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1 Abstract

This paper proposes a prototype solution for web-based resource tracking during a disaster or crisis situation using mobile devices. The system provides a real time data to a decision maker so that they can effectively and efficiently monitor resources and access the situation accordingly.

Resources are a human resource (e.g. a doctor, a policeman) and a moving resource (an ambulance, a police car). The resource with a GPS enabled-device does not only provide current location of the moving resource, it also notifies the system upon the resource arrival to the affected location automatically.

A simple user interface design and a hybrid emergency classification will help users get to the data as fast as possible.

The paper includes description of the system, review of current technologies, proposed methodology, and an implementation plan. The proposed future research area can be found in the discussion and conclusion section.

2 Introduction

The idea of the project is to utilize handheld devices (e.g. iPhone) and WWW technologies during a disaster or a crisis situation. The technology is a tool to provide moving resource (e.g. an ambulance, a doctor, or a policeman) prediction pooling and tracking features.

The project makes use of existing technologies such as GPS systems, mapping (e.g. Live Search, Google maps, and Yahoo maps), available data from a source such as Ushahidi mobile disaster warning system, Sahana disaster management system, and the location-aware routing prediction method such as in Zhang, Mayes, etc (2005) and Tiesyte, and Jensen (2008). Mobile position based information is one of the critical parts in the project to provide real time current information to a decision maker, especially when urgency and timing are highly critical. A position based tracking module is a module to replace the need of manual personnel reporting. A resource person with a GPS device is detected by the system in their current location.

In addition to the position based information or GPS information, other data included to feed into the prediction module, such as the emergency classification data, is pulled from one or multiple existing database banks. The system architecture of the web-based resource tracking during a disaster or crisis situation can be seen in figure 1.

The prototype includes three main applications – position tracking, resource management, and identity manager modules. The system will make the use of the Representational State Transfer (REST) web-service to bridge the connection between the server and clients. The REST web-service and the WWW solution for the prototype are selected to avoid certain mobile specific standards. REST provides a solution for the mobile device system to interface with the system in manageable lightweight implementation. Since, REST utilizes URI namespace technology, it makes the application becomes scalable and the data can be easily shared with different servers. In addition, REST uses HTTP and XML solutions and hence it is well understood by firewalls and security administrators.

The resource management system consists of emergency classification, search, and alert systems. The project aims to design an easy to use user interface for the system so that users, decision makers, can get to important information as quickly as possible. One of the solutions to such objective is to have a classification of emergency combined with a recommendation system. The application utilizes the pre-existing data to recommend resources (what are required resources and their locations) for a certain situation such as flooding. Apart from the recommendation system, the system offers another search option, nearest search option, for users to search for required resources for the crisis that they have to manage. If none of the system provided classified emergency resources matches a situation, users have option to define or pre-define the classified list themselves.

The identified available resource shall be alerted by the system. For a moving resource such as a doctor or an ambulance, the system should automatically provide routing or direction information to his/her GPS-

enabled device. This functionality links to the position tracking application. The human resource can then choose to accept or reject the job request.

The second application is the position tracking application that consists of real time location update, routing, and the time statistic module. As a doctor responds to the system alert, his/her GPS enabled device will automatically send his current geographic X, Y coordinate location in form of an XML file. The XML file also includes the login ID which is the unique mobile device ID. Before being past through the network, the XML file is encrypted and only the system can decrypt the information (the identify manager module). As each resource travels toward the site, the decision maker will have a virtual map showing real time information about the resources. In addition, the system shall be able to provide a report on number of resources at each near by location. The routing information and the estimate time statistic prediction on when each resource will reach the site will also be an option on the decision maker screen. Using API technology, a virtual map is requested from a map server.

The two main target user groups are emergency response teams and decision makers. Following are the two possible scenarios of use.

