Advancement of Geoservices

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Abstract

The combination of the internet and mobile communication technologies offer new perspectives for the geosciences, by providing location independent access to distributed geodatabases. New geoservices will contribute to a faster availability and an increasing data quality of environmental information. These services have to be designed for usage by static and mobile users through internet based networks. Beside the important aspect of data management for geoservices, data acquisition und visualization of multidimensional geodata are predominant factors. They are still topics of further research. Particularly the low performance and heterogeneity of not yet standardized mobile devices represent major problems. The project partners from Vechta, Karlsruhe, Heidelberg and Munich complement their different expertises in the areas of acquisition, management, usage and visualization of geodata, respectively.

1. Objectives and conception

Objective of this project is to develop an overall concept for acquisition, management, usage and visualization of geodata for mobile geoservices. The technical feasibility and acceptance of the used methods within the geosciences will be shown by components of a prototype system.

Within the project different aspects of geodata processing have to be examined: on the one hand a central server unit should allow geodata access from different sources. Data are provided to another kind of components, the mobile devices, through standardized geoservices from heterogeneous data sets as separate objects. The mobile device, which is carried by the user, allows for online communication to the data provided by the server unit. Using the connection to external sensors and measuring units the mobile terminal can use the transmitted data on site directly. Functionalities which are adapted to the used object structures are offered to the user. This allows an on site manipulation of proper data sets, when the necessary acquisition and transmission of geoobjects to the server are not possible online. Furthermore, augmented reality components (AR) have to be taken into account for visualizing the database query results. This should allow for mobile on site acquisition of spatial objects in the final stage of the project. Fields of application are all tasks where no visual objects (e.g. geological structures, soil parameters, DTM, upcoming engineering projects, boundaries of parcels, supply lines in the underground) can improve the on site data acquisition. In figure 1 the proposed system architecture is presented. The client applications at the Karlsruhe, Heidelberg and Munich nodes focussing on AR viewing, acquisition, update, use, analysis and visualization of geodata, are connected with a database component for a service-oriented 3D/4D-GIS (node Vechta) and with other geo-services at the server sites.

The project partners have separated the development of the above-described tasks as follows:

- Development of web based GIS components for online access of spatio-temporal objects in geoservices (Vechta);

- mobile acquisition, updating, usage/analysis and visualization to geodata (Heidelberg, Munich);

- online visualization, processing and acquisition of 3D datasets with a mobile terminal backed up by augmented reality (AR) (Karlsruhe);

- definition of standardized interfaces for geo-services (Munich).

During the development of all components the main intention is to use intensive and methodical research to ensure an ideal usage of new technologies within newly developed work flows. The need for a mobile geographic data management tool (particularly for the mobile data acquisition) is obviously existing in all different disciplines of the geosciences. A few examples shall be pointed out exemplarily. The qualified and methodical specification of theses scenarios will be described in a following paper.

- The transmission of just measured values into remote databases facilitates the use of the new findings and information to other users and this data is available for further data processing. The results of this processing has to

