APPLICATION OF MOBILE GISERVICES IN DISASTER MANAGEMENT

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ПРИЛОЖЕНИЕ НА МОБИЛНИ ГЕОГРАФСКИ ИНФОРМАЦИОННИ СИСТЕМИ ПРИ УПРАВЛЕНИЕ НА ПРИРОДНИ БЕДСТВИЯ

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Abstract: *Increasing data heterogeneity, fragmentation and volume, coupled with complex connections among specialists in disaster response, mitigation, and recovery situations demand new approaches for information technology to support crisis management. Advances in GIServices show promise to support time-sensitive collaboration, analytical reasoning, problem solving and decision making for crisis management. Furthermore, as all crises have geospatial components, crisis management tools need to include geospatial data representation and support for geographic contextualization of location-specific decision-making throughout the crisis. This paper provides introduction and description of Mobile GIServices applied to crisis management activity. The goal of Mobile GIServices in this context is to support situational awareness, problem solving, and decision making using highly interactive, visual environments that integrate multiple data sources that include georeferencing.*

Key words: DISASTER INFORMATION, NATURAL HAZARDS, GEOINFORMATION TECHNOLOGY, LOCATION-BASED SERVICES, MOBILE GIS, GLOBAL POSITION SYSTEMS.

1. Introduction

Present world is described with high speed and broad spatial range of changes, together with complex interdependences between running processes. This puts a lot of challenges for timeliness, accuracy and high quality about decisions and actions. Essential for implementation of these requirements must be Geographic information systems with incorporate Mobile technologies.

To meet the challenges of complex crisis management situations, new interactive visualization tools are in development to deal with large, complex datasets and similarly large and complicated analytical tasks. These systems must help enable connections between response, mitigation, and recovery specialists in disaster situations. Recent crises have revealed the need for visualization tools to support time-sensitive collaboration, analytical reasoning, problem solving and decision making in analysis, planning and time-sensitive response activities [1]. As almost all crisis management activity contains a geospatial component, these activities will necessarily include geospatial data.

To create a comprehensive disaster management system, our society needs to rely on advanced geospatial technologies and services [Ivanov M., Yankov Y., 2016 a]. Mobile GIS is one of the most vital technologies for the future development of disaster management systems. Mobile GIS and mobile Geographic Information Services (Mobile GIServices) extend the capability of traditional GIS to a higher level of portability, usability and flexibility. Mobile GIS are integrated software and hardware frameworks for access to geospatial data and services through mobile devices via wireline or wireless networks [8]. The unique feature of mobile GIS is the ability to Dynamic and Mobile GIS: investigating changes in space and time incorporate Global Positioning Systems (GPS) and ground-truth measurement within GIS applications.

This article introduces a new term, "Mobile GIServices", which describes a framework to utilize Mobile GIS devices to access network-based geospatial information services (GIServices). Mobile GIServices can be adopted in various GIS applications and scenarios, including car navigation systems, utility management, environmental monitoring and habitat protection tasks. Disaster management and emergency response are one of the most popular domains in the recent development of Mobile GIServices.

For example, mobile GIServices can combine GPS and satellite images to assist the local government and emergency response teams in identifying potential threat areas. So critical "hot zones" can be immediately created. Near real-time spatial analysis models supported by GIS could be used to rapidly generate the most effective evacuation routes and emergency plans during natural hazard events, including wildfires, floods and tsunamis. Wireless Internet-based GIS could also assist public policy officials, firefighters and other first responders with identifying areas to which their forces and resources should be dispatched. To accomplish these goals, it is important to introduce these new mobile GIServices technologies to emergency management personnel and related organizations. Also, emergency managers and first responders need to realize both the advantages and the limitation of GIS technologies in disaster management.

2. Performance of mobile GIS

Mobile GIS is the expansion of GIS technology from the office into the field. A mobile GIS enables field-based personnel to capture, store, update, manipulate, analyze, and display geographic information. Mobile GIS integrates one or more of the following technologies:

- Mobile devices
- Global positioning system (GPS)
- Wireless communications for Internet GIS access

Traditionally, the processes of field data collection and editing have been time consuming and error prone. Geographic data has traveled into the field in the form of paper maps. Field edits were performed using sketches and notes on paper maps and forms. Once back in the office, these field edits were deciphered and manually entered into the GIS database. The result was that GIS data has often not been as up-to-date or accurate as it could have been.

