m-ARCE: Designing an Ubiquitous Mobile Office for Disaster Mitigation, Services and Configuration

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ABSTRACT

Cooperation and mutual assistance in emergency situations is one of the main objectives of the Latin-American Association of Governmental Organisms of Civil Defense and Protection. To promote such collaboration m-ARCE has been developed; an ubiquitous mobile office for disaster mitigation where users can send and receive information anywhere and anytime. When a catastrophe happens in a country, and almost all infrastructure is destroyed, mobile technology, such as mobile devices and wireless networks, offers the user resources to ask for help and to manage it. Latin-American Countries often suffer catastrophes that provoke numerous human losses and major economic and social problems. International assistance and collaboration with the affected country is necessary to help in its recovery. The Web, like Internet, offers static office services to users who can access information using an infrastructure in indoor environments. On the other hand, mobile computing and networking use the Internet, together with mobile physical devices linked to it, and software platforms built upon it, to design and coordinate systems across countries. In the ubiquitous mobile office design, we describe how services, such as chat, email and wireless communication, should be configured for emergency situation. We make use of ubiquitous hypermedia -linked nodes in ubiquitous spaces- to ensure mobility and accessibility to the mobile device interface, such as PDAs and smartphones.

Keywords

PDA, Disaster Mitigation, Multinational Cooperation, Wireless Networks, Mobile Devices, Ubiquitous Computing.

INTRODUCTION

One of the main objectives of the Latin-American Association of Governmental Organisms of Civil Defence and Protection is to promote cooperation and mutual assistance in emergency situations. When a disaster occurs and almost everything is lost or destroyed, the only way that a Delegate (an eyewitness who travels to the country affected by the disaster to keep his/her country informed about the situation while s/he is there), can send and receive information is through the use of mobile technologies. The current process to deal with disaster mitigation has a number of drawbacks that can be solved using an application on a Personal Digital Assistant (PDA) and wireless communication. In this proposal we introduce ARCE (Aedo et al, 2002), a tool that promotes collaboration among twenty-one Latin-American countries and m-ARCE as the ubiquitous access to the system. The main goal of ARCE is to efficiently support emergency responses in a international context, and the main goal of m-ARCE is to keep countries informed by their Delegate, a traveling eyewitness with the previously explained functions and in need of working online with applications.

In this paper, we describe m-ARCE as a way of understanding what means being mobile and working anywhere, anytime. We try to answer: why and how should wireless communication be configured into mobile devices such as PDAs and smartphones. What kind of data services should be useful to access via mobile devices?. In addition to inform new design directions for ubiquitous mobile office, this research is also about developing an understanding mobile infrastructure. By reflecting on these issues, we can better understand the role of technology and information in ubiquitous mobile office, and thus identify the opportunities for the development of appropriate technological solutions to support mobile users. The rest of this paper is organized as follows. After introduction, we present the

ARCE system. We then describes m-ARCE – an Ubiquitous Mobile Office for Disaster Mitigation: Services and Configuration. Next, we discuss m-ARCE Architecture. Finally, we concluded some technical issues.

ARCE

ARCE (Aplicación en Red para Casos de Emergencia - Application in Network to Emergency Cases) is an international tool that promotes collaboration among Latin-American countries providing mechanisms to notify an emergency, request resources and offer assistance. In short, when an emergency occur the affected country or countries -which we will refer to throughout this paper as the emergency owner- can use the system to keep the other associates informed -referred to as the assistance suppliers. The basic requirements for efficient communication between countries and organisms can be addressed using the web. In order to develop a useful application a number of requirements were taken into account, including: accessibility, multi-user support, inter-state support, multi-purpose application, reliability, efficiency and maintainability. In order to increase the system´s usability, the user interface has been designed applying Human-Computer Interaction (HCI) principles, paying special attention to usability and consistency issues. Moreover, in order to improve this collaborative environment, an iterative and user-centered development methodology has been adopted. ARCE has been developed using ARIADNE (Díaz et al, 2001), a software engineering method to develop and evaluate hypermedia and web applications, and MARAH (Díaz et al, 2004), an access control model that provides security designers with mechanisms to specify security rules using elements and abstractions of the hypermedia domain (nodes, links or contents). ARCE operates in two modes: `routine` and `emergency`. The first, the application is used as a communication channel and to post news. The second, countries affected by a disaster can manage the emergency informing to the other associates, preparing a preliminary request for urgent resources, elaborating a more detailed request and coordinating the assistance offered by other countries. ARCE is accessed by different users with different responsibilities. This implies that each user has to be allowed to perform or not perform an operation (e.g. create an emergency, offer assistance or accept assistance) according to the role she plays in a specific organism. To deal with this issue ARCE assumes a Role-Based Access Control (RBAC). RBAC (Ferraiolo, Barkley, and Kuhn, 1999) is a security mechanism that regulates the access to resources on the basis of organizational entities called roles. A role represents a job function or a set of responsibilities for a set of users holding that role, together with the privileges granted to them. Each user of the application will be assigned one or more roles. This role, along with the country or organism to which the user belongs, determines the information each user receives as well as the tasks she can perform on the system. For example, the Delegate can manage disaster information when he is in the emergency situation as an eyewitness.