Senario1, a medical doctor receives an alert that contains information about a disaster in the area on a handheld device. The doctor can either accept or reject the job request. Upon job rejected, the system sends back the report to the central system to further send notification to the interested parties (e.g. the mayor or emergency personnel in charge). On the other hand, upon accepting the alert and he/she browses through the information provided on the device. The systems will provide information to the doctor as to the distance and time it would take to get to the location. The information will be updated in real time to alert the doctor about any possible traffic issues and unexpected conditions, for instance, when roads are closed or cut off unexpectedly during the disaster. Upon the doctor's arrival, the device will report his/her location directly to the central system, therefore eliminating the need for personnel reporting. The tracking system will

automatically be seen by authorized people such as the mayor or emergency personnel in charge. They would use the information to come up with an appropriate plan.

Scenario 2, a crisis manager on- or off-site browses information through the resource tracking system for latest information about required human and moving resources. Tiesyte, D., & Jensen, C. S. (2008, April) presents a technique for efficient cost-based tracking of scheduled vehicle journeys. They believe that geographical positioning and wireless communication technologies are useful to the managers and users of the fleets on vehicle status tracking. It will support a specific subset of management decisions. For instance, how many medical doctors have already arrived on-site, how many more are required, how many more are on their way, and how much time it would take to get to the site?

3 Review of the Literature

There are many technologies currently available that are useful to this project. Some identified core technologies include mapping, position tracking, information persistence, and resource management system. Following are some of the current solutions and technologies in the areas available up to date.

- An intelligent and situation-aware pervasive system to support debris-flow disaster prediction and alerting in Taiwan (Kung, Ku, Wu, and Lin, 2008,).
- A wireless first responder handheld device for rapid triage, patient assessment and documentation during mass casualty incidents (Killeen, Chan, Buono, Griswold, and Lenert, 2006).
- Cost-based tracking of scheduled vehicle journeys (Tiesyte and Jensen, 2008).
- Sahana open source disaster management system (Silva, 2006).
- Ushahidi web-based handheld device information distributing during a disaster by user generated content (Ushahidi, 2008).

An example of resource management system for deployment during a disaster can be seen in the Sahana system. Sahana is an open source disaster management system implemented by four main modules including

missing person registry, organization registry, camps registry, and request management system (Silva, 2006).

Other modules in the Sahana system consists of inventory management and catalog system, child protection module, volunteer management system, messaging module, and situation awareness. The system is designed to be run within a single computer or a network distributed system. The data for the system comes from user manual input data. The Sahana organization registry module is a meta-data module that contains information about relief organizations involved for a disaster. The information includes what kind of services and supports an organization provides. By the same token, the Sahana request management system is the part of the system that is available online to provide search solution for customized aid catalogs, aid pledges, and requests. Another management module of Sahana is the volunteer management system. The module is used to record volunteer skill information and their availability. Users use this module to search for available volunteers based on skills. While the organization registry, the request management system, and the volunteer management system concern themselves with the management aspect of a disaster, the Sahana camps registry module uses Google maps to provide a Geographic Information Systems (GIS) view of an affected disaster area. Decision makers use the module to view location of camps.

The proposed prototype system depends on the location-based technique to determine a real time position. According to Bellavista, and Corradi (2007), Katsaros, Nanopoulos, etc (2005), and Mallick (2003), the position technology relies on getting a location of an object via a meaningful X, Y coordinate or a latitude and longitude coordinate. In fact any available mapping tool such as Microsoft live search maps, Google maps, and Yahoo maps require the coordinate system to identify the location. The coordinate is required to plot the location on a map so called geo-coding. Mallick (2003) states that there are several available mobile positioning techniques which includes network-based solutions and handset-based solutions. Katsaros, Nanopoulos, etc (2005) suggest the satellite-based system or also known as the Global Positioning System (GPS) and the Terrestrial-Infrastructure-based system, also known as the network centric approach. Both

tracking of schedule vehicle journeys by Tiesyte, and Jensen, 2008 and the intelligent and situation-aware pervasive system in Taiwan by Kung, Ku, etc, 2008 use GPS system for the mobile positioning.