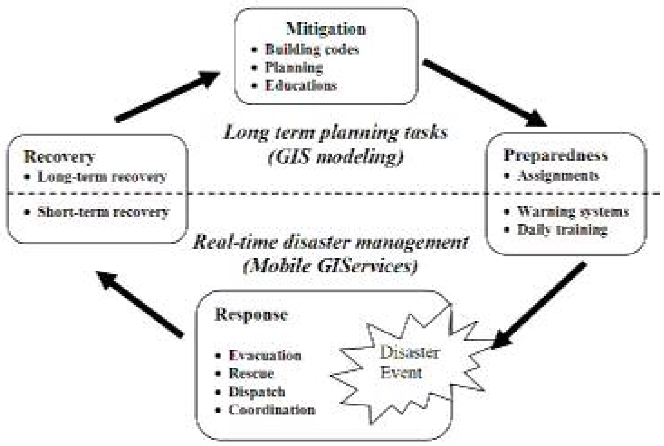

Fig. 1 Using traditional GIS and Mobile GIServices.

Changes in wireless communications have enabled GIS to be taken into the field as digital maps on compact, mobile computers, providing field access to enterprise geographic information. This enables organizations to add real-time information to their database and applications, speed up analysis, display, and decision making by using up-to-date, more accurate spatial data. Firefighters, police officers, engineering crews, surveyors, utility workers, soldiers, census workers, field biologists, and others, use mobile GIS to complete the following tasks:

- Field mapping - create, edit, and use GIS maps in the field;
- Asset inventories - create and maintain an inventory of asset locations and attribute information;
- Asset maintenance - update asset location and condition and schedule maintenance;
- Inspections - maintain digital records and locations of field assets for legal code compliance and ticketing;
- Incident reporting - document the location and circumstances of incidents and events for further action or reporting;
- GIS analysis and decision making - perform measuring, buffering, geoprocessing, and other GIS analysis while in the field. For details see Appendix №1.

The term "Mobile GIS" can be defined as an integrated software/hardware framework for access to spatial data and services through mobile devices via wireline or wireless networks."Wireless GIS" is a subcategory of mobile GIS technology that focuses on the wireless networking capability of mobile GIS services.There are two major application areas of mobile GIS:

1. Field-based GIS, which focuses on GIS data collection, validation and update (spatial and attribute).
2. Location-based services (LBS), which focus on business-oriented location management functions, such as navigation, street routing, finding a specific location or tracking a vehicle.

3. Architecture of mobile GIS

The architecture of mobile GIS is very similar to that of Internet-based GIS, using a client-server architecture. Client-server applications usually implement what is referred to as a Three Tiered Architecture. This architecture divides the application into a presentation tier, a business logic tier and a data management tier. Each tier can be replaced or updated without affecting the others. The presentation tier consists of client side components which are used to send requests to the server and to view the results (maps and data). The business tier is the core of any solution and consists of the server side components including the Web server and application server. The data management tier is responsible for the management of both spatial and attribute data in the application. In some cases, one server is used for both the business and the data management tier. In other cases each tier can be on a separate server.

Applications that use LBS are limited only by developer's imagination, but there are some categories where need opportunities have been clearly identified:

1. Mapping, navigation and directions applications;
2. Emergency services;
3. "Finder" applications that use the user's location to help locate something;
4. Location-based reminder applications that prompt users when they reach particular locations.

Major LBS Technologies

LBS is mobile computing anywhere, anytime. In practice, it represents the merger of four technologies: Personal Digital Assistants (PDAs) and 3G (3rd generation) mobile phones; location acquisition (automatic or manual); wireless Internet technology and infrastructure; and GIS solutions for wireless (data and application).

Location Acquisition

For applications to become location-aware, the wireless network must trace the location of the wireless device. This can be done either automatically, or manually. Automatic location acquisition uses a positioning network to locate a device using technologies such as a GPS or cellular base stations.

Each of these automatic positioning technologies has its advantages and disadvantages. Cellular base stations are ubiquitous across most urbanized areas, but their positioning is not precise enough to accurately locate a user (accuracy within tens to hundreds of meters). In contrast, GPS can be extremely precise (accuracy within meters), but in some cases the signal is obscured inside buildings and in areas with high traffic, narrow streets and high rise buildings.

Applications can be designed to enable quick manual inputs for location acquistion.These include using landmarks, stored locations or addresses and Zip codes.

5. The potential of WebGIS

More attention has been focused on developing GIS functionality in the Internet, Worldwide Web, and private intranets (sometimes termed WebGIS) recently:

- WebGIS holds the potential to make distributed geographic information (DGI) available to a very large worldwide audience.
- Internet users will be able to access GIS applications from their browsers without purchasing proprietary GIS software.
- WebGIS will make it possible to add GIS functionality to a wide range of network-based applications in business, government, and education. Many of these applications will be run on intranets within businesses and government agencies as a means of distributing and using geospatial data.
- Many experiments are now underway in WebGIS and related mapserver applications for interactive cartography. One of the important areas of innovation involves "pay-for-use" mapping and GIS services.

