Mobile AME: A Handheld Application to Support Decision Making for Ammunition Personnel

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ABSTRACT

Wireless technology and the emergence of handheld devices provide new ways to deliver and present information. In the military setting, availability of needed information can be crucial during the decision-making process, especially in a war zone. This paper describes the extension of a Web-based ammunition encyclopedia system developed for the U.S. Army Defense Ammunition Center (DAC) called the ammunition multimedia encyclopedia system (AME). The extension, known as Mobile AME, exploits handheld technology to provide Quality Assurance Specialist Ammunition Surveillance (QASAS) personnel with access to needed ammunition information via a personal digital assistant (PDA). The focus was on developing a highly usable system that supports QASAS decision making and training in choosing the best practices to properly handle an ammunition item including Discarded Military Munitions (DMM). This paper discusses the motivation behind Mobile AME, design and development of the system, and future directions.

Keywords

Mobile decision support, Handheld technology, Ammunition multimedia encyclopedia.

INTRODUCTION

Mobile devices such as cell phones and PDAs have gained increasing importance as systems and devices continue to improve their capability of distributed Internet-based services to support exchange and sharing of data and services. Mobile computing represents a dynamic environment that enables a vast array of varying interfaces, contexts, and automation (Abowd and Mynatt 2000). These technologies present an opportunity to offer the latest knowledge transfer to any worker in the field even after they complete formal training. For example, the development process, storage, and handling of modern ammunition has become increasingly more complex and thus the challenge of developing dynamic training to maintain the quality of ammunition inspections is a significant problem for the U.S. Army Defense Ammunition Center (DAC).

DAC is an organization within the Department of Defense (DOD) that prepares civilians, including former military personnel, to transport, manage, and supervise ammunition and explosives handling. DAC also supports the joint
ammunition community worldwide through training, engineering logistics, explosives safety and technical assistance. These civilians are named either Quality Assurance Specialist Surveillance Ammunition (QASAS) or Ammunition Managers (Kearney et al. 2007).

In modern war, ammunition is one of the most necessary materials consumed in battlefields. The safety and reliability of munitions are critical to the war fighters and are related to the optimal war-fighting capability of an armed force (Mullen 2002). Discarded Military Munitions (DMM) that are left in a remote areas and abandoned instead of returned back through the ammunition supply system can pose an explosive and environmental danger, and the errors in ammunition inspection, packaging, and shipping can lead to irreversible tragedy. Handheld technology can be used to improve access to ammunition knowledge and support QASAS’ decision making which is proposed in this paper as a solution for reducing such errors.

This research was conducted based on design science rather than behavioral science, following the framework drawn by Hevner et al. (2004). Thus, our main focus is on presenting a mobile application that supports QASAS personnel for decision making.

BACKGROUND

Web AME

Web AME is a Web-based ammunition multimedia encyclopedia being developed at Oklahoma State University that enables QASAS personnel to browse the ammunition information. Web AME is implemented under a partnership with the Defense Ammunition Center (DAC) in McAlester, Oklahoma. Key features provided by Web AME include ammunition pictures, important inspection points, packaging information, immersive views, and instruction video clips. These features can enable the ammunition personnel to refresh their knowledge about specific ammunition or learn about a new ammunition item that their training did not cover. This content is available for all QASAS personnel.

Web AME has been implemented under the client-server architecture. PHP scripting language is used to create user interface on the client side, while MySQL database is used as the database management system (DBMS) on the server side. Figure 1 presents an example of Web AME’s features. This feature provides QASAS personnel with images and hotspots to present a good overview of each ammunition item. The system can exploit mobile computing by creating a portal for dissemination of ammunition knowledge to the QASAS personnel when they need to access it in the field, either to decide how to handle a specific ammunition item that they have just encountered, or to prepare themselves for any new ammunition that was introduced since their formal training.
The use of wireless technology and handheld devices enriches today’s variety of e-services and extends opportunities for decision support. Users can get access to the most up-to-date information via wireless mobile devices, and then make real-time decisions. The application of handheld technology has been explored in various industries, both in private and public sectors. For example, Chen et al. developed a wireless handheld application for providing clinicians with patient information and communication to reduce potential proximal causes of medical errors (2004). Burstein et al. also developed a mobile application to help tracking and monitoring emergency services for clinicians (2005). In archaeology, Blunn and colleagues employed handheld technology for supporting geocarchaeologists in the field (2007). Cabrera and others used handheld devices to provide computer-supported collaborative learning activities in the museum (2005), whereas, Pestana et al. developed a handheld application to support decision making for airport management (2005). Thus many examples of mobile decision support have emerged.