Olla (2008) explains that GPS relies on satellites that send signal information back to the earth. The information is a navigation message of each satellite's position and time. An object location is calculated by GPS receivers by the use of triangulation and the signal information provided by at least three satellites in order to determine an object's location and four satellites for greater accuracy (Olla, 2008). The use of fourth satellite enhances the accuracy in the order of nanoseconds. GPS receivers compare the time difference between the arrival of satellite signals to tell the position (Katsaros, Nanopoulos, etc, 2005 and Olla, 2008). Olla (2008) explains that three satellites are needed in the calculation because the first satellite provides possible locations of an object narrowed down to the surface of a sphere. The position is recorded as a radius equal to range 1. On the same token, satellite number two provides confirmation that the object is located within the first sphere (as located by the first satellite). Satellite number two provides additional position circle of a radius range 2. The first and second satellite indicate that the object is positioned between the intersection between their two spheres - sphere one and sphere two. Finally, the third satellite shows a third sphere of radius range 3 for the positions. The object position is the intersect location of the three spheres. The fourth satellite is used to confirm the location and hence provides the time reference. Despite the fact that GPS system is widely used with many position tracking systems, it does come with some drawbacks. GPS can not provide indoor environment positioning and it requires costly power-consumption on mobile devices (Katsaros, Nanopoulos, etc, 2005).

The proposed system can request mapping information from an existing map server such as Google maps or Microsoft live search maps. Hillborg (2002) and Purvis, Sambells, etc (2006) state that geo-coding services respond to a request in a form of the Extensible Markup Language (XML). Google maps (Google, 2008) support the file format in XML and Microsoft live search maps (MSDN Blogs, 2007) has application to

support direct importing file for a map information request using the Keyhole Markup Language (KML) format. Supplying coordinate information of an object in XML format to the map servers enable data to be processed faster than requesting it directly.

There have been several research projects that address solutions for mobile location prediction. Tiesyte and Jensen (2008) propose a tracking of schedule vehicle journeys. Tiesyte and Jensen (2008) states that there are two main position-based tracking – using position-based tracking and time-based tracking.

Any wireless and resource management system has high vulnerabilities to data security. Dawson, Winterbottom, and Thomson (2007) suggest that data encryption and data integrity are necessary to protect privacy of users in such a system. The data integrity is used to protect the data from being tampered with unauthorized users. By the same token, the data encryption technique ensures that only authorized users can view the data.

Representational State Transfer (REST) is a web service that offers many advantages compared to Simple Object Access Protocol (SOAP) web service. REST can be a solution to mobile device web limitations. Amazon, EBay, and Yahoo are the examples of REST web services. REST service architect includes XML, HTTP, URI, and MIME type.

The first thing to consider when creating a REST is URI. Unlike URL, URI is suitable for REST since it points to a resource of a web service and hence does not change over time. Richards (2006) suggests a structure of URI for a web service.

A web service returns data in the form of XML format as defined by the service implementer (Richards, 2006). Therefore, different REST web services can have different XML format and there is no particular standard. MIME must be in the type of text/xml for XML (Content-type: text/xml).

HTTP methods that are commonly used for REST are GET, HEAD, POST, PUT, and DELETE (Create, Retrieve, Update, and Delete). Richards (2006) suggests to use GET and POSTING methods differently according to each functionality. He states that GET should only be used for retrieving a resource representation. In contrast, POST can be used for other operations rather than the resource retrieval including resource creation, medication, addition, and deletion. For security purposes, as a result of performing GET request, according to Gregorio (2004) and Richards (2006), there should not be any side-effects that users unaware of and therefore the implementation of GET method should be safe and idempotent. The idempotent method is the method that provides the same result every time a service is requested.

Apart from URI, data format and methods, we also have to consider the other types of web service status codes (Gregorio, 2004) – 2xx for success, 3xx for redirection, and 4xx for errors.

