Chapter 10

ENHANCING THE USABILITY OF THE COMMERCIAL MOBILE ALERT SYSTEM

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Abstract   The U.S. Department of Homeland Security initiated the Commercial Mobile Alert System (CMAS) to inform the general public of emergencies. CMAS utilizes the commercial telecommunications infrastructure to broadcast emergency alert text messages to mobile users in an area affected by an emergency. Because CMAS uses cell broadcast service, the smallest area that CMAS can broadcast messages is a cell site, which is usually quite large for local emergencies. This paper proposes an enhancement that uses CMAS as a transport protocol to distribute local emergency alerts to areas smaller than a cell site. The paper also conducts an investigation of the Common Alerting Protocol (CAP), the current emergency protocol standard, and suggests an enhancement to the CAP message structure for CMAS emergency alerts. The viability of the approach is demonstrated using a prototype implementation, which simulates broadcasts of emergency alerts to confined areas such as a city block or an apartment complex.

Keywords: Emergency response, cell broadcast service, CMAS, alert messages

1.   Introduction

Emergencies that require the services of specially-trained emergency personnel range from trivial injuries to major disasters such as flash floods, hurricanes, earthquakes, forest fires, tsunamis and terrorist attacks. Due to the unique characteristics of emergency situations, preparing for, responding to and recovering from them is always a challenge.

In the aftermath of the terrorist attacks of September 11, 2001, communications was identified as a major bottleneck for emergency activities. The telecommunications infrastructure experienced an extremely high overload of calls into and out of the targeted areas, which caused congestion at access points and in the core networks. While many calls were blocked and rejected, mobile

users were still able to text message each other [21]. However, text messaging did not see much use at the time because it was still rather expensive.

In 2006, the U.S. Federal Government established the Worker Adjustment and Retraining Notification (WARN) Act that supported research and development related to the Common Mobile Alert System (CMAS). CMAS is designed to use the existing commercial telecommunications infrastructure to broadcast emergency alerts and warnings to specified geographic areas. However, the smallest granularity of a CMAS broadcast is a cell, which is too large for small-scale emergencies whose effects are confined, such as a major car accident or a burning building. While CMAS is still in the design and development phases, we have identified two shortfalls in the CMAS cell broadcast service specification [18]. One is that CMAS cannot send alerts to confined areas. The other is that the protocol standard does not provide enough information to facilitate effective emergency communications.

We address the first limitation by constructing an Android mobile application that filters CMAS alerts using global positioning system (GPS) data and only displays the alerts to users who are inside the affected area. The second limitation is addressed by enhancing the message structure of the Common Alerting Protocol (CAP) version 1.2 [19] by adding XML tags to facilitate emergency communications.

2.   SMS for Emergency Handling

Informing the general public about emergencies has been a problem for many years. Traditionally, television and radio network broadcasts have been used to alert the public to emergencies. However, television and radio only reach a small percentage of the population at any given time. Americans aged fifteen years and older spend only 6.12% of their time watching television [5]. Americans aged twelve years and older spend 11.2 % and 7% of their time listening to commercial radio [3] and National Public Radio (NPR) [20], respectively.

On the other hand, more than 91% of the U.S. population subscribes to a wireless service [8], which is an extremely effective means of communicating information to the general public. Users carry their wireless devices almost everywhere they go. With the proliferation of Internet services, emergency information can be published on news websites and delivered right to a user's wireless device after a simple registration process. Moreover, various alert settings such as the vibration mode and special ringtones can attract attention almost immediately.

A survey conducted after the 9/11 terrorist attack in Washington, DC revealed that, although telephone service into and out of the area was highly congested, people were still able to use text messaging to communicate with each other [21]. Ten years later, Short Message Service (SMS) is an extremely popular mode of communication, especially among the younger generation [4]. SMS used to be expensive in the past – as much as 20 cents per text message sent or received. However, at this time, many service providers offer SMS as a low-cost or free service to attract new customers.