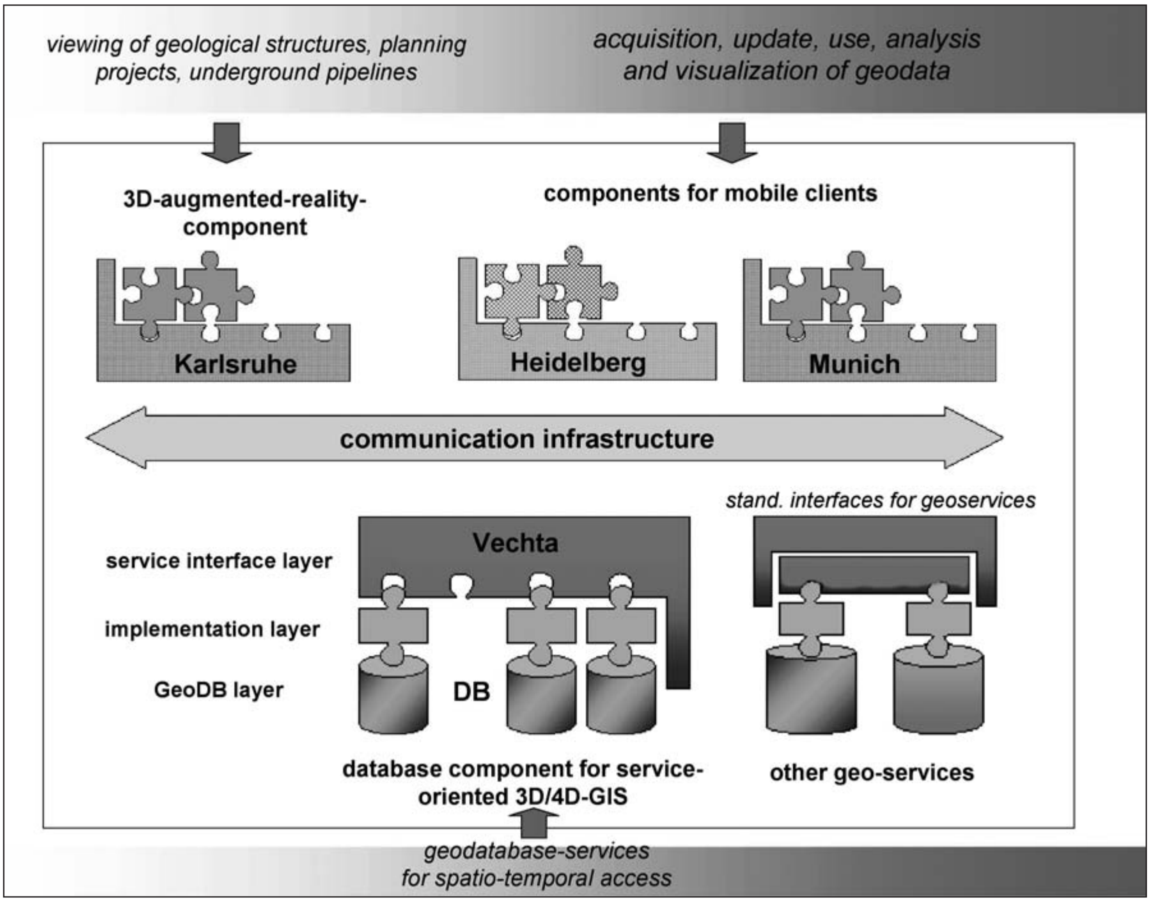

Figure 1: System architecture.

be made at the disposal of the field worker immediately. So data with high relevance to the present situation (e.g. meteorological data) is fast and easily achievable for the mobile user.

- In the opposite direction, all the data stored on the heterogeneous distributed databases are placed at the field workers disposal. There is no necessity to take all potential needed data out to the field. On the contrary, you can decide on the spot which data is needed and should be transferred to the mobile device. Newly acquired data could be compared with data stored in the databases and the attained knowledge supports the determination of the next measurement spot, without the necessity to interrupt the process of data acquisition by returning to the office.

- The integration into the geographic data infrastructure (GDI) currently under development facilitates furthermore the possibility to achieve data without knowing its concrete location of storage. E.g. a geologist who has problems to determine the actual strata due to a highly complex terrain morphology will be able to get further information about the area by sending requests against a catalogue server. Data registered at this server will be delivered to the user by further services. The user will receive parts of satellite images for instances. To take these images to the field is commonly restricted due to their immense size. If it happens in the field that only small parts are needed, the necessary request (specifying the required sector) could be sent to a remote server which starts the transmission of the demanded data. Of course transmission capacities have to be taken into consideration.

2. State of the scientific and technical knowledge

In the mid nineties a new generation of laptops enabled users to use spatial data offline without using a wired connection to a database. Due to the lack of mobile communications, offline data had to be synchronized before and after the mobile data acquisition process. The improvements in wireless communication enabled the user to connect to a spatial database in the field in general and even to manipulate the data (see ORACLE's and Autodesk's MAUI project: *http://www.gis-news.de/news/autodesk_ora_palm.htm*). But these approaches rely completely on proprietary systems and are focussed on technical implementation. There has not been any scientific investigation on these questions yet.

Naturally the heterogeneity of multiple spatial data sources is not taken into account – applications for common usage of spatial data have not been provided so far. Progress in the field of mobile geocomputing, online access to spatial databases and integration of external databases brings us in a leading position within the spatial scientific community (Caspary and Joos 2000).

Geodata access over internet and wireless communication is just in the beginning of its development. But there are several standardization efforts around which try to accommodate W3C standards (W3C 1998). OGC (Joos 2000, OGC 2000) is currently working on a XML-based representation of simple geographic features: GML. Further investigations have to be made, if these specifications meet the requirements in practice.