4 Methodology

According to Furht and Ilyas (2003), there are generally six groups of mobile devices including web phone, wireless handheld devices, two-way pagers, voice portals, communication appliances, and web PCs. [International Telecommunication Union](#) (ITU) predicts that by the end of 2008 there will be about four billion mobile subscriptions worldwide (Verclas, 2008). However, many mobile devices are technology dependent. While Nokia and Sony Ericsson phones are run by Symbian OS, some other devices are built based on J2ME (Java for mobile phone). Other technologies include Pocket PC, Opera Software A/S, Mobile Linux, and Palm OS (Hillborg, 2002). Nonetheless, any smart phone with internet service enabled with integrated web browser can access the World Wide Web (WWW). Hence, this project is fundamentally focus on the WWW technology and aims to transfer data to users via mobile web and Representational State Transfer (REST). A cellular network can be a bridge connection to the internet during the disaster situation. The cellular network should provide a fast and reliable connection. The project time line can be seen in Table 2: Project Time-line. Some system features can be seen in table 1.

As can be seen from figure 1, the system consists of mapping module, login management module, position tracking module, and resource management system. In order to track a real time position of a moving resource, it requires the resource to have the GPS enabled device. As stated in the review of the literature the GPS is being used by worldwide national mapping agencies for geographic information systems and for natural disaster prediction systems. Therefore, despite the power consumption disadvantages, GPS is still a reasonable choice for this system. The system provides location data in geo-coding coordinate (i.e. latitude and longitude coordinate). The mapping data and other additional positioning information are retrieved from an online available map server (e.g. Google or Live search map).

Table 1: Some System Features List

| No. | System Feature List |
|-----|--|
| 1. | Automatic login/ Semi auto login – detect hardware as a user ID and requests to confirm with a secure password |
| 2. | Manual login |
| 3. | Emergency classification list |
| 4. | Search for resource module |
| 5. | Sort resource list module |
| 6. | Send alert to a resource’s mobile device module |
| 7. | Display resources on a map module |
| 8. | a GPS Location updated module |
| 9. | a location prediction module |
| 10 | REST service for semi login – encryption service |
| 11 | REST service to provide a GPS location prediction module service |
| 12 | REST service to provide an Emergency classification module service |

System architecture of Web-based resource tracking during a disaster or crisis situation