3.   CMAS Overview

Recognizing the importance of SMS [6], the U.S. Department of Homeland Security initiated the Commercial Mobile Alert Service (CMAS) [15] to broadcast emergency alert text messages to the general public. Service providers and equipment vendors are actively involved in defining CMAS standards and implementations. Unlike sender-to-receiver SMS, CMAS uses a dedicated primary broadcast control channel (BCCH) to broadcast text messages, which can reach millions of wireless subscribers in minutes.

CMAS is still in the design and development phase. However, it inherits some weaknesses due to its reliance on cellular broadcast service and the existing emergency communications protocol:

- CMAS alert messages cannot be broadcasted to an area smaller than a cell site, which is defined in the Federal Information Processing Standard (FIPS) code [14]. The area covered by a cell site varies according to population density, but it is too large for broadcasting alerts about small-scale emergencies.

- According to the CMAS specification [2], the Common Alerting Protocol (CAP 1.2) is to be used to communicate CMAS emergency alerts. However, CAP 1.2 was designed for emergency communications between government entities of various levels (federal, state and local departments and agencies). Consequently, much of the CAP 1.2 message structure is not relevant to emergency mobile broadcasting. Also, the information carried in the CAP 1.2 message structure does not fully address the essence of local emergencies.

- CMAS is designed to disseminate three types of alerts: Presidential alerts, imminent threat alerts and America's Missing: Broadcast Emergency Response (AMBER) alerts [23]. CMAS is not designed to broadcast alerts about local (i.e., small-scale) emergencies.

4.   Cell Broadcast Service for Local Emergencies

This section describes the CMAS enhancement that enables the delivery of alert messages to areas smaller area than a cell site or FIPS code equivalent.

4.1   Enhancement Considerations

In 2003, OASIS sponsored the Common Alerting Protocol (CAP) initiative with the objective of providing fundamental messaging protocols to facilitate interagency emergency communications. The OASIS Technical Committee on Emergency Management has developed a set of standards [17, 18] that involve a set of XML tags for exchanging information needed to handle emergencies. However, CAP is intended for communications involving emergency responders, operators and other officials; it was not designed to broadcast emergency alerts

to a large population. For example, the *Sender ID* value in CAP is not relevant to members of the public who would receive broadcast alert messages.

Our investigation of the technical specifications of the GSM and UMTS cell broadcast service [1] revealed that there are no features or options that could be configured to support the broadcast of alert messages to an area smaller than a cell site. However, given the computing power and functionality provided by modern mobile devices, we opted to build an emergency response application (ERApp) to intercept CMAS alert messages and filter them based on the proximity of users to the location of an emergency. To accomplish this, it was necessary to enhance the CAP message structure to include additional tags. Interested readers are referred to [16] for our preliminary work on enhancing the CAP message structure.

4.2   CMAS Alert Message Structure

A CMAS alert message can be sent in one of two ways. The first is to send the message as raw text, where the values are separated by delimiters. However, this method does not provide enough space to squeeze the necessary information into the message. The second method uses the CAP 1.2 emergency messaging standard [19]. However, a CAP message is in XML format, which requires additional space to store an XML alert message.

Figure 1 shows the CAP 1.2 alert message structure. As mentioned above, CAP 1.2 was designed for emergency communications between officials. For example, when a tornado strikes Louisville, Kentucky, the City of Louisville sends an alert message to the State of Kentucky requesting resources for rescue operations. Officials at the state's emergency operations center then verify that the message is not a hoax. The verification is performed using data such as the message id, sender id, date/time sent, scope, etc.

On the other hand, a mobile user receiving a CMAS alert message would not need any data for message verification. Instead, the user would require information about the emergency such as its nature, location and the precautions to be taken. Much of the information in the CAP 1.2 schema is not relevant to CMAS alert messages. To address this limitation, we have enhanced the CAP 1.2 message structure for CMAS alert messages. Figure 2 shows the enhanced message structure.

