FEEDBACK ORIENTED MAPPING IN MOBILE ENVIRONMENT

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ABSTRACT:

Mobile data acquisition is a vital proposal for the fieldwork in a wide range of sciences. Current advances in telecommunications and high bandwidth availability enable effective wireless access to geodata in a field and bi-directional communication with the server site. Aim of the MobilDat project is to improve support of field mapping with mobile devices. This improvement is based on the idea of map field and user interface adaptation to current activity. Required adaptation is achieved by taking into account edited features, minimizing text inputs by iconic tags and pattern lists, and imprecise input (sketch) enablement. One of key abilities of the MobilDat system is a validation and automated generation of final map on the server site, thus minimizing the computation demand on the mobile client side. Validated results can be sent back to the field surveyor for additional corrections if necessary.

1. INTRODUCTION

Mobile GIS tools increasingly become the means for capturing and visualizing spatial data for a wide range of both environmental and socio-economic applications. They contribute to a complete digital data flow from data collection to analysis and visualization. The acquisition of spatial data with field based GIS can be carried out in an effective manner in terms of time and costs (Pundt, 2000). Services to support data acquisition in the field are knowledge-based diagnostic tools, automatic plausibility controls and the provision of additional visual and textual information (Hitchcock et al., 1996; Pundt and Kuhn, 1998). The quality of captured spatial data can be improved if the user can link the attributes directly to visual objects on maps even if the precision of data is not high.

Research and development in visualization had a tremendous impact on GIS in general and on field based GIS specifically. Efforts in computer science on the other hand lead to new concepts and techniques to solve problems related to visual information management. Some key approaches mentioned and envisioned by Pundt (2000) have become reality in current days (WWW based spatial databases for use in field based GIS, collection and provision of metadata to mention a few). Much attention has been focused on the development of concrete workflows in the field data acquisition and the tailored application tuning. Vivoni and Camilli (2003) have described and prototyped the concept referred to as *field data streaming*. The system consists of software applications and hardware components that enable wireless, mobile and Internet computing during field campaigns. In particular, two-way transfer and display of collected data is achieved between the field site and a remote location. Mobile field mapping, data analysis and data sharing are achievable by integrating a wide range of sensors with mobile, wireless computers. Effective performing the mobile mapping tasks while various teams are still in the field requires the capacity to transmit data wirelessly and methods for sharing, analysing and displaying data over a network. Application software resident on a remote server can provide data access, mapping and analysis functionality to the field worker through the same network. Interactive data collection and mapping has been shown to significantly enhance the scientific discovery process (Vivioni and Camilli, 2003, Carver et al., 1995). Practical GIS application in connection with on line wireless data access was described by Charvat and Holy (2002). During the WirelessInfo project they concentrated on remote sensing data interpretation and field controlling process in agriculture and forestry.

The efforts of the MobilDat project working group were focused on the proposal of architecture and development of framework for mobile GIS and data acquisition which enable the user to define spatial objects with imprecise input (sketch) and validate the input on the server site thus minimising the necessity of iterative field mapping. A main task was to support the user during the outdoor data capture as much as possible with relevant data and tools that should help carry out work effectively. This goal requires tailored applications for users in special thematic communities, such as landscape planning, forestry, geodesy, and marketing survey.

2. MOBILDAT DATA ACQUSITION AND VALIDATION SYSTEM

The mobile data acquisition system consists of a series of mobile computers and GPS receivers, sensors, wireless communication, the whole set of software components (see Fig.1), and theoretical presumptions which are discussed in the following sections