Prerequisites for mobile geoservices are innovations in the field of mobile technology and wireless communication. Recently a new data communication standard GPRS (General Radio Packet Service) was launched in Germany. In the next couple of years the changeover from GSM/GPRS to UMTS (Universal Mobile

Telecommunications System) is awaited.
Mobile devices for location based services are currently in rapid development and have very short innovation cycles. Additionally, the mobile hardware platforms are diverse (display size, computing performance, data rate) and there are many different system architectures around (Laptops, PDAs, cell phones, card phones). Because of that, it has to be investigated which data transformations and server applications have to be developed to achieve a common representation of spatial data on mobile systems.

3. Integration of the project in research programs and networks

Within the 5th frame program (5.RP) of the European Community the research in the field of "User-friendly information society (IST)" has been funded. The objective of the first main task "Services for citizens" is to provide users with an easy and cheap access to top quality services for different purposes. The goal is to allow an easy internet access to common comprehensible information within the EU. Supplementary to this main goal, during the project "Advancement of Geoservices" the development and access to high-end geoservices especially designed for geoscientific experts is intended. Within the project the main focus is not to provide EU citizens with location based services, but rather the development of location independent services for internet based and mobile access to geoscientific relevant information.

4. Expected research results and references to actual social discussions

An efficient handling of the valuable resources of geoinformation is one of the major challenges nowadays. In 80% of all decisions in private and public areas direct or indirect spatial information are involved, but there are still no systems, not to mention applications, which are capable of processing distributed and heterogeneous data and provide them for further use. Still there are no possibilities to modify existing heterogeneous data sets simultaneously by ensuring the consistency of the different databases during those updates. The importance of this topic is reflected in the »grossen Anfrage« of 29 representatives in the German Bundestag from 12th April 2001 (printed matter 14/3214). The economy also pays great attention to this matter, which results in significant investments in standardization promoted by the OGC and ISO. By active participation in these panels the latest results in these areas are available and should be taken as the basis of the project development.

The intended development of new concepts and techniques for the management of spatial and time based objects for mobile geoservices could be groundbreaking for other areas of applications too (e.g. life services and bioinformatics). Moreover an efficient internet based and mobile access to spatial and time based information offers new possibilities for the usage of geoinformation systems (GIS). Particularly mobile geoservices are enabled to access by the development of open system architectures basic functionalities of GIS, e.g. data visualization or data base queries. Furthermore, the development of concepts for new efficient access technologies, database queries and user interfaces for mobile location independent services offer a great innovation potential. Especially in this area intensive research is required on the national level. It could be expected that other key points of geotechnologies will benefit of the developed software concept in an advanced state of the project. The prospects of success are considered as excellent as partners from informatics and the geo-environment are involved.

The high availability and rising quality of information on our environment can play a major role in the management of social tasks in times of increasing globalization. The new technologies for usage of mobile geoservices developed within this project can easily be transferred to Internet services. Furthermore, the public availability of documented geodata results in a cost-saving for upcoming data acquisitions and will become a major aspect for the maintenance of our information- and knowledge society.

5. Description of project parts

5.1. Project »Development of component-software for the internet-based access to geodatabase services«

responsible: Martin Breunig, Research Centre for Geoinformatics and Remote Sensing (FZG), University of Vechta

Abstract
The project aims to make a contribution to 3D/4D geodatabase research for the development of new component-based and mobile geoinformation systems. The application of reusable database software shall enable the user to compose own geoservices with pre-defined components. This procedure is similar to the software engineering process supported by a CASE tool. The idea is to compose the functionality of different geoservices by object-oriented editors, user-defined data types and access methods in a service framework. The approach intends to eliminate one of the most obvious weak points of today´s geoinformation systems: their closed system architecture. This situation can only be improved by providing an open data and function access. Therefore the efficient spatial and temporal access to geodata managed by new geoservices is a central task for the development of new geoscientific information systems. Furthermore, the project aims at examining the efficient access to geodatabase services via the WWW. The representation and the efficient management of static and dynamic geoobjects in databases have to be examined in detail. Easy-to-use plug-in technology shall ensure a high acceptance of the developed software by the user. Finally, in close cooperation with the project partners, it is planned to transfer a set of selected functions of a platform-independent mobile geoservice prototype with the help of a laptop or handheld client.

