MOBILE GEOSPATIAL DATA COLLECTION – CONCEPTS AND FIRST EXPERIENCES

Wolfgang Reinhardt, Admire Kandawasvika, Stephan Mäs and Fei Wang

AGIS – Arbeitsgemeinschaft GIS
Universität der Bundeswehr München
Werner-Heisenberg-Weg 39
D-85577 Neubiberg, Germany
Wolfgang.Reinhardt@unibw-muenchen.de

ABSTRACT

This paper addresses concept and development of a sophisticated, open standards-based mobile geodata acquisition system for field workers in various fields of application. This system makes fully use of the possibilities of the ubiquitous access – via wireless technologies - to various sources of information. In the paper the example of landslide monitoring application is considered. There are two test areas in the south of Germany with unstable surfaces in which rock masses, soil and other loss material may fall, at anytime, from the mountain slopes and may be hazardous to people using the nearby roads, walking paths or to other close infrastructures. In one test area there are systems installed which generate alarm messages in case of significant changes of certain measurements. In this case the system supports the decision-making process in the field and enables mobile users to carry out their field-work with the dedicaded functionality.

INTRODUCTION

Mobile acquisition of geodata usually requires experienced users with knowledge about existing data and the underlying data models [Pundt, 2002]. All necessary data has to be examined and synchronized before going to the field. Later on, if any unexpected circumstances occur, there is no possibility for further download of data more relevant to the situation. After finishing the acquisition incorrectness and incompleteness of data are often only recognized when the fieldworker is back in the office during the server update. In case the newly captured data does not meet all conditions of the data model and corresponding quality constraints, the worker might even have to visit the exploration site again. This situation is quite typical for current acquisition systems.

Within the project "Advancements of Geoservices", the application of current evolutions in information and communication technologies and their usability for mobile data acquisition are investigated [Breunig et al. 2005]. Existing Location Based Services (LBS), e.g. presented in [Sayda et al. 2002], make use of these developments and offer information adjusted to the user's position and environment. The paper is presenting a field service extending the functionality of such LBS by methodologies for in-field accessing, analyzing, acquiring, quality checking and online updating of geospatial data. It is shown how a continuous workflow from position determination and object acquisition to the transaction of the newly captured data to the databases can be realized. We also describe the open standards based architecture of the system. Finally the advantages of the proposed system are illustrated by some experiences from field tests.

This research work is being carried out as part of a bundle research project called "*Advancements of Geoservices*" funded by the German Ministry of Education and Research (BMBF-*Bundesministerium fuer Bildung und Forschung*) and German Research Foundation (DFG-*Deutsche Forschungsgemeinschaft*). The project consortium comprises University of Vechta (*Research Centre for Geoinformation and Remote Sensing*), University Karlsruhe (*Institute for Photogrammetry and Remote Sensing*), EML (European Media Laboratory) Heidelberg and University of the Bundeswehr Munich (*AGIS GIS Lab*).

USAGE OF THE SYSTEM IN A LANDSLIDE APPLICATION SCENARIO

The system is conceptualised for use in landslide monitoring applications. In cooperation with local authorities (Landesamt für Geologie, Rohstoffe und Bergbau, Baden-Württemberg; Bayerisches Geologisches Landesamt; Wasserwirtschaftsamt Rosenheim) two test areas have been selected near Balingen and Rosenheim, Germany. These areas have unstable surfaces in which rock masses, soil and other loss material may fall, at anytime, from the mountain slopes and may be hazardous to people using the nearby roads, walking paths or to other close infrastructures. For that reason, the authorities installed permanent surveying systems, for example on-site extensometers (installed in cracks, gaps or ditches in the active landslide parts of the mountains) or automatic total stations, which register any surface movements (see figure 1). These systems generate alarm messages in case of significant changes in the measured values.

Figure 1: Picture from the test area

In case of an alarm, a responsible person has to go to the site and verify whether the alarm is true or false. For that reason, the proposed mobile client system should support the decision-making process in the field and should also enable mobile users to carry out their field-work with the following functionality. The geologist obtains a map for navigation in the field for locating measurement points or active zones. For these features of concern or interest he wants to download previous measurements for comparing them with the newly acquired observations. If any significant changes occur, there may be the need of updating and acquiring new features like new cracks or gaps. The geometry of the new features can be obtained by geodetic measurements and the attribute values should be filled in automatically or interactively. During this data acquisition process, some quality measures or checks should be handled on the client, e.g. validation of the entered values of the attributes. Afterwards the features should be created and then send to the database for updating. The client should also be able to support higher dimensions (e.g. 3-D, 4-D) of spatial data. For example the 3-D data has to be visualized using an Augmented Reality component being developed by the University of Karlsruhe [Breunig et al. 2005].