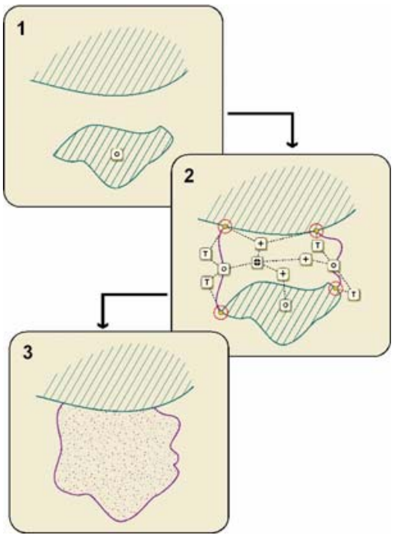


Figure 1. Example of the "sketch" proposal for reshaping of existing object

2.1 Sketch usage

One of addressed issues by MobilDat project is a field data acquisition. In the case of data acquisition we can distinguish two main complications against pencil&notepad solution – slow writing and imprecise drawing.
In the case of writing there is logical way to minimize handwriting with lists of values. This approach is widely adopted by all providers of PDA GIS software. Complication of lists is a long searching in pop-up menus. The way to improve the situation is to contextualize the user interface. When the selected feature is inside of the mapping mode only appropriate value lists are accessible. Order of values is depended on its frequency of usage, location and attributes already filed.
Method of sketches was selected according to imprecise (and inconsistent) drawing. The sketch is understood in a more general sense then in usual. Sketch inside of MobilDat project isn't only a symbolic drawing but the composition of drawings, symbols and transaction id. The sketch is a short transaction attached to the object (or group of objects) initiated by selection of type of object modification. Draw is used for identification of affected object (group of objects, pair of objects, part of object, place of object). Action is marked by symbol – for better user comfort. Beside sketch there are new object coordinates (sensor or man-made) inserted into transaction and user close transaction. Action and drawings are encoded into XML code, attached to the rest of the recorded information and sent to data validation.

Sketches cover following operations inside MobilDat user interface

1. geometric corrections
   - simple actions - deleting and moving of an object
   - with coordinate string – split and reshaping of an objects
   - pair operations – attach to existing object, copy of existing object from another feature
   - group operation – join of objects, multiple delete
2. attribute modifications – multiple change of attribute value

2.2 System architecture and components

The general concept is based on the idea that the web portal solution can be used as a unified environment for user's thematic projects development and unified geodata web tools accessibility. Following overview describes the architecture and main components of mobile data acquisition on the server site.
Technologically the system consists of four main components (Fig.2):

1. Data management
   a. metadata and catalogue services compliant with OGC specification and mediated by MICKA system
   b. data sharing services - map services based on OGC specification WMS, WFS, and WCS
   c. tools for map project management and generic data interface called MapMan
2. Data visualization,
   a. Visualization map client
   b. Web mapping services
3. Data collection tools and services
   a. communication and data transfer interface (Teredit)
   b. mobile mapping client – any open and interoperable mobile mapping client (ArcPad, Topol CE, eSVG)
   c. sensors interface extension
4. Data analysis and validation tools

The proposed web portal will ensure the access to the particular applications and mapping projects and also the data validation, management, querying, and catalogue services. Portal is secured by authorization service and offers two levels of access – basic user and expert. While the former is focused more on the pre-defined project service delivery based on the use case analysis (see bellow), the later is intended to be an authoring tool for experts with the rights to define editable entities, data sources, reference layers, visualization and validation tools, methods and tools for mobile data acquisition, and transactional data deposition.
Internal data sever is used both for base topographic data and for validated field updates. Specific part of portal is dedicated to the use cases applications and projects (marketing mapping, forestry inventory profile, landscape mapping).
Mobile data collection consists of two parts – server and field mobile unit. While the server part (broker) drives the data transition in transaction mode, the field unit is responsible for updating and pre processing of collected data. Mobile unit graphical interface and data environment is not static and changes according to the chosen user's context. Communication is executed in a batch mode in order to minimize the problems caused by potential wireless signal outages.