5.1.1. Preparatory work

The group of Martin Breunig has been working in several projects developing extensible geodatabase and geoinformation systems (Waterfeld and Breunig 1992; Bode et al. 1994; Balovnev et al. 1997; Alms et al. 1998; Breunig 2001; Breunig et al. 2003). Furthermore, the experiences gained in the completed IOGIS project (Voss und Morgenstern 1997) and in the Collaborative Research Centre 350, both at the Institute of Computer Science III of Bonn University (group of Armin B. Cremers), open new perspectives for the development of internet-based access techniques for spatial and temporal objects (Breunig et al. 1999; Breunig 2001; Breunig et al. 2001).

Concerning the development of open spatio-temporal database services the group also promotes a close exchange with the groups of the former European CHOROCHRONOS project and with other international groups (Worboys 1992; Snodgrass et al. 1996; Brinkhoff 1999; Sellis 1999; Güting et al. 2000).

5.1.2. Objectives and Conception

The objectives of the project can be formulated in the following three steps:

1) Concept for the management of spatio-temporal objects within client-server architectures for (mobile) geodatabase services: Hitherto, such objects being variable in space and time, cannot be managed efficiently by mobile clients of a database management system. Therefore new ways for the representation and the retrieval of these objects have to be developed. Furthermore, the distribution of the functions for

high-class database queries upon the client and the server have to be examined.

2) *Development of component software for the access to geodatabase services:*
Databases will play a central role in the development of new geoservices (Brinkhoff 1999; Dittrich and Geppert 2001; Friebe 2001). However, the efficient access to spatio-temporal databases from the WWW and the filtering of geodata for mobile geoservices are still subject of research. For example, functions for the processing of geometric 2D and 3D objects (e.g. in boundary representation) have to be developed and composed in a single component as part of a geoservice.

3 *Evaluation of the concepts developed in the steps 1) and 2) for the application field of geology:*
The software developed in the project shall be evaluated with a suitable application coming from the field of geology. We expect that by the evaluation new impulses will be given for the development of mobile services. The experiences are also expected to be transferable to other spatial application fields within and outside the geosciences like geomatics and bioinformatics. In future, mobile geoservices will also be more important for the flexible management of early diagnosis and the handling of environmental monitoring.

Methodically, one of the main ideas of object-oriented software technology shall be pursued: the re-use of geospecific database component software shall be used for the examination of the internet-based database access to spatial and temporal objects in new geoservices (Snodgrass et al. 1996; Szypersky 1998; Sellis 1999; Dittrich and Geppert 2001; Friebe 2001). Within a layer-architecture, application independent basic and advanced services shall be developed as tailored services for spatial applications. As OGC and AGILE member, the University of Vechta is also up to date concerning the current international standardization efforts.

5.2. Project »Development of mobile components and interfaces for geoservices«

responsible: Wolfgang Reinhardt, AGIS, University of the Bundeswehr Munich; Rainer Malaka, European Media Laboratory GmbH, Heidelberg

Abstract
This part of the project deals with the development of a mobile client for visualization and manipulation of spatial data. The potential arising from the online access to multiple heterogeneous spatial databases, will be investigated. In respect of international standardization efforts, required interfaces will be designed. Further investigation is required on assuring the consistency of the database during data transfers between database and mobile systems. During the conceptual phase, different system architectures for the mobile client will be considered and a concept for a mobile client-server spatial data infrastructure will be developed. A very new approach, supporting the user during the data acquisition process is combined under system aided data acquisition. The results of these investigations will be tested by the development of a prototype for the proposed system.

5. 2.1. Preparatory Work

The GIS lab at the University of the Bundeswehr (AGIS) is a member of the OGC and takes part within the standardization process of ISO/TC211. AGIS is experienced in the field of mobile GIS and location based services through the projects VISPA, ALOIS and PARAMOUNT (Caspary and Joos 2000; Heister et al. 2000; Leukert and Reinhardt 2000; Löhnert et al. 2000; Reinhardt 2001; Reinhardt and Sayda 2001; Sayda and Wittmann 2001).

The Project VISPA (Virtual Sports Assistant) funded by the EU is accomplished by AGIS and IfEN GmbH. In this project a prototype for a mobile value added service for mountaineers is developed. The system is based on a mobile device, which can be used by the mountaineers to connect to several GIS-based services like mapping or emergency call services.

ALOIS is a navigation system for the localization of locomotives on railway networks. The system consists of an onboard navigation unit and an office controlling segment. The position is obtained based on sensor fusion technologies with DGPS, inertial sensors and odometer. Additionally a communication protocol was established which allows the transmission of both position information and other textual information.