One of the main objectives within the project "Advancements of Geoservices" is the development of concepts for the online mobile acquisition of geodata. In particular, the following aspects are taken into consideration:

- Establishment of an online access to all relevant databases from the field site
- Definition of an open platform based on standards, avoidance of proprietary developments and interfaces
- Design of an architecture for a mobile client
- Development of a generic acquisition concept, which is flexible adjusting to differert application domains and data models
- Definition of main workflows like initial acquisition or update of data
- Extensive and throughout quality assurance for these workflows

In general, the proposed mobile client system should enable mobile users to carry out their field work. The system should allow for:

- optimal, location-based access to the geospatial databases residing on a single or distributed servers,
- acquisition of new data by observations or measurements (i.e. geometry and related attributes for newly captured features/objects),

- automatic online update of the databases while in the field and still being consistent with the requirements imposed by the business or organization's data model or schema,
- and analysing and checking of the overall quality of the newly acquired data in the field.

SYSTEM ARCHITECTURE

The overall architecture of the system is presented in Figure 2. The selected conventional, standardized GIS client /server interfaces like WMS and WFS [OGC 2002a] can also be applied for mobile services. On basis of the available mobile communication technologies like WLAN, GPRS, UMTS and Bluetooth it is possible to network different mobile system components. It's conceivable that the bandwidth of UMTS and WLAN supports the transfer of larger amounts of data. So the problem of the small bandwidth faced by previous technologies is solved and the principal requirements for online mobile access to heterogeneous databases are meet. The usage of standardized interfaces and therewith the avoidance of proprietary developments leads to an open structure of the GIS platform.

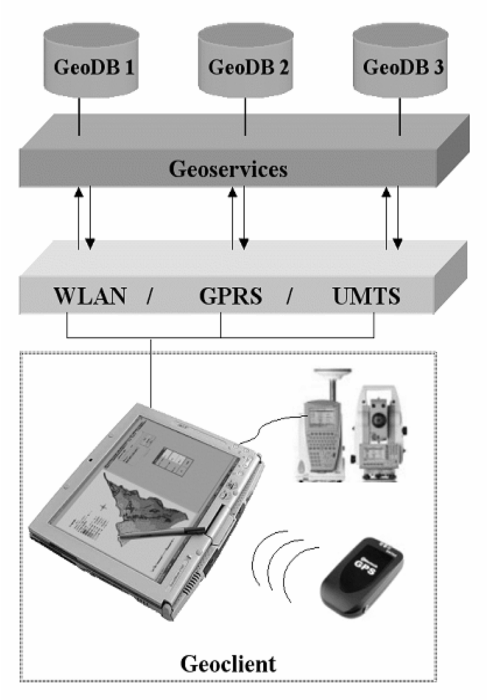

Figure 2: Architecture of the mobile acquisition system

The client equipment should be portable, enable visualization under outdoor conditions and have convenient possibilities for data input. Rugged devices like tablet PCs or laptops with pivoting touch screens fulfill these requirements and offer the necessary performance for the application aimed at. Often communication components like WLAN or Bluetooth are already included in the standard equipment. Since the collection of new data will be done using different sensors another main issue of the implementation design of the system architecture is the interoperable interfacing to these various instruments. Therefore research is also focusing on the interoperable handling or usage of different types of geodetic sensors like GPS, total stations, laser scanners, extensometers, etc..[Kandawasvika & Reinhardt, 2005]

GENERIC ACQUISITION CONCEPT

The architecture of the system allows for applications in different spatial domains and allows the fieldworker to access any information source that might be of interest for the current use. But the possibility to have interoperable access to heterogeneous databases and not being restricted on a certain, well-known data model has great influence on the whole client application structure and the acquisition process. At first, it requires the client to download schema information at runtime. Such schema may contain all necessary details about the modeled objects / features, their geometry and attributes as well as the relations between objects of one or different types. Moreover the client application has to be able to adjust to the requirements imposed by the data model. In particular, the measuring process and the templates for input of further attributes must be flexible and adaptable. Figure 3 schematizes how the proposed application solves these problems.

