Advanced web application for editing purposes in disaster management
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Abstract. The paper describes a unique idea - on-screen editing of both spatial and attributes data directly via the Internet environment. It takes advantage of WebGIS 2.0 principle as a combination of WebGIS and Web 2.0 approaches (Rich Internet Application and Service-oriented Architecture). It allows the creation of a web-based map application with customized and advanced functionality. The concept of Rich Internet Application (RIA) brings tools, practices and conventions from the desktop platform into fully web applications, thereby providing greater user comfort. In the case of Service-oriented architecture (SOA), a user does not deal with original data as was typical before. The data are shared as web services independently on the platform. Web Map Service (WMS) or Web Feature Service (WFS) are now widely used for GIS solutions. An extension called Transactional Web Feature Service (WFS-T) enables data editing by remote access. Usually, a desktop or server solution is required for map display and/or editing. This case study uses the WFS-T innovative approach for WebGIS 2.0 solutions. The WFS-T support has been developed and implemented into a customized application by an additional widget. It extends the visualisation feature by the editing feature. Both visualization and editing tasks are fully accessible online. The map client allows on-screen editing of map content. Both spatial and attribute data could be modified in real time directly via a web browser (no installation process is required). The case study is developed with the aim to support crisis management, especially in collaboration with the Fire Brigade of the Olomouc region.

Key Words: editing, real-time, WebGIS 2.0, services.

Introduction and motivation. Fire brigade of Czech Republic handles with central data warehouse in Lázně Bohdaneč city. Currently it collects data from 25 major providers of both public and commercial sector. Data are updated, optimized and completed centrally at one single place for whole Czech Republic. Finally data are distributed into regional and local fire stations as a raw files (ESRI geodatabase) two times per a year. Furthermore major data layers are provided as web services. If any essential change in spatial and/or attribute data is required than: the change is announced to central warehouse – the change is entered into the central database – data are redistributed into stations (Figure 1). Centralized management provides lot of advantages. On the other hand update process in that way is quite uneffective. According to Cutter (2003) the time of response by rescue teams play crucial role in Crisis management. Modern geographical information systems (GIS) can significantly speeds up intervention in case of any event if right data are provided as fast as possible.

There is a long term collaboration between Dept. of Geoinformatics, Palacký University in Olomouc and Fire brigade of Olomouc region, especially in implementation of Geographical Information Systems. There was a requirement to develop a flexible web client for real time visualization and editing purposes by local fire station. The general trend of information technology is relocation, sharing and distribution of data and programs via the Internet environment. The paper describes the process of designing a web client used for the Fire Brigade of the Olomouc region. It is based on WebGIS 2.0 concept. WebGIS 2.0 takes advantage of the combination of Service-oriented architecture with the Rich Internet Application. In fact, the Transactional Web Feature Service allows real time editing and updating of both spatial and attributes data via the web environment. The main advantage of described solution is all processes occur through the web browser only and could be managed by the operator in the real time. Data are stored in one central location but could be updated immediately. The motivation of described study points to a clear requirement for a real deployment and real requirements by Fire brigade.
Methods and technologies. The case study operates with a term WebGIS 2.0. Despite the fact that there is a potential to involve WebGIS 2.0 since a few years ago, there are almost no records in neither popular nor scholarly literature. GIS and WebGIS 2.0 principles are mostly mentioned by Mairo (2013). The appendix 2.0 in GIS field was used by Tilio in 2010 for the first time.

In stylistic way WebGIS 2.0 concept combines ideas of WebGIS and Web 2.0. WebGIS is accepted as a paradigm for how people access and use geographic information via Internet since the last decade. It is mentioned and adopted by all crucial resources. Web 2.0 does not refer any version or update of World Wide Web. It indicates different approach for web development. A permanent content has been replaced by sharing, customizing and content creation. Web 2.0 has been used for the first time in 1999. Both of mentioned terms are worldwide known, respected and accepted. It is surprising fact that WebGIS 2.0 is still not widespread. In general, it extends GIS tools by current Internet approaches and behaviour.

In technological way WebGIS 2.0 concept combines state-of-the-art in combination with GIS opportunities. It put emphasis on Service-oriented architecture (SOA) and Internet platform such as Rich Internet Architecture (RIA), Cloud computing, Web Map services, etc. The application described in the paper is built on ArcGIS Viewer for Flex technology as a typical example of RIA. Data process is managed by Transactional Web Feature Service (WFS-T) according to SOA principles.