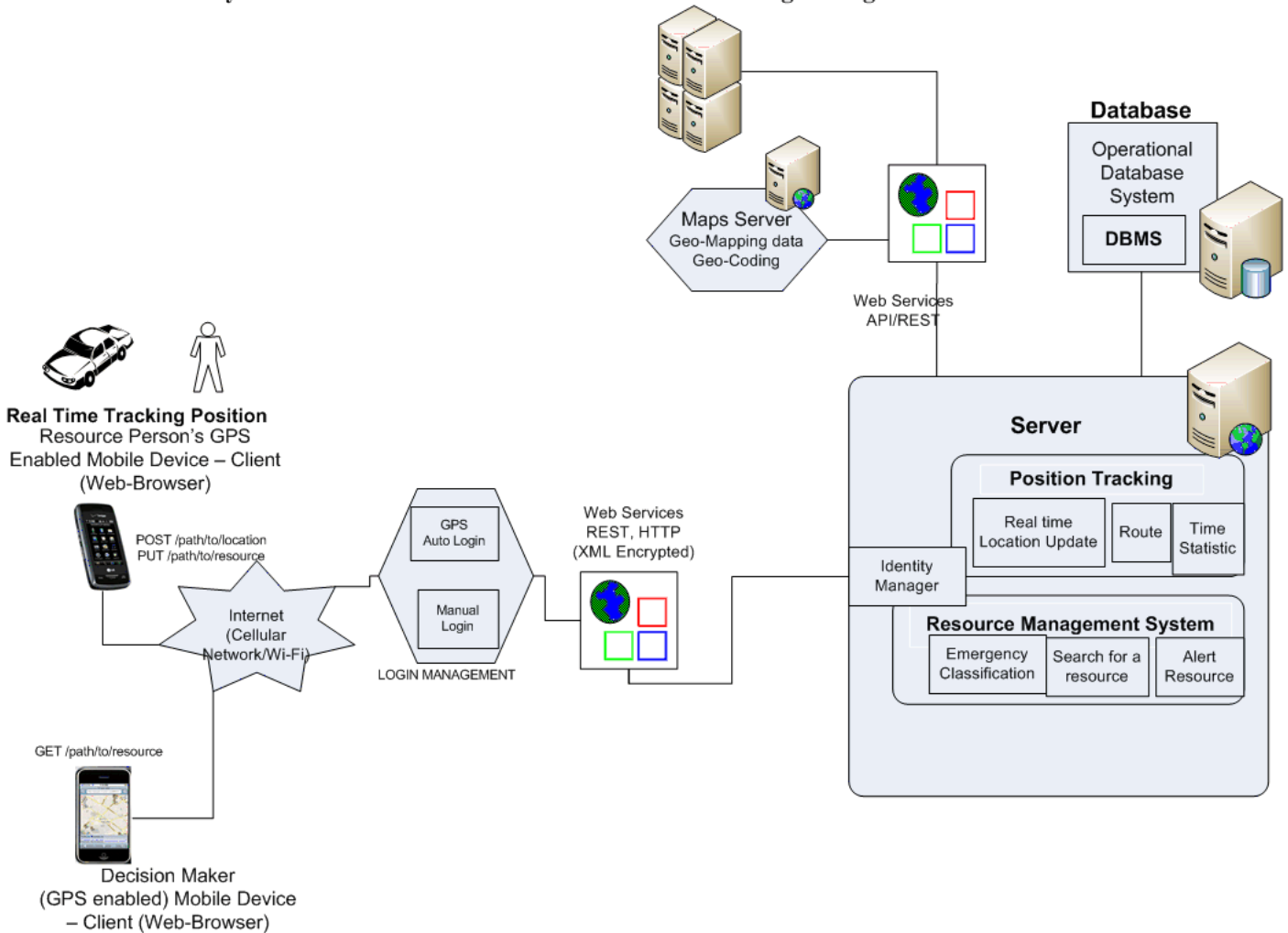


Figure 1: Overall System Overview for Web based mobile device resource tracking system during a disaster or crisis situation.

Login management module is the module to check user authentication before granting access to the system. There are primarily two types of login agents – a secure automatic login and a high security authentication login. During mass casualty incidents or a disaster, timing and availability of both human and material resources are highly critical. Therefore, an automatic login system for trusted registered resources is desirable to keep track of resources' real time positions. The device MAC address or the device pre-registered on the system is the user id that the system detects to recognize the device. Users still have to provide a secure password to login to the sytem. A resource person is automatically logged to the system upon receiving alert or request of duty from the system. The system provides recommended destination routing and direction information to the disaster area. While resources can log-on to the system automatically, a decision maker is required to have user name and password together with system device validation.

The user interface is designed to be user friendly where information can easily be found in particular during a critical situation.

The position sensitive information is encrypted in its correspondent cipher value element to protect any unauthorized activities ([O'Neill et al., 2003](#)). Richards (2006) recommends HMAC encryption method since HMAC can be used for both authentication and integrity at the same time and hence it increases security. With this method, both the client and the server must have a secret key. As the data is being POST or PUT, it will first be encrypted using a hashing method (e.g. HMAC). The encrypted data is then sent to the server via REST service. The XML format for the encrypted data can be seen in Figure 2: Encrypted XML location data and its equivalent XML location data can be seen in Figure 3: Equivalent XML location data as plaintext. Richards (2006) shows a generic HMAC algorithm as can be seen in Figure 4: A generic HMAC algorithm taken from Richards (2006), Chapter 12: XML Security, Introducing XML Signatures.

```
<?xml version='1.0'?>
<LocationInfo xmlns='http://xxx/location/geocoding/current'>
  <Name id="xxx123">Phavanhna User</Name>
  <EncryptedData Type='http://www.w3.org/2001/04/xmlenc#Element'
    xmlns='http://www.w3.org/2001/04/xmlenc#'>
    <CipherData>
      <CipherValue>X11X22X33</CipherValue>
      <CipherReference URI>http:// xxx/location/geocoding/cipher</CipherReference URI>
    </CipherData>
  </EncryptedData>
</LocationInfo>
```