PARAMOUNT aims at improving user-friendly info-mobility services for over 150 Mio. Mountaineers (EU) by combining telecommunications (GSM/UMTS) and satellite navigation (GNSS) with geographic information systems (GIS). The main intention is to use these technologies to provide a LBS, which increases the security of mountain hikers and climbers.

5.2.2. Objectives and Conception

Six main research topics are considered within this project:

1) Methodical examination

The change from mobile geoinformation systems used nowadays to on site mobile online data acquisition results in a series of scientific questions that should be topic of further research. First of all it should be investigated, which methods are capable of mobile analysis and modification of heterogeneous data. Therefore solutions should be developed on how emerging data inconsistencies could be resolved. Starting from the current available and planned data communication standards, research should be focussed on how the performance of the system can be improved depending on the data transfer rate. Within the workflow that has to be defined, new quality assurance methods should be implemented. This includes the registration of quality control parameters during data acquisition as well as a revision by a controlling instance.

2) Definition of standard interfaces

The specifications, which are currently released, or being under development by the OpenGIS Consortium (data services, feature service, coverage service, catalogue service, exchange service, mapping services) do not meet the requirements of mobile computing. Additional interface specifications have to be developed during this project. Within this development process we aim to contribute our experiences to the OGC standardization process. In addition, the research topic of differential updating of spatial databases has to be picked up. This means standardized interfaces have to be designed allowing modification of single objects in the database. Beyond that, the location services (location application servers, location data servers) currently under development by the OGC have to be examined and advanced.

3) ecure and consistent data transmissio

Data consistency is a major issue within the domain of mobile geographic data management systems. Recorded data have to be stored on the mobile device until the end of the data transmission to ensure the consistency even in the case of a connection breakdown. Techniques and methods to ensure the lossless data transmission form an important aspect of the project. Those techniques have to be independent from the underlying protocol, no matter if it is a packet-switched (GPRS, UMTS) or contrasted circuit-switched network connection (GSM, HSCSD).

4) Concept for mobile clients and the client-server architecture

Different probable kinds of architecture will be analyzed during the first stage of the conceptual phase. Mandatory and needful functionalities of the mobile devices will be surveyed (e.g. data capture, object building, etc.) to figure out the demands on the system architecture and hardware.

The data capturing on site is accomplished by measuring instruments equipped with digital outputs or with analogue instruments. The analysis and the interpretation of analogue devices are supported by graphical user interfaces, generated automatically by distinct applications running on the server side.

The spectrum of supported instruments could contain GPS-receiver, tachymeter, digital cameras, seismographs and other devices specified at a later date within the projects timeframe. The captured data will be made usable to the application instantly. The conversion of the proprietary measured values, a necessity up to now, will be dispensable.

Successful use of mobile data capturing systems within distributed client-server architectures depends mainly on two distinctive components. Firstly the performance and stability of the cellular phone network connection established, secondly the performance of the mobile device. Therefore some preliminary inspections have to be carried out, particularly to explore the mobile radio transmission capacity and stability in different terrains. The use of interfaces and transmission protocols as well as the dispersion of the intelligence and functionality on the mobile client or the server respectively depend on the experiences made during this early stage. The goal is to tweak the system to a maximal performance. Further on, the dispersion of the functionality will be adjusted to the type of mobile devices in use. Experiences made during the prototypical implementation and performance testing will be provided to update the used interface and protocol specifications.

5) Server-side supported data capture
The applications to be developed, provided by application servers, simplify the read and write access to inhomogeneous distributed databases. To facilitate a simple maintenance of previously recorded data in the field, the applications will generate graphical user interfaces automatically. The definitions will be read from metadata information. Consequently, the system ensures the maintenance of all attributes attached to the geographic data stored in the databases. This brings a first quality control mechanism to reality.

Further services will be developed to support the user recording data in the field and to ensure a high level of quality assurance. These could be: (1) A service generating optimal measuring nets for specific tasks, providing propositions for the next location the next measurement will take place. (2) Interpolation services that process the already captured data and provide a huge bulk of information to the user in the field. The user will be able to determine the follow on measuring point location interpreting the interpolation results provided by the server side. (3) Quality assurance services use further information stored in the databases (e.g. DGM) to inform the user if the location of the actual measuring point could not be taken within a fixed level of discrepancy using GPS-facilitated positions due to shadowing effects.
In all cases as much functionality as possible will be placed on the server side to reduce the requirements for the mobile devices. In any case, the transmission capacity has to be taken into consideration.