Mennecke and Strader categorized mobile devices into the laptop computer, handheld devices (PDA), telephone, hybrid (e.g., smart phone/pocket PC phone), wearable (e.g., jewelry, watches), vehicle-mounted and enabling technologies such as global positioning system (GPS) (2002). Even though many such portable devices can provide decision support capability, PDAs and hybrid are of great relevance, and are becoming increasingly popular for general users. In this study, hybrid devices such as pocket PC phones (PPCs) were used for Mobile AME.

Advancement in handheld technology enables handheld devices to perform as workstation computers for task-specific applications, such as collecting, storing, processing, and providing access to data. There are several architectures for mobile decision support: client-based, server-oriented, proxy-based, or distributed across an ad hoc network of similar peer devices (Bukhres et al. 2003). Currently, one of the most popular environments for mobile decision support is the client-server architecture. In this configuration, massive amounts of data are located on a server, while handheld devices provide the user interface (UI) and store user-sensitive data. The analytical model (AM) is also distributed across the client-server architecture by using handheld devices to perform elementary computations and send requests for more complex and resource-intensive computations to the server as presented in Figure 2, according to Burstein et al. (2008).
As mentioned earlier the motivation behind Mobile AME development is to support QASAS operations when they inspect DMM either in war zone or during the training operations. Mobile AME provides QASAS with necessary information so that they are able to handle the unfamiliar ammunition properly. We note that QASAS receive formal training early in their careers only. All new knowledge is acquired on the job. The context for Mobile AME is illustrated in Figure 3.

As can be seen in Figure 3, having obtained the most updated ammunition database through the portal residing on a base station where the desktop computer and the Internet connection are available, Mobile AME is deployed with a QASAS into the field, and the system comes into use when a QASAS team member needs to inspect an unfamiliar or discarded military munitions (DMM). The QASAS retrieves the ammunition information from Mobile AME identifying inspection points, shipping and packaging information. Once the ammunition has been identified and processed, it can then be securely delivered to an ammunition storage facility.
Device Independence and Usability

In this study, two major aspects of mobile computing are investigated; device independence and wireless usability (Lum and Lau 2003; Venkatesh and Ramesh 2006). Consequently, those two approaches are used as development frameworks of Mobile AME.

Device independence refers to the separation of data and presentation capability to support the movement of data between different technologies and heterogeneous computing systems. Device independence describes the presentation of information on different devices without affecting data, services, workflow, or personal computing style. Therefore, device independence provides users with accessibility to the same information, where the data are independent from a particular device, irrespective of the device from which the request originates and the delivery and presentation of data to a variety of devices with unpredictable screen sizes and technological capabilities as well as the rapid delivery of data over heterogeneous networks.

Usability is a term that generally refers to the ease with which people can employ a particular tool or other human-made object in order to achieve a particular goal (Neilsen 2000). In human-computer interaction, usability refers to the clarity with which a computer program or a Web site is designed. It is a critical aspect of success in Web application. Several studies identified a key impediment for wireless sites as being the lack of usability (Ramsay and Nielsen, 2000; Jackson et al., 2002). However, directly applying the principles of Web site design to a wireless site design may not produce desirable outcomes. Consequently, several researchers have studied the differences between the design of Web and wireless sites (Housel et al., 1998; Jones et al., 1999; Buyukkokten et al., 2000; Holzinge et al., 2004; Tamminen et al., 2004), while others proposed a framework for designing wireless site by employing the Technology Acceptance Model (TAM; Davis et al. 1989) (Lu et al., 2003; Siau et al., 2003; Fang, X., 2005). However, Venkatesh and Ramesh proposed an alternative framework which follows Microsoft Usability Guidelines: (Keeker 1997) that outperformed the technology acceptance model and proved more powerful for understanding usability of wireless sites and applications (Venkatesh and Ramesh 2006). Therefore, in this study, the framework of MUG in wireless sites proposed by Venkatesh and Ramesh was employed in Mobile AME development.