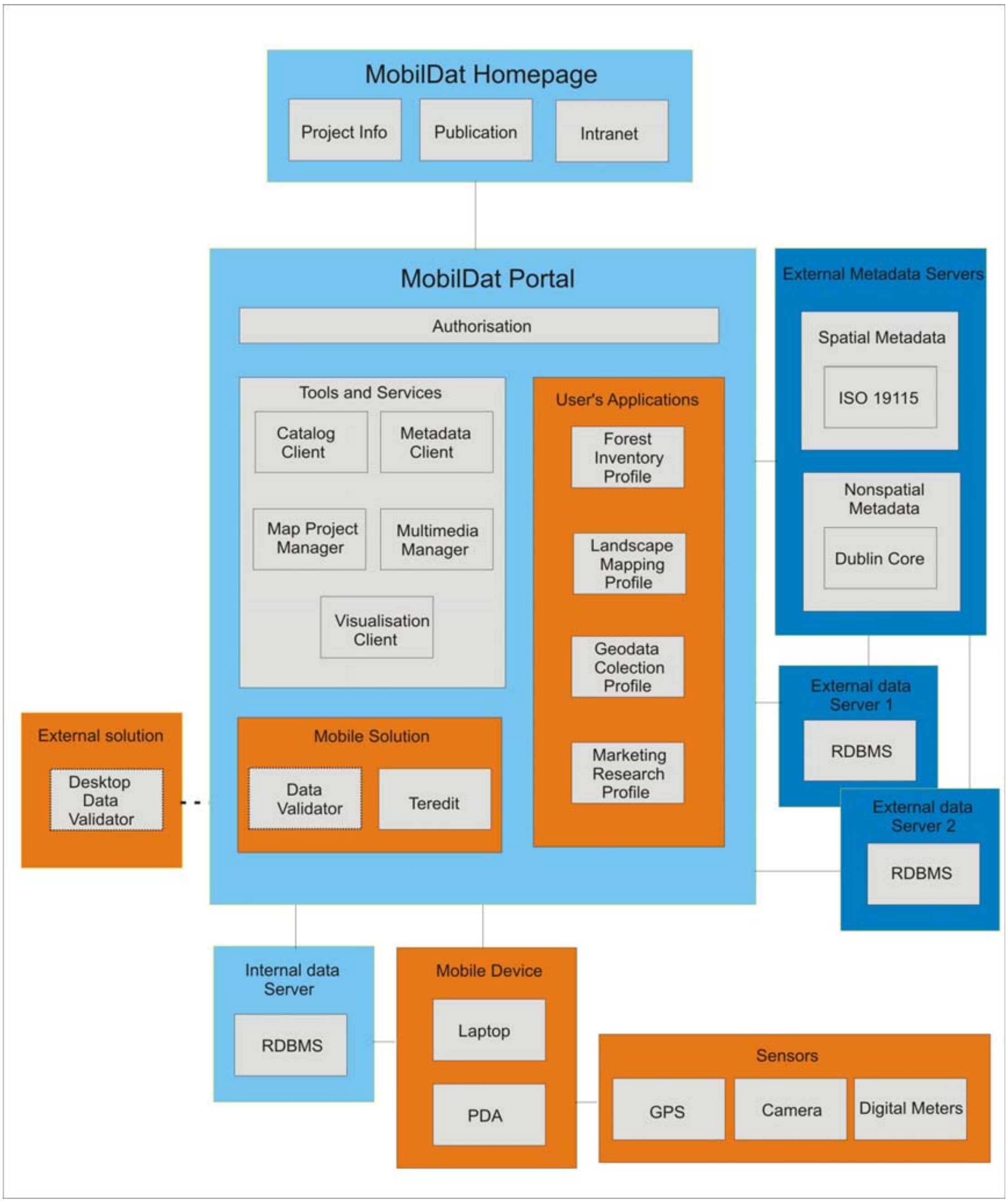


Figure 2. MobilDat architecture and components

Server side functionality consists of the set of tools compliant with OGC standards:

- ***Catalogue service*** – enables the management and querying of information and data sets. Manages particular projects created by MapMan and communicates on the base of OGC standard protocols
- ***Metadata service*** – consists of two independent parts – metadata query engine and metadata authoring tool compliant with both ISO metadata standards and Dublin Core standards.
- ***MapMan*** – map project composition manager. This tool is able to access different data sources (Fig.3) both internal and external in the form of web services (WMS, WFS) or file systems. Resultant map project composition can be further shared. MapMan serves as the authoring tool for background data composition development for selected mobile mapping use cases. Projects created by MapMan are similar to the concept of „context services" in the OGC specification sense.
- ***Portal visualization client*** – MapMan reference data can be visualized together with field data acquired by particular mobile mapping use cases. DHTML client based on Open Source Mapserver is used for standard visualization.
- ***Multimedia manager*** – an independent tool for the management of multimedia files (photos, video..) acquired by the mobile mapping.

