences from the disaster.

In this paper we present, EVResponse, a state-of-the-art emergency response system that integrates web services, GIS, VoiceXML and knowledge store. The EVResponse is a robust and effective solution that can save valuable time in the face of a crisis. The visualization mechanism available through EVResponse enhances perception (identify information needed to managed the crisis), comprehension (combine information from knowledge base with feedback from the crisis zone) and projection (ability to make effective predicitions based on the evolving dynamics of the situation) by presenting only information pertaining to the crisis (Endsley, 2000).

EVResponse utilizes the benefits of VoiceXML to provide a reliable, bidirectional response notification system to address the drawbacks and limitations of traditional systems. The architecture takes advantage of newer mature standards of VoiceXML 2.0 and novel technologies associated with open web standards to develop a seamless response notification system that requires minimal human intervention. The EVResponse is a distributed application strongly grounded on XML and uses a simple, yet innovative approach to logically combine spatial and crisis specific data to enable authorities coordinate and take informed decisions in a timely fashion. Built-in support for multi-modal, multi-device notification through easy Text-to-Speech translations and communication via CAP, OGC interface allows fast dissemination of vital information that will help to lessen the impact of disasters on human lives and properties.

VoiceXML offers a flexible approach to synthesize speech and acoustics. The architecture presented in this paper only looks at the use of VoiceXML for bidirectional message transactions in an emergency situation. The ability to translate voice to text implies that the real power of VoiceXML is yet to be fully utilized. Tremendous research opportunities exist to explore how VoiceXML can assist in making intelligent decisions based on semantic interpretations. Future research can look at ways in which semantic interpretation can be applied to extract and translate text from the output of a speech recognizer based on incident specific inputs.

Currently the feasibility of the system is being tested at various county and state level emergency planning agencies. Evaluating the effectiveness and efficiency of the solution and addressing issues that arise through a longitudinal study will help identify the shortcomings of the system. Identifying the deficiencies and improving the model are areas of interest for future research.

## Appendix A

Comparative analysis of EVResponse and traditional emergency response systems.

Functionality	EVResponse	Traditional Systems
Messaging and priority queuing	VoiceXML allows easy message prioritization using xml tags.	Prioritization is non existent or a manual process.
Multi-device capability	Support for Connected Device Configuration (CDC) devices such as cell phones, email, MMS pagers, PDAs, smart phones and tablet PCs.	Mostly restricted to two-way radio devices depending on provider.
Multi-modality	Customizable text message (or Voice translations using VoiceXML) delivered to all devices simultaneously.	Mostly limited to pre-recorded generic messages delivered to phone (standard text messages are emailed or faxed which point recipients to check their voice mail).
VoiceXML	Text-to-Speech, Speech Recognition Grammar specification and Automated Speech Recognition allow higher level interactivity.	VoiceXML not available
Ability to collect user responses	Collects responses which are mapped, and can be integrated with other applications and reporting software.	Not available
GIS capabilities	Provides tightly integrated, web-based GIS capabilities	Provides desktop and web-based mapping
Location specific notification	Higher granularity through integrated GIS and map control, based on user definable attributes such as zip code, address location, etc.	Available through GIS software with no drill down functions.

## REFERENCES

1. Chrisman, N. (1997). *Exploring Geographic Information Systems*. New York: John Wiley and Sons.
2. Endsley, M. R. (2000). Theoretical Underpinning of Situation Awareness: Critical Review. In M. R. Endsley & D. J. Garland (Eds.), *Situation Awareness Analysis and Measurement* (pp. 3-32). Mahwah, New Jersey.
3. ESRI. *GIS and mapping software*. Retrieved November 15, 2004, 2004, from <http://www.esri.com/software/arcgis/arcims/index.html>
4. Fuhrmann, S., Brewer, I., MacEachren, A., Cai, G., Sharma, R., Wang, H., et al. (2003). *Collaborative emergency management with multimodal GIS*. Paper presented at the ESRI International User Conference, San Diego, CA.
5. Grimshaw, D. J. (1999). *The potential for spatial data integration: a case study of geographical knowledge in a small business*. Paper presented at the Fifth Americas Conference on Information Systems, Milwaukee, WI.
6. Gunes, A. E., & Kovel, J. P. (2000). Using GIS in Emergency Management operations. *Journal of Urban Planning and Development*, 126(3), 136-149.
7. Keenan, P. B. (1997). *Geographic information systems their contribution to the IS mainstream*. Paper presented at the Third Americas conference on information systems, Indianapolis, IN.
8. Mennecke, B. E., Crossland, M. D., & Dangemond, J. (1994). *Geographic information systems: mapping its future in the business school*. Paper presented at the Fifteenth International conference on Information Systems, Vancouver, BC.
9. NewsForge. (2004). *VoiceXML promises voice-to-Web convergence*. Retrieved October 25, 2004, 2005, from <http://www.newsforge.com/article.pl?sid=04/10/15/1738253>
10. Pick, J. P., Viswanathan, N., & Hettrick, W. J. (2000). *A dual census Geographical Information System: Is it a data warehouse?* Paper presented at the Sixth Americas conference on information systems, Long Beach, CA.
11. Speier, C., & Swink, M. (1998). *Presenting map-based information when using Geographical information systems*. Paper presented at the Fourth Americas Conference on Information Systems, Baltimore, MD.
12. Stone, A. (2004). Powerful combination: GIS and web services. *IEEE Distributed Systems Online*, 5(2), 1541-1545.
13. Sugumaran, V., & Sugumaran, R. (2003). *Spatial decision support systems using intelligent agents and GIS web services*. Paper presented at the Ninth Americas conference on information systems, Tampa, FL.