M-ARCE

Technological advances have been the main factor in changing the workplace of the future – allowing workers to be disconnected from the desk, and changing the nature of what type of work is done. Outdoor environments are greatly facilitated by the proliferation of wireless technology. The increasing variety of wireless devices offering IP connectivity, such as PDAs, handhelds, and digital cellular phones, is beginning to change our perceptions of the Internet.

m-ARCE Scenario

Mobile devices and wireless networks let researchers and designers define scenarios and architectures to access the system infrastructure, permitting users to be more intensely connected, either face-to-face or at distance. In our m-ARCE scenario, a user playing a basic role is the Delegate, an eyewitness who travels to the country affected by disaster to keep his/her country informed about the situation which he has experienced there, not only receiving and sending information, but also working online with applications. He uses tools such as laptop, PDAs, wireless router, battery, IP voice service, and applications such as ubiquitous web, database, and web server. After reviewing tools and applications, the Delegate travels to the emergency area and when s/he arrives to the country affected, s/he installs the ubiquitous mobile office. The Delegate is in charge of obtain Internet service access from indoor or outdoor environment to the subnetwork. Also the Delegate has to configure the m-ARCE application (Aedo et al, 2005) to allow ARCE system (Aedo et al, 2002) to be operational in a wide range of possibilities: from a simple template in any mobile device to a robust computation in any desktop. After installing ubiquitous mobile office, having gained access to Internet via wireless, the Delegate goes around to the disaster area and studies what people's first needs are, and how help from other assistance suppliers is coming. After studying the disaster situation, the

Delegate returns to the mobile office and starts working with m-ARCE, sending information about what has been found in the disaster area.

The above scenario shows how the ubiquitous mobile office design for disaster mitigation would adapt the resources as if it were a static office. The design objectives of m-ARCE are to offer mobility and accessibility to the user while interacting with the applications and information, anytime and anywhere.

Ubiquitous Mobile Office: Services and Configuration

In case of emergency, ubiquitous mobile office must resolve `communication network coverage` and `information overload`.

When fixed infrastructures collapse, access to satellite resources might represent the only means of communication. Unfortunately, satellite coverage has limitations in practices. For example, as mentioned (Borriello, Chalmers, LaMarca and Nixon, 2005) Global Positioning System (GPS) is truly ubiquitous, covering the entire Earth's surface by using a constellation of low earth orbit satellites (LEOS), but the radio signals sent by the GPS satellites are too weak to penetrate most buildings or pass through dense vegetation. As a result, GPS works well outdoors. In addition, (Pousti and Hasan, 2005) notes that communications networks could not operate in the high pressure environment as radio transmissions were unable to work in high-rises on September 11, 2001. Ubiquitous mobile office resolves `communication network coverage` implementing a heterogeneous network, as shown Figure 1, consisting of a broadband satellite network, complemented by a Wireless Local Area Network (W-LAN) in areas where satellite coverage is unavailable or in "hotspot" as (Liang, Ong, Chan, Sheriff and Conforto, 2003). Broadband satellite network uses a constellation of geosynchronous earth orbit satellite (GEOS) and W-LAN uses a constellation of low earth orbit satellites (LEOS). W-LAN "hotspot" areas are utilized to complement the satellite network. The W-LAN link is used to extend the satellite link when satellite coverage is inaccessible.