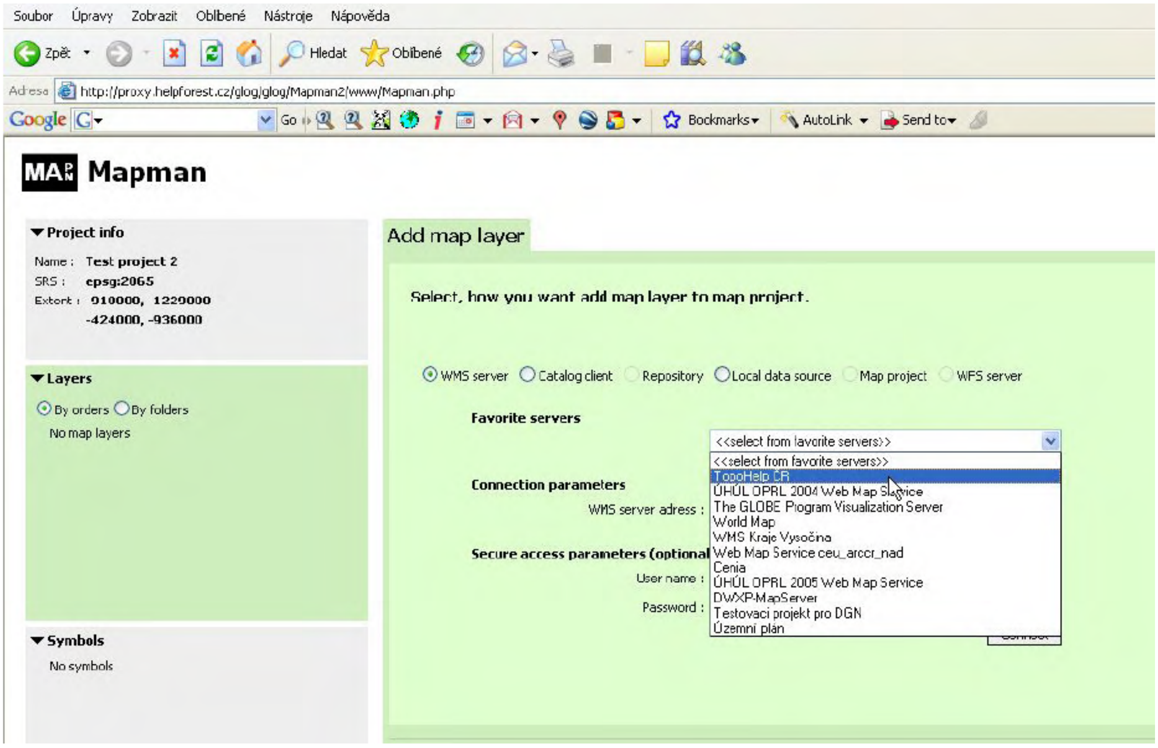


Figure 3. MapMan map project management tool interface (courtesy of Lesprojekt sluzby, Ltd??)

2.3 Data flow and validation

The mobile mapping system data flow begins in portal environment, where the administrator prepares and defines the mapping projects data sources, mobile client modification file and preferences use case code list, and cartographic legend key. These resources are wrapped up by Teredit mediator and posted to mobile client either by communication lines (GPRS, WiFi) or synchronised download from the server via cradle.

In the field the mobile worker just uses the Teredit import and opens the appropriate use case in his/her mobile mapping environment including data, code lists, tools, and graphic user interface. The mapping process is then divided into sections and particular features/thematic groups are collected within each section. Finished sections are then exported to Teredit and transferred to the server to be saved on temporary database for transactional processing.

There are several possibilities how to process data on the server site and the final decision depends on the thematic use case. The basic idea is to assure the validation of processed data either by operator or semi- automatically. Both desktop software and web services can be utilised as the validation tool. An example of validation process for selected use case is given bellow. Data after validation are either send back to the filed for re-checking and adjustment or advance to the final database for further processing and transaction termination.

2.4 Hardware solutions

Two disposable hardware mobile client solutions were used during the project test phase. The first was p**rofessional** PDA device with GPS, external communication Trimble GeoXT. This tool is often used for data collection by field workers in rugged conditions. As an inexpensive alternative **Compact PDA with GPS and GPRS/**EDGE (HP iPAQ HW 6515 Mobile Messenger) was used. The main challenge with the later is the overall batteries durability especially with the WiFi or GPRS module on.

3. APPLICATIONS AND FIELD STUDY DEPLOYMENT

There were several use cases defined by project partners from pilot thematic regions. The use cases cover the tasks, which the partners want to solve in MobilDat project. General use cases were made on the basis of specified use cases which have similar or almost identical solution. We employ the “Standard Use Case Template” for a general description. The research is mainly focused on customisation of the general OAS model to concrete services and on finding similarities in practical terrain analysis in everyday work in different user domains. The interviews with users demonstrate the existence of basic modules fulfilling general user needs, but have to be modified. The user access for collecting information about forest management and agriculture measurement are differences are in used sensors.

Feature catalogues were developed for particular use cases describing the whole hierarchy of feature types, attribute types and coded values from a data dictionary. Those reference relevant feature types; binds attribute types to selected feature types and coded values (code lists) to these bound attribute types. Additional information may also be specified for selected cases, for example about the spatial characteristics of a feature type or topological constraints.