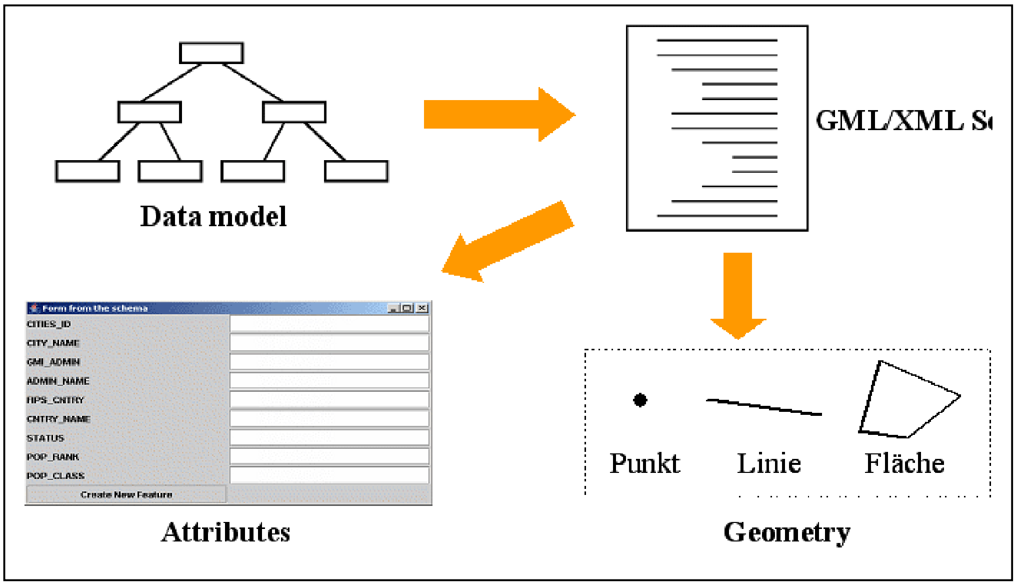

Figure 3: Attribute and geometry extraction for generic acquisition

The server connection and data flow are based on OGC standards like WFS and GML (OGC 2002a & 2002b). For the acquisition of an object, the user firstly has to select the desired object class, i.e. feature type. Information about the classes the server is supporting and some other basic information is available through the WFS capabilities document. The particular data schema of the server (i.e. schema information of the selected feature type) is specified in XML-schema documents. Such XML-schema is used to describe what kind of data has to be collected and how this data has to be organized. The client application can download these documents for the defined feature types using the WFS interface. With the information contained in the XML-schema, it is possible for the client application to adjust the acquisition process in regard to the required attributes, geometry types and relationships of a particular feature type and to guide the user through the whole data collection procedure. The templates for the input of attribute values are generated automatically at runtime and the process of measuring geometry elements is adjusted to the requirements of the feature type currently being measured. Comments, for example on the meaning of certain attributes (i.e. their semantic), can be included in the XML-schema and requested by the user during the acquisition process.

Through the exploitation of generic data schemas, the system is flexible and independent of specific user domains. The decision, which data stock is most adequate to the current situation and requirements, can be made spontaneous in the field. The addressed WFS interface servers are self-describing and the acquisition process can flexibly be adjusted to the particular data model.

QUALITY ASSURANCE

Accorting to the relvant ISO documents the following quality elements have to be considered:

- completeness
- logical consistency
- positional accuracy
- temporal accuracy
- thematic accuracy

Completeness normally can only be checked visually. A system as introduced here allows for this visual check directly in the field which should improve this process especially when Augmented reality can be used in future [Breunig et al. 2005].

In this project main focus was given to logical consistency with specific emphasis on:

- Validation of schema information

- Constraints between object/feature classes

Regarding the first issue the XML-schema (eXtensible Markup Language), is available through the WFS (Web Feature Service) Interface, it contains information like object types, their geometry, attributes and interrelations and therefore allows for several checks like:

- Geometry type of a feature
- Basic geometry rules (e.g. closed polygons etc.)
- Attribute types and ranges
- Relations to other features

Regarding the second issue (constraints between object classes) the XML-schema does not contain any information in the moment. So it is not possible for example to define restrictions like a forbidden intersection of feature types or semantic conflicts between certain attribute values. Such integrity rules are necessary to incorporate conditions on/betweeen object classes defined by the users. For example it might not be allowed that one object class crosses another one.

For that reason a new concept based on Ontologies defined in OWL was developed which is explained in detail in [Mäs et.al 2004]. With this new concept it is possible to define restrictions, for example:

- on spatial relations between features of the same or of different feature classes,
- on single attribute values,
- a defined relation between two attribute values of one feature
- or a combination of spatial relations and attribute values of different features.

More information on that issues can be found in the literature mentioned last.

FIRST EXPERIENCES WITH FIELD TESTS

For the field test the configuration given in figure 4 has been used. As a permanent access to the servers in the remote offices was required and the very steep and ondulated terrain covered by wood did not allow for an access to these servers via gsm in the whole area a two-stage solutuíon has been used: A notebook installed in a car at a place where gsm was available served as field server. Then with the help of 2-3 additional WLAN accesspoints the whole area (200 * 300 m^2 approximately) was covered with WLAN.