We focused on extracting relevant information from the existing emergency messaging standard CAP 1.2 that would be beneficial to mobile users. Also, we created three tags: `affected area`, `spreadable` and `location`. The `affected area` tag holds the radius of the affected area measured in meters from the emergency location. The value would depend of the specific emergency and would be entered by the emergency coordinator. All mobile users within the affected area would receive CMAS alert messages. The `spreadable` tag is important in environmental emergencies such as pollution alerts, toxic gas releases, and biological or radiological attacks. The alert might urge users to seek shelter and use gas masks. The `location` tag holds the latitude and longitude of the
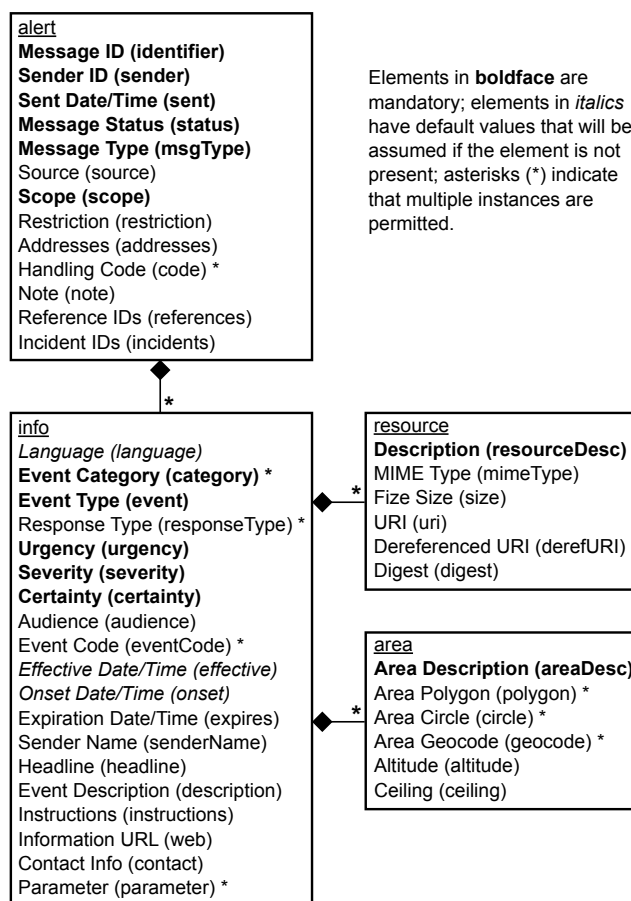
alert
Message ID (identifier)
Sender ID (sender)
Sent Date/Time (sent)
Message Status (status)
Message Type (msgType)
Source (source)
Scope (scope)
Restriction (restriction)
Addresses (addresses)
Handling Code (code) *
Note (note)
Reference IDs (references)
Incident IDs (incidents)

Elements in **boldface** are mandatory; elements in *italics* have default values that will be assumed if the element is not present; asterisks (*) indicate that multiple instances are permitted.

info
Language (language)
Event Category (category) *
Event Type (event)
Response Type (responseType) *
Urgency (urgency)
Severity (severity)
Certainty (certainty)
Audience (audience)
Event Code (eventCode) *
Effective Date/Time (effective)
Onset Date/Time (onset)
Expiration Date/Time (expires)
Sender Name (senderName)
Headline (headline)
Event Description (description)
Instructions (instructions)
Information URL (web)
Contact Info (contact)
Parameter (parameter) *

resource
Description (resourceDesc)
MIME Type (mimeType)
Fize Size (size)
URI (uri)
Dereferenced URI (derefURI)
Digest (digest)

area
Area Description (areaDesc)
Area Polygon (polygon) *
Area Circle (circle) *
Area Geocode (geocode) *
Altitude (altitude)
Ceiling (ceiling)

Figure 1. CAP 1.2 alert message structure.

emergency, which is easily shown on a map. Figure 3 shows a sample CMAS mobile message corresponding to a tornado alert.