Figure 2: Encrypted XML location data

```
<?xml version='1.0'?>
<LocationInfo xmlns='http://location/geocoding/current'>
<!--ID represents the device unique identification!-->
  <Name id="xxx123">Phavanhna User</Name>
    <current>
      <longitude>-104.441056</longitude>
      <latitude>32.176991666</latitude>
      <Point>
        <coordinates>-104.441056,32.176991666,0</coordinates>
      </Point>
    </current>
</LocationInfo>
```

Figure 3: Equivalent XML location data as plaintext

```
function hmac ($key, $data)
{
  $b = 64; // byte length
  if (strlen($key) > $b) {
    $key = pack("H*",sha1($key));
  }
  $key = str_pad($key, $b, chr(0x00));
  $ipad = str_pad("", $b, chr(0x36));
  $opad = str_pad("", $b, chr(0x5c));
  $k_ipad = $key ^ $ipad ;
  $k_opad = $key ^ $opad;

  return sha1($k_opad . pack("H*",sha1($k_ipad . $data)));
}
```

Figure 4: A generic HMAC algorithm taken from Richards (2006), Chapter 12: XML Security, Introducing XML Signatures

| Task | Time-line | Note |
|--|------------------|-------------|
| Sahana system investigation | Dec, 2008 | Done |
| UI (User Interface Design) | Jan, 2009 | |
| Emergency classification | Jan, 2009 | |
| System Flow Chart | Jan, 2009 | |
| Database design (ERD diagram) | Jan, 2009 | |
| Investigate how to get location coordination from a GPS enabled device or IP address | Jan, 2009 | |
| Submit final proposal project paper | Jan, 2009 | |
| Set up REST service | Jan - Feb, 2009 | |
| Set up Resource Management module | Feb, 2009 | |
| Set up identity Manager module | Feb, 2009 | |
| Link Resource Management module and the identity Module | Mar, 2009 | |
| Mapping module | Mar, 2009 | |
| Position tracking module | Mar, 2009 | |
| Link Position tracking module to the rest of the system | April, 2009 | |
| Initial review of the system | April, 2009 | |
| Final review of the system | May, 2009 | |
| First draft of final report | May, 2009 | |
| Final prototype and report | June, 2009 | |

Table 2: Project Time-line

5 Conclusion and Research Direction

One of the main objectives of the project is to provide real time prototype resource tracking solution during a mass casualty incidents and a natural disaster situation. The system is created to provide real time tracking of resources, sending position information of the resources to a decision maker; so managing resources, human and material resources, can be performed effectively and efficiently during a time sensitive situation. With the internet connectivity and the mobile accessibility, the system offers an advantage of information availability anywhere on- or off-site. Another important focus of the project is the ease of web-based

usability targeting mobile devices to make it suitable for a time sensitive scenario. However, this project does not address the hardware challenges of mobile devices (e.g. battery life time) and the wireless network connection issues. Research that addresses the significance of wireless network connectivity and mobile device battery life-time during a crisis situation would expose the limits for improvement of the system.

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iesyte,+D.;+Jensen,+C.S.

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a. The article proposes a user-centric design approach for a mobile payment technology. From the solution, several technologies can be identified in creating the technology. It provides a technical solution which can be used to investigate on how to develop the technology.