The challenge of WebGIS lies in creating software systems that are platform independent and run on open TCP/IP-based networks, that is on any computer capable of connecting to the Internet (or any TCP/IP-based network) and running a Web browser. This task is different from running proprietary GIS software over local-area networks (LANs) or intranets on just a few types of computer hardware. Such systems already exist.

Many strategies can be employed to add GIS functionality to the Web:

- Server-side strategies allow users (clients) to submit requests for data and analysis to a Web server. The server processes the requests and returns data or a solution to the remote client.
- Client-side strategies allow the users to perform some data manipulation and analysis locally on their own machines.
- Server and client processes can be combined in hybrid strategies that optimize performance and meet special user needs.

Developers can program their applications from scratch or now, more commonly, purchase the necessary GIS modules from commercial vendors. The visual design of the WebGIS interface, though not discussed in this unit, requires great care to assure that users can understand and make use of the information and functions provided by the system.

Although software usage has increased in the last few years, some emergency managers and staff are still reluctant to adopt computers and GIS for their main tasks (based on the authors' own experiences). One of the major obstacles is the concern for system portability and reliability. Traditional GIS are not considered portable by first responders (such as local police officers, fire fighters and emergency medical personnel who can arrive first and take actions to rescue people and protect property) [Ivanov M., Yankov Y., 2016 b]. Emergency managers are also worried that loss of electrical power during a disaster might cause the whole computer system to break down. Recent development of Mobile GIS and Mobile GIServices might solve these problems by providing their own independent power supply systems (batteries and Uninterruptible Power Supply - UPS) and having a great portability (cellular phones, Pocket PCs, etc.).

6. Online GIS

After its introduction, the Internet has been widely adopted and has experienced an enormous growth. Therefore, it has become a very important information and service dissemination medium for many companies. Nowadays GIS functionality has been implemented and is being offered on many sites over the Internet, so some authors have coined the term 'Online GIS' [8] to call this new way of working with GIS.

Most of the existing Online GIS systems are either spatial query systems (publishing of datasets with a viewing interface and some predefined GIS functionality), or map-building programs [10]. These sites offer mainly viewing and exploring capabilities and are therefore intended for the general public and do not offer actual GIS analysis or processing tools. And when they do, they can only be applied on predefined datasets, not on the user's datasets. Therefore, Online GIS still cannot make general GIS analysis tools available, so more specialised GIS users that need to perform analytical or specialised tasks, can make use of these components and integrate them in chains to analyse their data. This is the issue on which the present research concentrates.

To have GIS components residing at different locations across the network would allow thousands of potential new 'online users' to access them. But this also sets the need for brokers who can control and coordinate the flow components to the clients [6]. Under a GIS components implementation the users would only pay for the few functions they need to use instead of buying complete GIS software licenses. They would be able to pick the GIS functions that better fit their requirements (robustness, price, data formats, etc.) from different providers as they require them [10]. The chosen components would be sent to their web browsers, without needing to locally install software. A well-developed implementation of this kind will allow the seamless integration of data and GIS functions, and the access to GIS by many new non-expert users who will only need to be connected to the Internet. Additionally, the approach of 'Online GIS' appears to be very appropriate for the actual topology of GIS projects which have moved from being stand-alone projects to multi-agency, multi-disciplinary and multi-software ones[10].

7. Conclusion

Disaster management is a complex domain of human activity involving multiple agencies and stakeholders, a collaborative approach utilizing state-of-the-art Mobile GIServices that can facilitate a comprehensive and functional disaster management plan. Many emergency tasks and disaster management works will need advanced GIS analysis functions that require significant computing power and computer memory. Most mobile GIS devices are tiny and only have very limited computing capability. The pre-processing and post-processing time for spatial analysis and remote sensing images might prevent the adoption of Mobile GIServices for real-time response tasks due to the hardware limitations. One possible solution is to send the complicated GIS model and spatial functions via the Internet to remote GIS engine services. Then, the analysis results will be sent back to the Mobile GIS devices via the network.

With recent advances of GIS technology, it is now possible to map and determine the risks (together with their magnitude) of different natural hazards and man-made catastrophes. Very large amounts of data can be processed, quantified and displayed on digital maps, allowing decision makers to assess the situation rapidly and take appropriate actions.