3.1 Generic use case of mapping

To establish contextual service generic use case was created.. This use case cover whole field mapping process from selection of sensor devices to data capture. Generic use case process involves:

a) session control – open and close mapping session with basic settings

- identification of the user – user id is imprinted in all records and can help to ensure data acquisition quality, also play role in visualisation and user interface settings, in special cases it can be used by data validation services
- selection and identification of devices –each record of coordinate stream is equipped by the id for purposes of data validation services. In another part of MobilDat project characteristics of measurement devices and their potential impact on record accuracy were evaluated
- selection of theme and location – this selection affects geodata and list of attribute values used in mapping session. Together with user id it is also main influencing factor of user interface
- mode selection – basically there are modes for navigation, additional data request and mapping. The mapping is decomposed into several tasks
- feature selection – edited part of theme is selected and appropriate map face and list of values are compiled into user interface
- edit – new object is created by combination of user function selection, sensor data and user sketch
- correction – existing object is modified. This mode is also used in cases where data validator modify object according to database consistency. Operator can commit changes or make corrections.

This generic schema decomposes all actions related to the mapping process. On the basis of this schema particular mapping cases were implemented within MobilDat project.

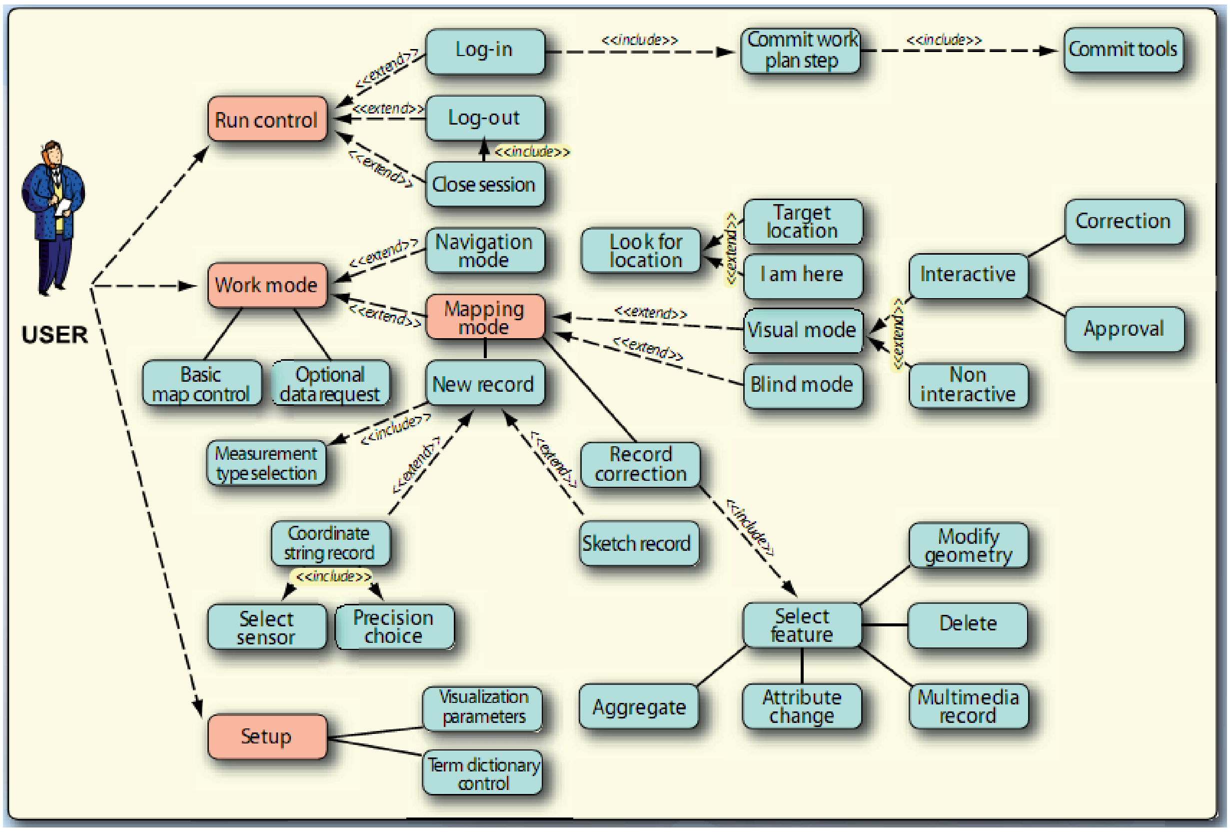


Figure 4. General use case of field mapping in the MobilDat project context

3.2 Marketing mapping use case

As a pilot study the marketing mapping of retail shops in Brno city centre was accomplished. This use case represents the simplest example without the necessity of geometry handling and only selected thematic attributes are captured and validated.

