Application of Mobile GIS and SDI for Emergency Management

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Abstract

Emergency management requires precise and reliable information about the current situation of emergency, existing sources and facilities, while more than 80% of this information has spatial component or location. Considering the urgent and time sensitive nature of emergency situations, it is necessary to collect and use spatial information of the current state of the emergency within the minimum waste of time. This will be achieved if in the context of a collaborative effort, each of the parties involved in emergency management, takes responsibilities for collecting some parts of spatial information required for emergency management and sharing them to be accessible for wider emergency management community. In this regard, Spatial Data Infrastructure (SDI) is an appropriate framework to facilitate such collaboration in spatial data collection and sharing. Mansourian (2005) showed the improvement of emergency management by developing an SDI conceptual model and web-based GIS to facilitate spatial information management.

Based on SDI framework for emergency management, field data collection and real time updating of Emergency Operation Center (EOC) on current emergency situation can be highly improved using Mobile GIS. Mobile GIS can also improve in-filed decision-making for emergency workers. Meanwhile, in order to use mobile GIS for emergency management, it is necessary to expand the developed SDI conceptual model to support Mobile GIS applications.

This paper aims to address the role of Mobile GIS and SDI as an integrated framework for facilitating emergency management by improving field data collection and in-field decision-making. This is based on a research project which is ongoing in Iran.

INTRODUCTION

Emergency is a course of events that endangers or adversely affects people, property, or the environment. In other words, emergency situation is a deviation from planned or

expected behavior of ideal state. Nowadays, emergency situations are a serious threatening to human's life and property. Hence, appropriate management of these emergencies has become one of the most notable topics of mankind in current century. Emergency management procedure consists of several phases from planning to mitigation and preparedness (as pre-emergency phases) and response and recovery (as during and post-emergency phases). In all phases, emergency management requires precise and reliable information about the current situation of emergency, existing sources and facilities.

The experiences of disaster management activities have proven that spatial data can considerably facilitate disaster management because most of the required information for disaster management has spatial nature (Bruzewicz, 2003 and Donohue, 2002). In this regard, Geo-Spatial Information System (GIS) as a tool to collect, store, model, analyze and display large amount of spatially information layers, supports all aspects of emergency management. However, current studies show that while spatial data and GIS can facilitate disaster management, but there are substantial problems with collection, access, dissemination and usage of required spatial data for disaster management (SNDR 2002 and Jain and McLean 2003). Such problems become more serious during emergency response phase with its dynamic and time-sensitive nature. In other words, any problem or delay in data collection, access, usage and dissemination has negative impacts on the quality of decision-making and hence on the quality of disaster response.

The problem with spatial data management can be resolved if in the context of a collaborative effort, each of the parties involved in emergency management (such as fire and rescue services, emergency medical services, police, or local authorities) takes responsibilities for collecting some parts of spatial information required for emergency management and sharing them to be accessible for wider emergency management community (Mansourian, 2005). In this regard, Spatial Data Infrastructure (SDI) and web GIS are an appropriate framework to facilitate such collaboration in managing spatial data for disaster management (Mansourian et al., 2006). Mean while, mobile GIS is an appropriate technology for in-field data collection, sharing and usage.

This paper aims to address the role of Mobile GIS and SDI in emergency management. It first reviews the role of SDI and WebGIS in disaster management and previous studies in this regard. Then the role of mobile GIS in emergency management will be investigated and the necessity to develop the SDI conceptual model to support mobile GIS applications in emergency management will be depicted.

The Role of SDI and WebGIS in Disaster Management

Although a partnership model for spatial data collection and sharing can resolve the problem with collection, access and dissemination of required spatial data for disaster response, relevant research into collaborative efforts in spatial data production, sharing, and exchange shows that there are different technical (such as standards and interoperability models) and non-technical (such as social, cultural, and institutional) issues that create barriers for such participation (Nedovic-Budic and Pinto, 1999 and McDougall *et al.*, 2002). SDI is a framework for resolving such problems.

SDI is fundamentally about facilitation and coordination of the exchange and sharing of spatial data between stakeholders from different jurisdictional levels in the spatial data community (Rajabifard et al., 2004). One of the fundamental applications of SDI can be in emergency management. SDI is an appropriate framework to facilitate the collaboration in spatial data collection and sharing among the parties involved in emergency management.

Mansourian (2005) could improve emergency management by developing an SDI conceptual model and a web-based GIS as an integrated framework to facilitate spatial information management. On the basis of this developed model and system, each of the involved organizations in emergency management is in charge of collection and updating some part of required spatial data based on its responsibility during disaster response. The collected data is stored in the custodian's database. There is also a database in the EOC where representatives of involved organizations are gathered to coordinate disaster response operations and control the general emergency situation. Some parts of the general and base datasets are regularly copied from organizations' databases into EOC database after any data entry or updating through a replicate mechanism. In EOC, representatives of organizations have access to EOC database through a web-based GIS which can be based on a Local Area Network (LAN). Having access to EOC database, EOC is aware of the latest status of emergency situation for general planning, coordinating the response process and controlling the situation.

At the same time, each organization has access to EOC database through a web-based GIS to use base information in EOC database besides their own specific information. This accessibility explains the concept of sharing spatial information. Emergency management organizations will have coordinated response operations while using spatial information in EOC database.