The first tests included the following issues:

WLAN test

It was possible to be connected to WLAN (and to the servers via gsm accordingly) in the whole area!

Support of user work flows

As mentioned before a user has to go out to the area in case of an alarm. As the system allows him to visualize all the data already acquired as well as previous measurements he easily can get find out what has been changed or caused the alarm.

Further new features can be acquired if they occur (for example new ditches) as the system can be connected to different sensor which allow for a coordinate registration [Kandawasvika & Reinhardt, 2005].

GPS availability

With cheap GPS receivers developed for the mass marketing it was not possible to receive signals in most parts of the wooden area. First tests have shown that this is much better when profesional receivers are used.

These first tests clearly have shown that such a system is of great help in applications like that and supports the user very much in order to improve decisions or to safe time.

In the near future it will be investigated in more detail how other user processes can be supported. Further the system will be applied to other application fields.

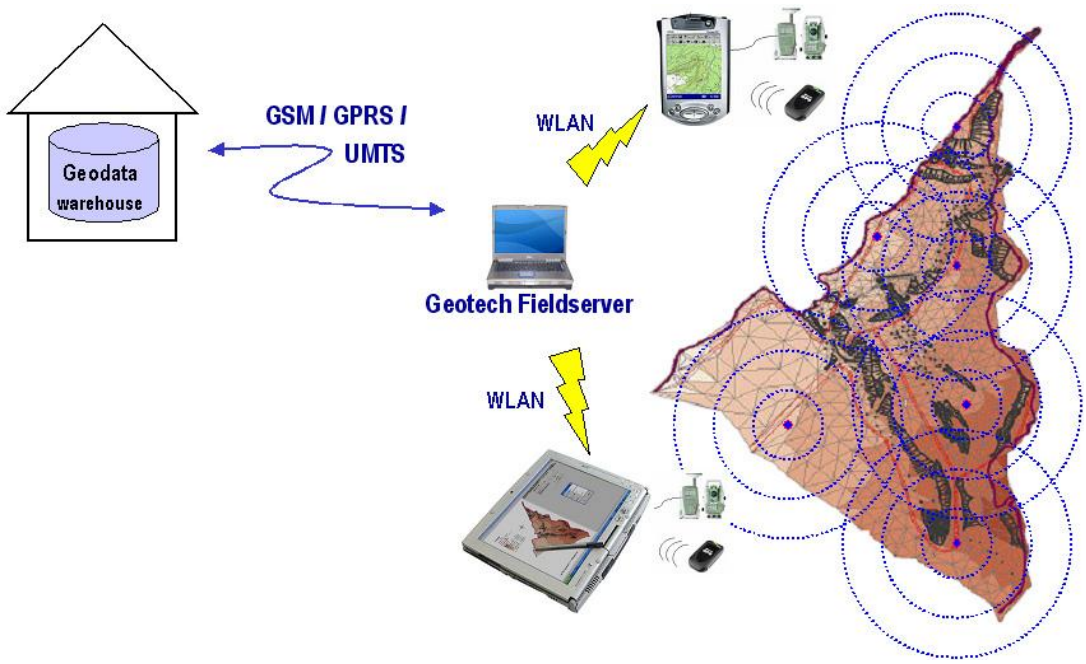

Figure 4: Balingen test konfiguration

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LITERATURE

Breunig, M.; Bär, W.; Häussler, J.; Reinhardt, W.; Wiesel, J.(2005): Further developing mobile spatial services for the Geosciences, 19th International CODATA Conference, Berlin, Data Science Journal

Kandawasvika, A. & Reinhardt, W. (2005): Concept for interoperable usage of multi-sensors within a landslide monitoring application scenario. Proceeding 8th AGILE Conference on GIScience, Estoril, Portugal

Stephan Mäs, Wolfgang Reinhardt, Admire Kandawasvika, Fei Wang (2005): Concepts for quality assurance during mobile online data acquisition, . Proceeding 8th AGILE Conference on GIScience, Estoril, Portugal

OGC (2002a): Web Feature Service Implementation Specification, Version 1.0.0, OpenGIS® Project Document: 02-058; 19 September 2002

OGC (2002b): Geography Markup Language (GML) Implementation Specification, Version 2.1.2, OpenGIS Project Document Number 02-069, 17 September 2002

Pundt, H. (2002): Field Data Collection with Mobile GIS: Dependencies Between Semantics and Data Quality, In: GeoInformatica 6:4 2002, pp. 363-380, Kluwer Academic Publishers

Sayda, F.; Reinhardt, W.; Wittmann, E.(2002): GI and Location Based Services for Mountaineers. In: Geoinformatics, Magazine for Geo-IT Professionals, 2002, Nr. 5.