4.3 Enhancement for Small-Scale Emergencies

Enhancing the cell broadcast service itself is a complex and time-consuming task. However, given the computing power and functionality provided by modern mobile devices, it is simpler, far less expensive and just as effective to create an emergency response application (ERApp) that would assist mobile users in times of emergency. ERApp is a mobile application (app) written in Java for the Google Android API 2.2 platform. The current version of ERApp intercepts CMAS alert messages and filters them based on the proximity of users to the location of an emergency. It is designed to work in conjunction with

Figure 2. Enhanced CMAS CAP 1.2 alert message structure.

```
<?xml version = "1.0 encoding = "UTF-8"?>
<alert xmlns = "urn:oasis:names:tc:emergency:cap-cmas">
  <identifier>CMAS-01</identifier>
  <status>Actual</status>
  <info>
    <category>Met</category>
    <urgency>Expected</urgency>
    <severity>Severe</severity>
    <certainty>Observed</certainty>
    <expires>2010-10-02T17:00:00-0500</expires>
    <description>Multiple tornados are expected around
                 2PM in the Washington, DC area.
    </description>
    <affectedarea>1000</affectedarea>
    <spreadable>No</spreadable>
    <event>Tornado</event>
    <location>
      <lat>38.882334</lat>
      <lon>-77.171091</lon>
    </location>
  </info>
</alert>
```
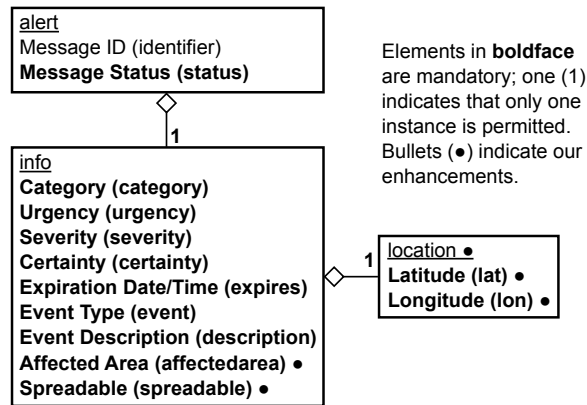
Figure 3. CMAS mobile alert message (tornado example).

ERAlert, a CMAS prototype implementation that simulates the broadcasting of CMAS alert messages to mobile phones using the email texting feature.

When a mobile user launches ERApp, it: (i) updates the local repository; and (ii) retrieves and displays the user's current GPS location on a map on the mobile device. The GPS location of the user is updated periodically based on
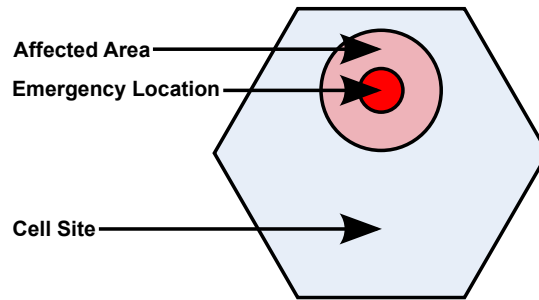
Figure 4. Typical emergency scenario.

time and distance, which are set to default values of 60 seconds and 50 meters, respectively. The user can adjust these parameters to reduce the frequency of GPS location queries in order to conserve power.

Under the default settings, the location update is triggered when the 60-second time period has expired or the user has moved 50 meters from the last recorded location. GPS data is used to estimate the movement of the user assuming that the user carries the device all the time. Thus, a user headed towards the emergency location could be advised to leave the area immediately.

ERApp receives an alert message from the ERAlert system in a byte-encoded XML format. ERApp decodes the message into its original XML form. It then locates and displays the emergency on the map using the `location` tag information. In addition, ERApp displays the user's current position with respect to the location of the emergency. If the mobile device is within the affected area, ERApp alerts the user according to the device alert settings (e.g., vibration mode or ringtone) and displays the alert message. The user must acknowledge the alert within a configurable time period or ERApp will continue to alert the user about the emergency. If the user is outside the affected area and ERApp detects that the user is moving towards the affected area, it alerts the user and displays the alert message. Upon acknowledging the alert, the user can view his/her current position on the map along with the location of the emergency and the affected area (Figure 4).