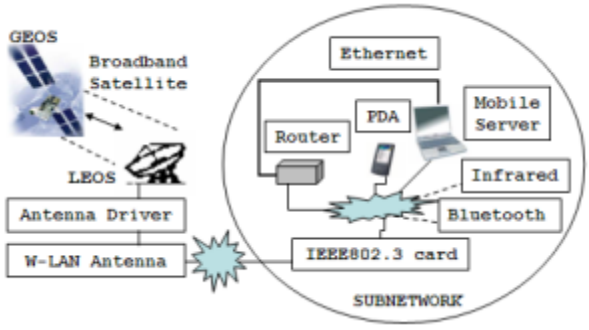

Figure 1. m-ARCE Network Architecture

m-ARCE network architecture offers Internet access to mobile devices, as shown in Figure 1. In the right place, a subnetwork is designed using W-LAN architectures, which are based on the IEEE 802.11g standard. Subnetwork gives Delegate the opportunity to work with any mobile device, such as PDAs, laptops, and smartphones. In the left place, the W-LAN Antenna gets signal from broadband satellite passing by Antenna driver. GPS (Imieliński and Navas, 1999) or Iridium and Teledesic (Gavish and Kalvenes, 1998) could provide LEOS services. Inmarsat could provide GEOS services.

Ubiquitous mobile office attempts to resolve `information overload` with online conversations and emails. Online conversations are when the Delegate is walking around the catastrophe area, s/he can have online conversations with his/hers partners using his/her PDA. S/he can open the ubiquitous web on his/her PDA and sign in m-ARCE chat session, as shown Figure 2. Online conversations with Delegates are structured to facilitate the capture and retention of important emergency information. Emails session is when the Delegate can write, send and receive online and offline messages. S/he opens the ubiquitous web browser on his/her PDA and s/he signs in m-ARCE email session. Messages to Delegates are be forwarded over his/her mobile devices. m-ARCE utilizes predefined rules and reasoning mechanisms, information received from variety of sources is verified quickly, used to generate standard reports using templates, and forwarded to the appropriate emergency centers.

An emergency can occur anywhere at any time, and the people whose job is to respond might be geographically dispersed. Ubiquitous computing (UC) plays a key role in facilitating information sharing among Latin-American Association during rescue operation. UC supports a collaborative knowledge based environment that facilitates timely and relevant information exchange leading to the successful resolution of the disaster. UC embeds technology to support three tasks - monitoring and reporting, notification, and operation – in the emergency response.

Figure 2. m-ARCE: Online Conversations

m-ARCE Role in Ubiquitous Computing

Ubiquitous mobile office attempts to solve the ubiquity issues surrounding in terms of time-aware, location-aware, device-aware, and personalized services. This implies that ubiquitous mobile office has to take into account, individually for each Delegate, time and location of access, together with the different capabilities of devices comprising display resolution, local storage size, method of input and computing speed as well as network capacity. As result, m-ARCE uses ubiquitous web browser to manage `information load` as described below. Consequently, the fundamental objective of ubiquitous mobile office is to provide services not only to Delegates at anytime, anywhere, with any media but specifically to communicate the right thing at the right time and the right way. The pre-requisite for supporting ubiquity is that the application is aware of it's context (Weiser, 1993). When designing ubiquitous mobile office, we try to understand what emergency response context is to determine its relevancy and how it can be exploited for adapting the provided services towards this context.

m-ARCE Architecture

m-ARCE architecture is shaped as funnel. At the top level resides the centralized system (ARCE). At the middle level resides the distributed system (m-ARCE). At the bottom level resides the interface. m-ARCE is based on software, hardware and network architecture. Software architectures have the potential to substantially improve the development and evolution of large, complex, multi-lingual, multi-platform, long-running systems. When software architecture is very complex, design and coding are likely to take more time and contain more errors. Software architecture concerns the design of the gross structure of a software system, including its overall behavior and its decomposition in simpler computational elements. Software elements are applications, such as web browser, web server, programming languages, and database, available to satisfy the design's perspective: structure, content, navigation, security, usability, accessibility, and mobility. Hardware elements refer to infrastructure to allow people work and communicate. Hardware elements are mobile devices, cables, antennas, and towers. Network refers to the technology of the information transmission. Networking elements are Wireless, UMTS, Bluetooth, Infrared, Radio, Ethernet, and Internet networks.

CONCLUSION

We have proposed an ubiquitous mobile office for disaster mitigation system to understand how mobile technology, such as mobile devices and wireless networks, should be organized to support an emergency situation, and to allow users to work in outdoors environments. We have designed wireless subnetwork where users can travel with PDAs, laptops, mobile phones, digital camera, and a wireless router to build their ubiquitous mobile office, and to stay in touch with their country of origin. In terms of direct implications for the design of ubiquitous mobile office, this research may inform the development of a number of possible issues. The technologies that would have supported the behavior of those mobile users we interviewed, would have the following properties:

- Be lightweight and highly flexible (rather than highly specific) integrated systems. Technologies that could be adapted to a variety of situations would be more useful than highly complex and powerful, but single-use, devices.
- Allow the location, use of, and access to locally available resources (e.g., thorough Bluetooth).
- Support effective use of remote activities, perhaps through radio or reduced-bandwidth mobile voice over IP, broadcast over WAP, or SMS/text messaging.