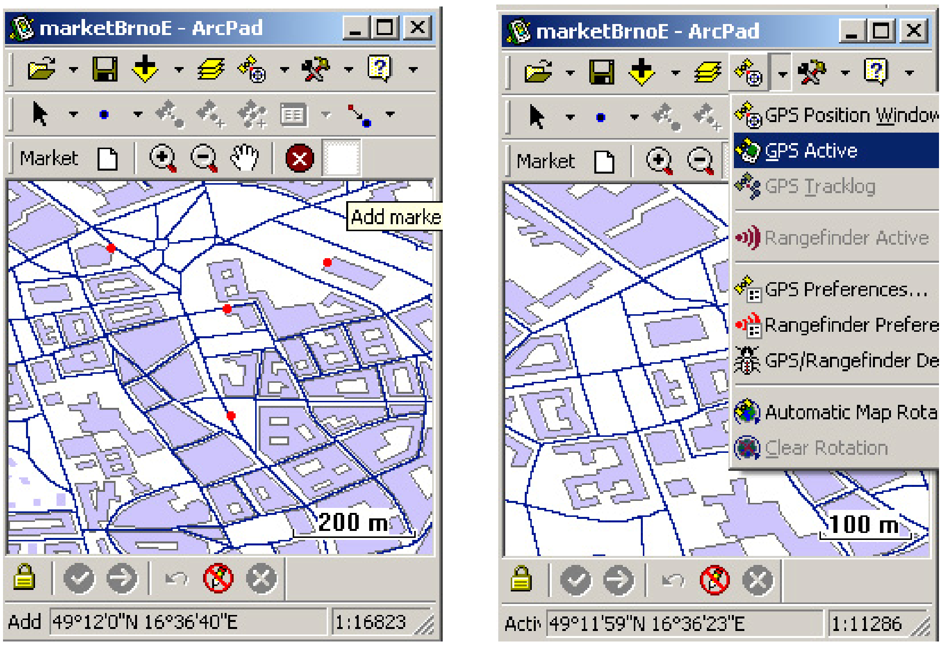
Goal: Mobile data acquisition about retail shops in the city centre and their further exploitation for marketing purposes
Reference data: Raster city plan 1:10 000, street networks, address points (if available)
Proposed field features: localisation of retail shops and update of following attributes – current status, address, (street name,

street number), shop type, retail area, product selection (based on code list), available parking plots for customers.

Every retail shop location is either associated with an existing address point or with a new location measured by in built GPS receiver seamlessly integrated with mobile client software.

After executing the whole street segment the data are sent to the server for validation against the existing marketing database and GPS location refinements.

ESRI ArcPad software was tested for the purpose of marketing mapping (fig. 5). Customised user interface and user scripts were created within the desktop client and consequently sent to mobile client including code lists. While the usage of commercial of the shelf product has several strong points (no programming approach, easy definition of forms and code lists, widely used.) it has also some drawbacks. The standard ArcPad development procedure unfortunately does not support the full customisation of either user interface or feature list without further extensive development using ArcPad Builder. In order to pursue the MobilDat approach it would be necessary to prepare new project for every single use case. Besides the above mentioned limitation there were some inconsistencies with the photograph integration.



a) b)

Figure 5. User graphic interface for mobile marketing mapping using ArcPad (a) and integrated GPS interaction with mobile mapping tools (b)

Figure 6. Image integration with mobile database

4. DISCUSSION AND FUTURE DEVELOPMENTS

Mobile mapping and data acquisition issues are becoming obvious in day by day practice. While the technological background (HW, communication services) is ready to use, the importance of user environment is still in the stage of experimenting and research development. Improvement of data acquisition efficiency is one of the user's requirements.

The generic architecture and particular functional blocks have been proposed and tested in the framework of MobilDat project. The back bone of the solution is already functional and has been tested on a series of use cases. Current development concentrates on the refinement of client application front-end. Since the existing front – end solution are less flexible than demanded by the project presumption, the development team is working on a new solution built from the scratch on Java script and SVG.

Variant sketch inputs are designed and tested in order to find equilibrium between the user friendliness and implementation simplicity.

Validation services specifications are under discussion. The first to be accomplished is the coordinate transformation from global reference system to the national grid compliant with legally bounded national geodetic standard. The MobilDat project is supported by Czech Academy of Science programme: IS, no.1ET101630421.

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