5.   Prototype Implementation

Our prototype system is implemented in Java. The client GUI was developed as a Java Applet. The service engine was developed in Java Web Services running on a JBOSS Community Server 5.1.0 GA with MySQL Server 5.1 as the backend database. The entire ERAlert project was developed using NetBeans IDE 6.9.1. All the Java archive (JAR) files are self-signed with our own certificate to ensure that the files come from a trusted source.

Cell broadcast service has been a standard for many years, but it has not yet been implemented by U.S. carrier networks. Therefore, in order to test our
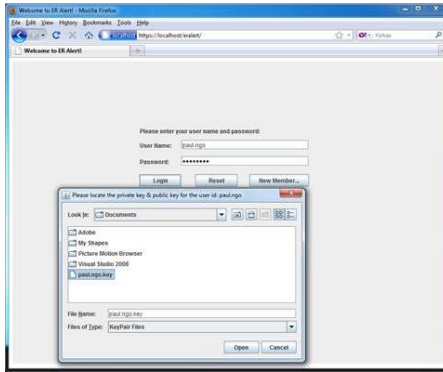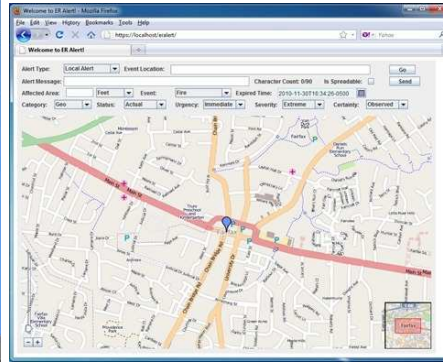
Figure 5.   ERAlert login screen.   *Figure 6.*   ERAlert map screen.

prototype, the only option was to simulate the cell broadcast service functionality. To simplify the testing process, we used the email texting feature offered by service providers.

In the following sections, we describe the various phases involved in the operation of our system. The emergency scenario considered is a tornado touchdown in Arlington, Virginia.

5.1   User Login

The user is registered with the ERAlert System by an emergency coordinator. The registration process involves recording the user's information and saving the PKI keys. The PKI keys are used to encrypt and decrypt messages between the web interface and the backend server to mitigate security threats such as man-in-the-middle attacks and password hijacking attacks. The PKI certificate is saved on the local system in our prototype merely to demonstrate that two-factor authentication is implemented. However, in a deployed system, the PKI certificate would be stored on a common access card (CAC) or on a secured universal serial bus (USB) thumb drive. By default, passwords are required to have two lowercase alpha characters, two uppercase alpha characters, two numeric characters and two special characters. The password restrictions can be strengthened or weakened depending on the requirements of the deployed system.

Figure 5 shows the login screen for a registered user. The user enters his user id and password and clicks the Login button. The system then prompts the user to locate his PKI-key file. Once the user locates the file, he clicks the Open button. Upon successful login, ERAlert map screen is displayed as shown in Figure 6.
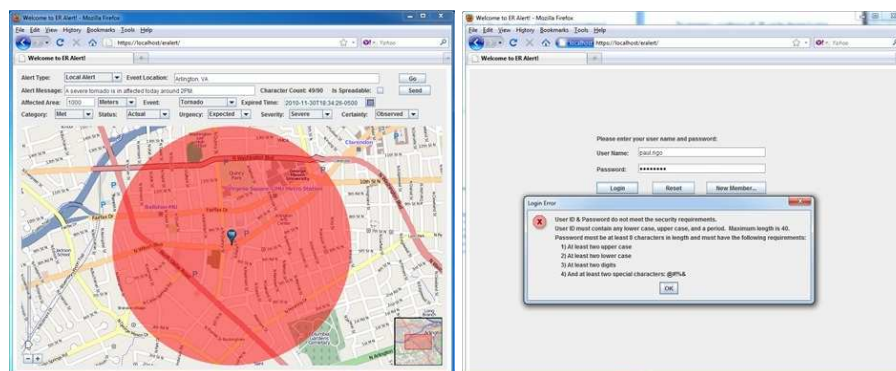
Figure 7. ERAlert CMAS alert message.