DESIGN OBJECTIVES

As already stated, the motivation behind Mobile AME is to satisfy QASAS information needs by providing the necessary ammunition information anytime and anywhere. In the design and development of Mobile AME, there are two major concerns; content delivery and usability. The system must be able to deliver the content to QASAS where there is a lack of Internet connectivity. Usability issues also become another concern of Mobile AME. In designing user interface, the screen should be able to display content as much as possible while allowing QASAS to navigate and read the content easily.

A related key factor for the success of Mobile AME is the human-computer interface issue. Several studies have been conducted to tackle the major common problem of mobile applications: attempting to give users access to powerful computing services and information through small interfaces, which typically have tiny visual displays, poor audio interaction facilities and limited input techniques (Kristoffersen and Ljungberg, 1999; Dunlop and Brewster, 2002; Kjeldskov and Graham, 2003; Kjeldkov et al., 2004). According to Dunlop et al., challenges for mobile HCI are categorized into five main areas (Dunlop and Brewster 2002): (1) Designing for mobility: small working area such in mobile device limits working environment for mobile users (e.g. no notes on desk like typical working environments), (2) Designing for a widespread population: lack of formal training for new mobile application users, (3) Designing for limited input/output facilities: lack of keyboard input and poor quality of audio output, (4) Design for context information: mobile devices fit well with context-aware application. However, unreliable network coverage may bring problems for mobile users, and (5) Designing for users multitasking at levels unfamiliar to most desktop users: for mobile application, the interruption regarding to use of multitasking is likely to be much higher than that in desktop design.
Several technologies have been developed to improve mobile device capability. Most mobile devices used a small keyboard, or a touch screen and stylus for input. Newer generations of PDAs include a virtual keyboard which allows designers more flexibility to alter the size and shape of a device. In order to achieve Mobile AME user interface goals, the system needs to be able to deliver and present the content in an organized way under limitations of the wireless handheld environment such as screen size, memory storage capacity, and processor speed.

**SYSTEM ARCHITECTURE**

Mobile AME is developed under a client-server architecture framework. On the one hand, according to its context of use, Mobile AME works as a stand-alone application by storing presentation, logic, and data module in the internal memory. On the other hand, the system can work on client-server architecture by connecting to the server through either a base station with Internet connectivity, or through its wireless capability to retrieve the most update content available. Figure 4 illustrates the system architecture of Mobile AME.

![Figure 4. Mobile AME Architecture](image)

The major scripting technologies employed by the Mobile AME architecture include HTML document object model (HTML DOM), JavaScript, Extensible Markup Language (XML), and MySQL database on the server side. This solution is capable of working on various handheld devices and operating platforms so that it achieves device dependency requirements.

**Mobile AME Data Source**

After the handheld device had been selected, we needed to evaluate the options for data source of the system. Since we chose to pursue a platform-independent solution, we decided to use the XML as the database for ammunition content for Mobile AME.