In this way, SDI with related concepts and models, can be used as a framework for creating such an environment and consequently, facilitating disaster management. The SDI conceptual model developed by (Mansourian et al., 2006) for disaster management, appoints to a set of requirements (standards, policies, access network, people and data), while being supplied in emergency management, the concept of partnership and coordination will be provided during the emergencies.

Based on the mentioned SDI conceptual model, similar to volunteer bodies that are trained for relief and rescue operations, specific staffs in each organization and volunteer bodies should be trained for spatial data collection during an emergency. In-field data collection while moving in the emergency area and the need to real time updating of EOC database brings mobile GIS as an appropriate data collection tool into front.

The Role of Mobile GIS in Emergency Management

Mobile GIS is a movable GIS that makes spatial data acquisition, storage, sharing and analysis in every time and everywhere possible for users. In mobile GIS, not only data are movable but also hardware and software are. This characteristic makes mobile GIS an efficient technology in managing spatial data, particularly in emergency management.

Mobile GIS has two fundamental applications in emergency management:

- As mentioned earlier, mobile GIS facilitates in-field data collection and real time updating of EOC database. Collected data can be about location of victims, burning buildings, closed routes, etc.
- Using mobile GIS emergency workers can access to EOC database which represents current status of emergency situation. Mobile GIS provides the capability of analyzing these data to make the best in-field decisions for emergency operations. Finding the best path to get into specific destinations and priorities emergency operations based on current situation are two examples of this analysis.

Many parameters should be considered while designing a mobile GIS for a specific application especially for emergency management. One of them relates to the architecture of the system. Generally there are 5 different architectures for mobile GISs (R7 Solutions, 2001):

- **Stand-Alone Client:** This is the simplest mobile GIS architecture. In this architecture geodata, mobile GIS software and the customized application reside entirely on the client that is a mobile device.
- **Client-Server:** Here the geodata is moved to a separate computer and served to the client by GIS server software through a wireless network. However, dependency of this system to the continuous connection between client and server reduces its flexibility. In other words, if the connection fails, the mobile GIS will no longer work.
- **Distributed Client-Server:** Similar to previous architecture, geodata is stored in the server but some parts of information are also stored into mobile device. In this architecture, the mobile GIS (client) is usable even if being disconnected with the server. When the mobile device is connected to the server again, the data is synchronized with the server.
- **Services:** This architecture views the GIS server as a web service and allows for other web services to be part of the application as well. As long as these web services use the same communications protocol, the mobile device(s) can communicate with all of them. Furthermore, the web services can also communicate between themselves.
- **Peer-to-Peer:** In this scenario, a peer-to-peer architecture will allow for communication between mobile devices. Each mobile device will store a part of information so that the requirement to a server will be removed.

For the mobile GIS in emergency management one or a composition of these architectures should be chosen.

Wireless network is another issue that should be examined in the context of mobile GIS. Nowadays wireless environment has been propounded as one of the most important human's inventions not only in GIS but also in many other sciences and technologies. Wireless network is the most important infrastructure that is required for implementation of mobile GIS in emergency management to provide online communication between emergency workers and EOC. Technical specifications of the network should be planned

in accordance with the existing facilities in the country. Wireless networks have passed several generations in recent decades but still have some limitations compared to wired networks. These limitations consist of low bandwidth, inconsistent connectivity and transmission latency. In the context of emergency management, mobile environment should be considered from two aspects: the size of the network and the used protocol. The size of wireless networks can be personal (WPAN), local (WLAN) and wide (WWAN). Each of these has its specifications that should be considered under the emergency situation but generally the size of network has a direct relation to the extent of incident. Therefore, different network architectures should be considered with respect to extent and levels of emergencies. In addition, the efficiency of networks strongly depends on the used protocol. So, it should be considered which protocol has more compatibility with the emergency management specifications.

User interface limitation (consisting of small display monitor, restricted graphical capabilities and limited input and output interfaces), limited CPU power and low memory capacity of the mobile devices are also some other issues compared to PCs that should be considered while designing mobile GIS for emergency management.

Moreover, in the context of spatial data management based on a collaborative effort, there are some other technical issues such as production, sharing and storing standards in wireless environments and interoperability issues in wireless and mobile environment between different systems that should be resolved for emergency management. There are also some non-technical issues such as capacity building for partnership in data production and storing, data security in mobile/wireless environment, instructional arrangements for data sharing, skill formation for working with mobile GIS, etc. that should be brought into consideration. Lack of attention to these technical and non-technical factors makes mobile GIS not to work in practice during emergency management so particular attention should be paid to these factors in order to have a practical mobile GIS for emergency management. SDI is the framework that facilitates application of mobile GIS in emergency management in the context of a collaborative effort in spatial data collection sharing and usage. Thus, it is necessary to develop the SDI conceptual model for emergency management (Mansourian et al., 2006 and Mansourian 2005) in such a way to support using mobile GIS in emergency management.

Conclusion

In this paper, the applications of mobile GIS in emergency management and different technical and non-technical issues in this context were described. Then the necessity of expanding SDI conceptual model for emergency management to support mobile GISs was depicted.

In the context of a research project, expanding SDI to support mobile GIS application for emergency management together with development of a prototype system is ongoing. As the first step of the project evaluating of emergency management community from mobile GIS and SDI perspectives has been conducted. The second step of the project including development of the SDI conceptual model to support mobile GIS applications for emergency management is under work.

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