Figure 8. Login error message.

5.2   Local Alert Generation

During an emergency, the emergency coordinator enters the event location and clicks the Go button, which pinpoints the emergency location on the map. The coordinator then enters all the necessary information about the emergency such as alert type, event type, message, spreadable nature, affected area, expired time, category, status, urgency level, severity and certainty. As soon as the radius of the affected area is entered, a red transparent circle appears around the emergency location on the map (Figure 7). Finally, the emergency coordinator clicks the Send button to broadcast the alert message to all the mobile users in the affected area.

5.3   ERApp Alert Handling

After the emergency alert is broadcasted to a particular cell site, all the mobile phones in the cell site receive the alert [2]. At this point, ERApp, which listens to the broadcast control channel, decodes the alert to extract the emergency location, affected area, event type, etc., and proceeds to display the location of the emergency, the user's current location and the affected area. ERApp calculates the distance between the user's current location and the location of the emergency. If the user is outside the affected area, ERApp stores the alert on the mobile device until the alert expires (left-hand side of Figure 9). If ERApp detects that the user is moving into the affected area and the alert is still in effect, it sounds the alert until the user acknowledges it. If the user is inside the affected area, ERApp sounds the alert until the user acknowledges it (right-hand side of Figure 9).

5.4   AMBER Alert Generation

The prototype also handles other CMAS alert types such as Presidential alerts, imminent threat alerts and AMBER alerts. Due to the amount of in-
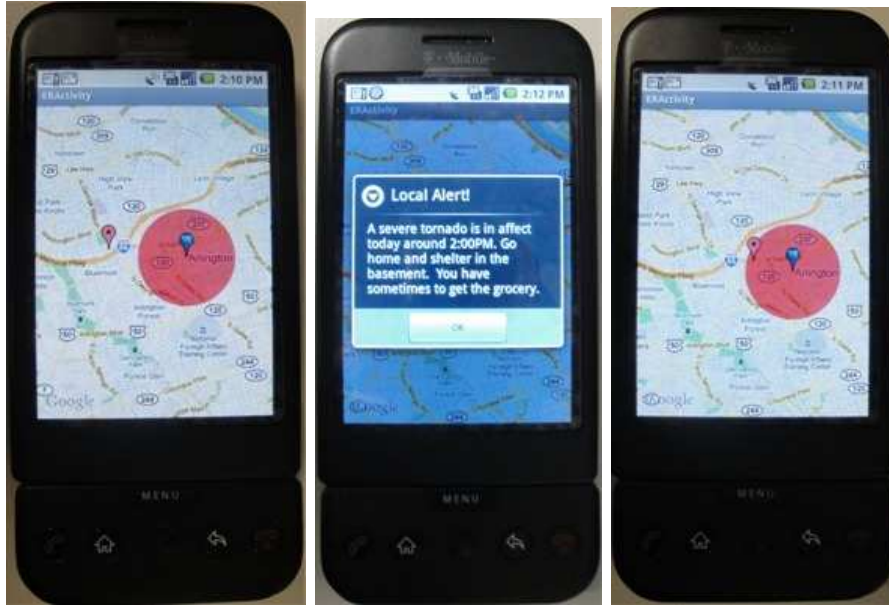
Figure 9.   Alerts outside and inside the emergency affected area.

formation included in an AMBER alert, sending one broadcast message is not enough. Consequently, the prototype breaks up the AMBER alert information and inserts it into smaller CMAS AMBER alerts, which are broadcasted. Upon receiving the smaller CMAS AMBER alerts, ERApp assembles to create the original CMAS AMBER alert and displays it as shown in Figure 10.