XML has emerged as a powerful language that uses a structural approach to describe objects. It empowers content developers to define the tags which are used to provide the desired description of any objects. In the following table (Table 1), XML tags are used in Mobile AME to describe various attributes and elements of the ammunitions.
<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Content Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Ammunition&gt;</td>
<td>Ammunition</td>
<td>Root tag that contains the collection of ammunition tags for different ammunition.</td>
</tr>
<tr>
<td>&lt;Munition&gt;</td>
<td>Munition</td>
<td>Contains collection of tags to describe a single ammunition (DODIC).</td>
</tr>
<tr>
<td>&lt;Category&gt;</td>
<td>Category</td>
<td>Specifies the sub-category details of the ammunition. It includes name, size and image for every ammunition sub-category.</td>
</tr>
<tr>
<td>&lt;Sub-Category&gt;</td>
<td>Sub-Category</td>
<td>Specifies the sub-category details of the ammunition. It includes name, size and image for every ammunition sub-category.</td>
</tr>
<tr>
<td>&lt;DODIC&gt;</td>
<td>DODIC</td>
<td>Department of Defense Identification Code (DODIC) is the unique indicator for every ammunition.</td>
</tr>
<tr>
<td>&lt;Name&gt;</td>
<td>Name</td>
<td>Contains the name for the ammunition.</td>
</tr>
<tr>
<td>&lt;Common Name&gt;</td>
<td>Common Name</td>
<td>Contains alternate names used for the ammunition.</td>
</tr>
<tr>
<td>&lt;Nomenclature&gt;</td>
<td>Nomenclature</td>
<td>Contains the name of the ammunition as stated in the Ammunition Manual based on its DODIC.</td>
</tr>
<tr>
<td>&lt;Use&gt;</td>
<td>Use</td>
<td>Contains the brief description about the application or the use of particular ammunition.</td>
</tr>
<tr>
<td>&lt;Description&gt;</td>
<td>Description</td>
<td>Contains the brief description of the ammunition.</td>
</tr>
<tr>
<td>&lt;Thumbnail&gt;</td>
<td>Thumbnail Path</td>
<td>Contains the URL for thumbnail image of the ammunition.</td>
</tr>
<tr>
<td>&lt;Videos&gt;</td>
<td>Videos</td>
<td>Contains the collection of video URL for each ammunition.</td>
</tr>
<tr>
<td>&lt;Immersive&gt;</td>
<td>ImmersiveVideos</td>
<td>Contains URL for immersive views.</td>
</tr>
<tr>
<td>&lt;Specification&gt;</td>
<td>Specification</td>
<td>Contains the URL for specification details document in PDF format.</td>
</tr>
<tr>
<td>&lt;Inspection&gt;</td>
<td>Munition Inspection</td>
<td>Contains the URL for ammunition inspection details document in PDF format.</td>
</tr>
<tr>
<td>&lt;Packaging&gt;</td>
<td>Packaging_Shipping</td>
<td>Contains the URL for packaging and shipping details document in PDF format.</td>
</tr>
<tr>
<td>&lt;Hotspots&gt;</td>
<td>Hotspots</td>
<td>Contains collection of hotspot tags. Every hotspot tag includes HotspotName, URLLink (Links to the zoomed image of that hotspot), co-ordinates, related images, related videos related to a particular hotspot.</td>
</tr>
</tbody>
</table>

Table 1. XML Structure for Mobile AME

The main advantage of the XML is that it is capable of working on a majority of the mobile device platforms. It also provides the application with flexibility to work in either standalone mode or delivering of dynamic content from the server. The content alterations (add, update, or delete) can be triggered when QASAS connect the mobile device to a computer running an application that enable data synchronization to transfer the data between mobile device and the computer.

In order to retrieve ammunition information from the XML file, we used JavaScript embedded in the HTML page to interact with the Document Object Model (DOM). JavaScript is also used to perform navigation functions of the application.

**Screen Design**

One of the critical issues of mobile devices is that there is a limited amount of screen space on which to display information, and this poses a challenge for handheld application developers to design the screen layout (Forman and Zahorjan, 1994; Eisenstein et al., 2001; Brewster, 2002). Thus, in Mobile AME, the screen was developed based on the largest display on handheld devices available at the time the system was designed. The application display size was set to 240 width by 320 height pixels (Brown 2008).

HTML tables are the major technique used as screen layout to organize data. However, the use of tables in mobile applications is not the same as in the desktop web environment. Since not all browsers support nested table, the use
of tables in a mobile environment has to be limited to a simple layout (MobileDesign 2008). In addition, all the tables are specified as percentage rather than fixed width to dynamically present the content according to a variety of screen sizes across different devices.