The use of advanced tools for computation and modelling of natural hazards such as floods can be combined with a GIS that has the capability of decision support and advanced visualization to produce the models that will represent the risks of natural hazards and man-made disasters in the form of risk maps, where the risks are categorized and quantified. Furthermore, we have shown that these processes can be automated, enabling near real time access to the risk maps. This can greatly help decision makers with the emergency measures and mitigation in most of the cases. What is more, their significance for decision-making and risk prevention can be evaluated for future real-life situations.

Appendix №1

Mobile GIS Application Areas and Crises Management

		Industry			
		Government	Utility and Infrastructure	Environment	Public Safety
Task	Field Mapping	• Recording Building Footprints • Right-of-Way Mapping • Based mapping	• Centerline Review and Mapping • Facility Mapping	• Forest Boundary Mapping • Trail Mapping • Geochemical Mapping • Volcanic Deposit Mapping • Wetlands Delineation	• 911 Address Mapping • Minefield Mapping • Military Fieldwork and Mapping
	Asset Inventory	• Street Sign Inventory • Municipal Assets Inventory (GASB 34) • Tree Survey • Census Data Collection • Housing Condition Survey • Cemetery Inventory	• Recording Installations • Storm Water Inlet Inventory • Storage Tank Mapping	• Toxic Inventory • Mineral Exploration • Vegetation Survey • Wetland Survey • Archaeological Site Survey	• Aerial Survey • Fire Perimeter Mapping
	Asset Maintenance	• Road Condition Survey • Streetlight Survey • Patient Registration	• Power Pole Maintenance • New Equipment Installation • Pavement Condition Assessment	• Crop Management • Vacant Land Condition Management • Timber Harvest Management • Drainage System Management	• Locating Buried Infrastructure • Recording Avalanche Observations • Facility Maintenance Survey
	Inspections	• Road Pavement Management • Code Enforcement • Health Inspection • Housing Condition • Water Rights Enforcement	• Meter Reading • Septic System Inspection • Documentation • Compliance Monitoring • Dam Safety Inspection	• Habitat Studies • Weed Abatement • Well Sampling • Wildfire Sightings	• Damage Inspection • Tracking Violations • Street Sign Inspection • Flood Risk Assessment
	Incident Reporting	• West Nile Virus Incidents • Public Nuisance Surveys	• Locating Outages • Regulatory Compliance	• Animal Migration Tracking • Oil Spill Assessment • Radioactive Contamination Tracking	• Property Damage Assessment • Accident Reporting
	GIS Analysis	• GIS Data Validation • Routing to Locations • Property Records Management	• Locating Customers for Meter Reading and Billing • Routing to Locations • Tracing Network Outages	• Agricultural Statistics • Vegetation Boundary Validation	• Locating Customer Addresses for Investigations • Emergency Identification of Affected Areas • Navigating to Accident Locations

Literature

1. Cova, T. (1999) 'GIS in emergency management', in Longley, P. A., Goodchild, M. F., Maguire, D. J. and Rhind, D. W. (ed.) *Geographical Information Systems,* Second Edition, pp. 845–858.
2. Directive 2007/2/EC of the European parliament and of the council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)
3. Green, W. G. (2001) E-emergency management in the US: a preliminary survey of the operational state of the art, International Journal of Emergency Management, vol.1, no.1, pp. 70–81.
4. Kamarashev G., Crisis management, V. Tarnovo, 2014
5. Ivanov M., Yankov Y., Determination of potential floodings through geoinformation technology, Bulletin Stiintific XXI, Sibiu, 2016
6. Ivanov M., Yankov Y., Application of geographic information systems in crisis management, Revista XXI, Sibiu, 2016
7. MC 296/1 NATO Geospatial Policy, 2006.
8. Peng, Z. R. and Tsou, M. H. (2003) Internet GIS: distributed geographic information services for the Internet and wireless networks, New York: John Wiley & Sons, Inc.
9. STANAG 7016 IGEO – Maintenance of geographic materials, edition 4, 2002
10. Tsou, M. H. (2004) 'Integrated Mobile GIS and Wireless Internet Map Servers for Environmental Monitoring and Management' Special Issue on Mobile Mapping and Geographic Information Systems in *Cartography and Geographic Information Science*, vol. 31, no.3, pp 153–165.
11. Valchinov V., Geoinformatics, UASG, Sofia, 2003
12. www.isaca.org
13. http://www.nwgis.com, Spatial analysis, accessed 15.04.2017
14. http://www.esri.com/arcgisdefensemapping, Defense solution, accessed 14.07.2017