6.   Related Work

In April 2007, the Integrated Public Alert and Warning System (IPAWS) [7] was established by the Federal Emergency Management Agency under Executive Order 13407 signed by President George W. Bush on June 26, 2006. IPAWS seeks to ameliorate public safety at all levels of government by providing integrated and interoperable services to communicate timely alerts and warnings to help conserve life and property. IPAWS uses two communication modes, radio broadcast and mobile broadcast. IPAWS also promotes a standard protocol to communicate alerts and warnings across all government emergency systems. In addition, IPAWS focuses on modernizing and expanding the legacy Emergency Alert System (EAS) to take advantage of cutting-edge technologies. CMAS, which focuses on mobile devices, is one of the major IPAWS projects.

Several universities such as George Mason University [9] and Louisiana State University [13] have implemented alert mechanisms that require cell phone and/or email registration by users. These systems leverage the existing telecommunications and Internet service provider infrastructures to deliver emergency
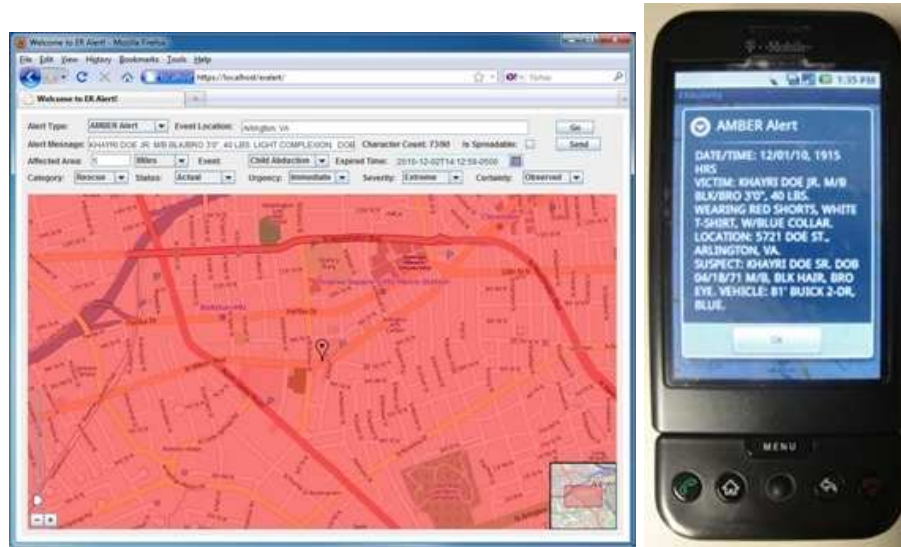
Figure 10.   CMAS AMBER alert.

alerts to users. During an emergency, however, these systems potentially place extreme loads on the associated networks that can lead to service disruptions [6]. Consequently, these alert messages are not guaranteed to be delivered to user devices in a timely manner.

In a recent publication [16], we proposed an enhancement to the Emergency Data Exchange Language (EDXL) [17] and to CAP by adding tags to ensure the availability of responders during an emergency. The tags capture the roles and tasks of emergency personnel. Each emergency responder is associated with his/her role and list of relevant tasks, all of which can be searched in a flexible manner. The search results include a default contact, a list of alternate contacts, even a contact for registering complaints. The search results may also be accessed by a private branch exchange (PBX) to automate the process of contacting emergency responders.

7.   Conclusions

CMAS suffers from two major limitations. The first is that it cannot send alerts to confined areas. The second is that the protocol standard does not provide enough information to facilitate effective emergency communications. We address the first limitation by constructing an Android mobile application that filters CMAS alerts based on GPS data and only displays the alerts to users who are inside the affected area or are moving towards the affected area. We address the second limitation by adding XML tags to the CAP 1.2 message structure to hold the additional information that must be passed to the general public during small-scale emergencies. The viability of our solution is demon-

strated by a prototype implementation that simulates broadcasts of emergency alerts to confined areas such as a city block or an apartment complex. Our future research will attempt to leverage advanced mobile device capabilities to advise users during emergencies. In particular, we will extend ERApp to provide intelligent assistance to users.

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