ACKNOWLEDGMENTS

This work is supported by the ARCE++ project (TSI2004-03394) funded by the Spanish Ministry of Science and Education (MEC) and a cooperation agreement between "Universidad Carlos III de Madrid" and "Dirección General de Protección Civil y Emergencias" (Ministry of the Interior).

REFERENCES

1. Aedo, I., Gómez Bello, P., Sanz, D., Diaz P., and De Castro J. (2005) Using a PDA to access ARCE system, *Proceedings of the First Euro Conference on Mobile Government*, mGOV2005, Brighton, UK, 27-35.
2. Aedo, I. et al, Diaz, P. and De Castro, J. (2002) Supporting efficient multinational disaster response through a web-based system, *Proceedings of the First International Conference on Electronic Government*, Aix-en-Provence, France, 215-222.
3. Berners-Lee, T. (1996) WWW: past, present, and future, *Computer*, 29, 10, 69 - 77.
4. Borriello, G., Chalmers, M., LaMarca, A., Nixon, P. (2005) The disappearing computer: Delivering real-world ubiquitous location systems, *Communications of the ACM*, 48, 3, 36 – 41.
5. Denning, D.E. (1976) A lattice model of secure information flow, *Comm. of the ACM*, 19, 5, 236-243.
6. Díaz, P., Sanz, D., and Aedo, I. (2004) MARAH: an RBAC model and its integration in a web server, *In proceedings of Data Security 04*, Skiathos Greece. 243-252
7. Díaz, P., Aedo, I., and Montero, S. (2001) Ariadne, a development method for hypermedia, *In proceedings of Dexa*, 2113, 764-774.
8. Ferraiolo, D.F., Barkley, J.F. and Kuhn, D.R. (1999) A Role-Based Access Control Model and Reference Implementation within a Corporate Intranet, *ACM Trans. on Information and Systems Security*, 2, 1, 34-64.
9. Gavish, B. and Kalvenes, J. (1998) The impact of satellite altitude on the performance of LEOS based communication systems, *Wireless Networks*, 4, 2, 199 – 213.
10. Imieliński, T. and Navas J. C. (1999) GPS-based geographic addressing, routing, and resource discovery, *Communications of the ACM*, 42, 4, 86 – 92.
11. Jiang , X., Hong , J. I., Takayama, L. A., Landay, J. A. (2004) Ubiquitous computing for firefighters: field studies and prototypes of large displays for incident command, *Proceedings of the SIGCHI conference on Human factors in computing systems, ACM Press*, 6, 1, 679-686.
12. Liang, X., Ong, F.L.C., Chan, P.M.L., Sheriff, R.E., Conforto, P. (2003) Mobile Internet access for high-speed trains via heterogeneous networks, Proceedings on Personal, Indoor and Mobile Radio Communications, PIMRC 2003 14th IEEE, 1, 177 – 181.
13. Pousti, H., Hasan, H. (2005) Knowledge management through mobile networks in emergency situations, *International Conference on Mobile Business*, 2005. ICMB 2005. Sydney, Australia, 573 – 580.

14. Turoff, M., Chumer, M., Van de Walle, B., Yao, X. (2004) The Design of a Dynamic Emergency Response Management Information System (DERMIS), *Journal of Information Technology Theory and Application (JITTA)*, 5, 4, 1-36.
15. Turoff , M. 2002 On site: Past and future emergency response information systems, *Communications of the ACM*, 45, 4, 29-32.
16. Wang, Y., Kar, E., Meijer, G. (2005) Designing mobile solutions for mobile workers: lessons learned from a case study, *Proceedings of the 7th international conference on Electronic commerce ICEC '05*, *ACM Press*, 113, 585 – 589.
17. Weiser, M. (1993) Some computer science issues in ubiquitous computing. *In Communications of the ACM*, 36, 7, 75-84.
18. Stuart M., Omran B. (1997) Utilizing mobile computing in the Wishard Memorial Hospital ambulatory service, *Proceedings of the 1997 ACM symposium on Applied computing*, San Jose, California, USA, 287 – 294.