**Presentation of the Content**

Mobile AME maintains consistency of the content presentation across different pages in the application by using Cascade Style Sheet (CSS). The key characteristic of the style sheet is that it is a separate file from the HTML page. Every display element of Mobile AME is controlled by its style defined in a style sheet file, hence every page in Mobile AME has consistent design if they refer to the same style.

**Application Navigation**

In Mobile AME, application navigation is another primary concern that extends functionality from the desktop environment. Even though connectivity, cursor navigation, and text input are the same as the desktop, the small screen means that less information is able to be displayed on each page or screen. This is unlike the Web version of AME, which was developed under desktop environment and allows several screens at different levels to display information. However, when the information is presented on a handheld device, the extra information has to be altered to avoid overlong page scrolling. Accordingly, the content was divided into multiple pages.

As presented in Figure 5, the basic navigation for Mobile AME is fairly standard. Upon launch, an ammunition type screen identifies major type of the ammunition in Mobile AME. Then users browse through the ammunition subcategories to get access to the desired ammunition.

![Figure 5. Navigation Architecture of Mobile AME](image)

Usually, mobile applications have two ways to use the Back function for navigation: a breadcrumb or history list, or as a path home as depicted in Figure 6 (MobileDesign 2008).
Figure 6. Two major Back functions for mobile applications (Source: MobileDesign 2008)

The first approach, history list, allows users to jump across different functions of the application. Many users get used to this approach using internet browsers. However, with the mobile application small screen size, users may easily get lost. Mobile AME employs the second approach, a path home, which the Back function takes the user back or up one level. The major advantage of this approach is that users are less likely to get lost and can fairly quickly get back to known territory which provides Mobile AME with ease of use. In addition, Mobile AME has a “Home” key on every page so the users do not have to press Back several times to get to the main menu.

Server-side Development

On the server-side of Mobile AME, the server application is responsible for performing database transformation from MySQL to XML format for serving as a data source of Mobile AME. In this state, several approaches that allow the transformation between MySQL and XML were examined. After the evaluation, the best solution for Mobile AME database transformation is to develop a PHP script that generates XML content from the MySQL database.

MOBILE AME FUNCTIONALITY

As the main objective of Mobile AME, the system should be able to provide QASAS interns with ammunition content through a variety of content presentations. Mobile AME consists of six major features: ammunition information, ammunition specification, inspection points, packaging and shipping information, three-dimensional immersive views, and visual inspection video clips.

Ammunition Information and Inspection Points

When a desired ammunition item is selected, this feature provides QASAS with general information and all the details of each ammunition including ammunition name, category, Department of Defense Identification Code (DODIC) number, nomenclature, common name, use, and description (Figure 7).
Ammunition Specification, Packaging and Shipping Information

Ammunition specification, inspection, and packaging information are stored in portable document format (PDF) format. Storing the ammunition information in PDF provides several advantages to Mobile AME. PDF is a platform dependent application which is used for representing two-dimensional documents in a manner independent of the application software, hardware, and operating system. PDF document also enables QASAS to perform document encryption, document sharing, and document searches for desired information using keywords (Figure 8).

Each ammunition is presented with its picture which includes the inspection points or “hotspots” which are used for showing further detail of a specific area when a user clicks at a hotspot (Figure 9). This feature enables QASAS personnel to evaluate specific areas on the ammunition as required by DOD ammunition inspection guidelines.
Three-Dimensional Immersive Views

The immersive view is an advanced feature of Mobile AME which brings the QASAS closer to the virtual reality experience when they need to perform an inspection on any ammunition. This is particularly useful for ammunition recently introduced to the community. The ammunition is presented in three-dimensional interactive image-based animation that allows the user to manipulate the picture by rotating it in both vertical and horizontal orientations (Figure 10).