6) Prototypical developments and field inquiry
The developed concepts and architectures will be tested and proved together with the EML Heidelberg. The prototype will demonstrate the capacity and efficiency of the chosen technologies and architectures as well as the technical realization of the entire project. EML has long lasting experiences in the field of databases and mobile technologies.

5.3. Project »Mobile Augmented Reality GIS-Client«

responsible: Joachim Wiesel, Institute of Photogrammetry and Remote Sensing (IPF), University of Karlsruhe

Abstract
A mobile GIS Client for the collection and update of 3D databases shall be developed on the basis of Augmented Reality (AR) techniques. AR Techniques can significantly improve quality and productivity of GIS client components by superimposing feature data with the real world.

5.3.1. Preparatory Work

A multi-tier 2D/3D GIS Architecture (GISterm) has been developed in the research projects GLOBUS and AJA (Hofmann et. al. 2000a; Hofmann et al. 2000b; Veszelka and Wiesel 2000). The Ministry for the Environment of the State Baden-Wuerttemberg is financing and deploying this technology into its state agencies. GISterm is a platform independent Java framework, which allows it to place different functionalities on several nodes of a federated spatial information system. Recent developments are the integration of 3D-visualization functions for hydro geological applications and for studying the impact of planned buildings and infrastructures on the groundwater system using Java-3D.

In Project C6 of the joint research center 461 »Strong Earthquakes« financed by DFG, first experiments have been performed to use AR-Hardware and Software (Bähr and Leebmann 2001) in disaster management scenarios.
In the project »Geodetic Deformation Analysis«, sponsored by DFG, 3D-Visualization methods are studied and implemented for 3D/4D-visual inspection of spatial movements and their interactions with variations of model parameters (Faulhaber and Wiesel 2001).

In Project C5 of the joint research center 461 »Strong Earthquakes« methods for the extraction and modeling of topographical objects (Bähr et al. 2001) from laser scanner data are studied.

5.3.2. Objectives and Conception

Mobile data communication is nowadays common at quite low bandwidth (GSM, HSCD, GPRS up to 48kb/s), future 3G cell phone networks (UMTS) will transport data up to several hundred kbits/s. These techniques will enable multi media applications on hand held computers in real time. The goal of this project is to use AR methods, as they are already used in e.g. CAD, facility maintenance (Müller 2001) and GIS (Afshar 1997; Zlatanova and Verbree 2000), to support and improve 3D data capture and update in the field – wireless in real time (Hollerer et al. 1999). To reach this goal, we can define 6 work packages:

1) Selection, evaluation and test of hard- and software for 3D-projection in a mobile environment.
Design and experimental implementation of a multi tier software architecture taking under consideration the limited resources of mobile systems (speed, storage, communications capacity). Porting and adaptation of the GISterm framework to the selected hard- and software environment.

2) Orientation and navigation of the AR visualization and data capture system using DGPS and INS.
Evaluation of methods to improve the precision of the system by using control features from the surrounding natural objects (e.g. by imaging, range finding)

3) Study of methods for 3-D measurement in a mobile real time environment
Examination of which methods are economic, feasible and precise enough (e.g. Laser Scanners, Cameras, Range Finders)

4) Development of an interface for real time access to a 3D spatial database system for data capture and update.
Study of the impacts generated by slow and less stable communication links. Development of protocols to deal with this environment.

5) Visualization of data and features in an AR environment.
Study on how 2D cartographic concepts can be transferred into the 3D case, which display techniques will result in readability of features, what is the impact of feature abstraction and simplification. Study of how user interfaces have to be implemented in the AR environment, how to precisely overlay displayed features and real world, study eye tracking and other AR technologies.

6) Test of the developed technologies (hard- and software) embedded into the common mobile testbed (2D mobile clients, spatial data base).
Evaluation of commercial markets for the developed solutions.

6. Outlook

In future, new mobile geoservices could help to give solutions to one of today´s most challenging requirements of geoscientists concerning information technology: the capture, modification and visualization of underground geoobjects to analyse planning processes or geological processes directly in the terrain. This vision could come true by providing efficient geodatabase management systems and modern augmented reality methods within a web-based geoinformation infrastructure. Without any question, then the interactions between micro-, meso- and macro-scale geological processes referred to limited areas could be better understood and analysed. Furthermore, new insights could be obtained by the synopsis of underground observations and the application of new information technology methods.

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