Inspection Point Video Clips

Another key feature of Mobile AME is the inspection point video clips. Video has become an important element of multimedia computing and communication environments in several areas such as in business, education, and military settings. For our system, video clips are used to deliver instruction of ammunition inspections to the QASAS in the field. The video clips are organized into different categories which allow the user to inspect a specific point directly without having to watch all the content from the beginning. The video clips were recorded in several formats (e.g. Windows Media Player, QuickTime, or FLV) so that they can be viewed in different device platforms (Figure 11).
EXPLORATORY EVALUATION OF MOBILE AME

In order to demonstrate the benefits of utilizing Mobile AME for the QASAS, our system needs to be evaluated based on the key requirements addressed by the U.S. Army Defense Ammunition Center (DAC) for successful deployment. As part of the evaluation, we aim to ascertain its overall feasibility, effectiveness, and efficiency of Mobile AME functionality.

Due to the difficulty in Mobile AME’s context of use, we have not yet been able to run our experiment in an actual QASAS operational setting. Instead, Mobile AME was presented to the subject matter experts (SME) and to high-level military leaders at U.S. Army. The general reaction was that Mobile AME can provide ammunition information in an efficient and effective manner. There is enthusiastic support for the technology. However, the cost deploying Mobile AME to QASAS and QASAS interns in the real-world setting incurs much technology expense which is still under evaluation. In order to deploy Mobile AME, the handheld device (HTC Tilt) has to be distributed to every QASAS personnel. However, at the time of Mobile AME development, the cost of the device was approximately $500.

DISCUSSION

Wireless handheld technology is constantly evolving and improving. With more advanced handheld devices, new capabilities such as a higher processor performance, larger and better display, and more storage capacity can significantly improve the capabilities and performance of Mobile AME.

In terms of deployment, one concern from the evaluation of Mobile AME is the issue of cost of the device. The major features of Mobile AME, the immersive views and the inspection point video clips, require higher performance device hardware, and consequently increases device cost.

Security and privacy are also of primary concern when dealing with ammunition information. Thus far, we have utilized user-level authentication to get access to Mobile AME. However, we note that this level of security will not be sufficient when dealing with actual deployment in the actual setting. Therefore, further study would need to incorporate a more comprehensive security issues which include the security of the XML database stored in the device’s internal memory. An encryption technique could be put in place to prevent unauthorized access to the XML database. In addition, we can ensure another level of security by protecting the handheld device that Mobile AME
runs on. Most PDAs have built-in a locking feature that, when activated, requires users enter a password before allowing them to use the device. Moreover, more advanced security features are available in newer PDAs such as a biometric authentication can be implemented on Mobile AME as well.

Mobile AME is currently purely a data retrieval system which provides access to all ammunition information presented in different multimedia formats. Our future research will focus on a development of a collaboration system that exploits wireless capability of the handheld devices. Consequently, the new version of Mobile AME will allow QASAS to share knowledge and information for more effective team collaboration and decision making.

CONCLUSION

Wireless handheld applications used in military settings have the potential to alleviate the problem of inadequate ammunition information for QASAS. Mobile AME is a wireless handheld extension to the Web-based ammunition information system, Web AME, which provides direct access to the ammunition data repository.

Our goal of Mobile AME development is to provide ammunition information to QASAS when and wherever they need it. Inadequate access to ammunition information and lack of collaboration among QASAS team members have been identified as causes of inspection errors in several reports and studies. Handheld technology and information systems can be used to alleviate these problems by providing QASAS with access to desired information of discarded military munitions (DMM) when it is needed. The handheld technology is used in the study to provide a new way for facilitating QASAS’ main operations. According to the comments by subject-matter experts (SMEs) and high-level military leaders, we have developed a wireless handheld solution to alleviate the problem of inspection errors. Our next step is to develop the collaboration system which would allow QASAS to share knowledge decision making in operations.

Due to the unique limitations of the wireless handheld environment, new challenges are presented to system developers for producing effective and efficient applications. We have taken these limitations into consideration when designing Mobile AME’s architecture, its user interface, and its functionality. For Mobile AME, we have developed a usable, and platform-independent mobile decision-support application that effectively and efficiently provides ammunition information to support operations of ammunition personnel.

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