ArcGIS Viewer for Flex. ArcGIS Viewer for Flex has been one of the most popular solutions in the field of WebGIS. It enables visualization of spatial data, interactive querying and lot of additional functionality such as data editing, printing or geocoding via Internet platform (Pinde & Jiulin 2011). In fact, it is API (Application Programing Interface) developed by ESRI company but it is not oriented only on ESRI standards. OGC Web Services, REST and SOAP protocols, KML services and number of other standardized formats are supported. The combination with open API allows creating highly interactive application that could be customized according to individual requirements.

The additional widgets are supported - the core of the application could be extended by new widget at any time without any intervention into the source code. Every tool/functionality is served as a separate widget. Every widget can be added/modified/erased quite independently of the entire application. There is a friendly graphical interface for developing process available. If any widget is already developed and available, the Application Builder allows you to create application by drag & drop (Figure 2). That is the reason why ArcGIS Viewer for Flex is popular solution based on Rich Internet Application concept (Netek et al 2014).
Service-oriented architecture and web services. According to Schreiner (2007) SOA is a paradigm (general concept) for services composition independent on platform. The basic SOA model is based on two sides: the service provider and the service consumer (Figure 3). The consumer (user) searches for the service in some Registry that provides metadata about services. Than user is connected with pro-vider and provider provides service to the consumer (Panda 2005). Crucial benefit is a fact that user does not handle with data in raw form as was typical before. The data are shared as services according to basic SOA attributes: independence, interoperability, and standardized contract. In general, WebGIS 2.0 requirements and trends exactly reflect SOA attributes. Currently SOA principles are crucial for develop modern GIS application.

Web services are a characteristic example of SOA implementation. In the case of spatial data number of standardized Web mapping services is available. They are used for sharing geospatial data in the Internet environment according to SOA principles. Users can share data, maps as well as whole applications without any local access to them. In fact, users do not handle with raw data and/or files, they work with services. According to Schreiner (2007) the main advantages of SOA are:

- user can work with data from more sources;
- it is not required to save any data on a local computer or server;
- data are saved and managed in one place;
- data are still updated;
- centralized data management provides higher efficiency;
- lower financial costs;
- platform independence;
- only a web browser is required to access;
- data cascading.
Transactional web feature service. Currently web services are one of the main trends in the field of Geoinformatics. Depending on the provided data users can take advantage of number web services, for example: Geography Markup Language (GML), Representational State Transfer (REST), Web Processing Service (WPS), Web Map Service (WMS) or Web Feature Service (WFS). While WMS handles with raster images, WFS enables data visualisation in vector form. For editing purposes is crucial WFS extension called Transactional Web Feature Service (WFS-T). There are 11 features available (ESRI 2007):
- GetCapabilities – metadata description;
- DescribeFeatureType – kinds of data;
- GetPropertyValue – allows you to get the value of parameters;
- GetFeature – draw chosen objects;
- LockFeature – disable editing from more clients at one moment;
- GetFeatureWithLock – lock objects;
- Transaction – data editing (insert, delete, update);
- Other operations: Create StoredQuery, Drop StoredQuery, List StoredQueries, Describe StoredQueries.

Pilot application. The main motivation for developing pilot application was absence of editing tool given by Fire Brigade of the Olomouc region. There was an idea to record and edit events in the field in the real time. According to the classical approach, map services could be separately divided to visualize and edit services. The study describes a unique approach that combines these services into one interface. The current trend is towards visualization clients that enable the generation of maps according to the user's request (scope, scale, extent, layers, attributes, map composition). An innovative step is the implementation of editing tool. It activates the possibility of modifying both geometry and attributes on-screen. There are two options on how to implement on-screen editing. The first one uses direct access to the database to the original data through a robust server solution. A robust map server is usually used, but this solution is not efficient nowadays. A more efficient solution is based on the approach of SOA - geodata are shared as services.

There has been developed a central map client for Fire brigade of Czech Republic in 2010. It has been built on ArcGIS Viewer for Flex technology. It is an application for crisis management support available for all fire stations in Czech Republic. The support of cascading web services enables combination of map services from different sources with the aim to create synthetic crisis maps. The hypothesis was that it should enable on-screen editing in real time by additional widget. Based on these two requirements and discussion with operator it has been decided to develop a pilot application for Fire brigade of Olomouc region – the duplicate of map central client, moreover extended by additional editing widget with aim to test on-screen editing in the field.

Smart client. Any GIS application could be defined as a thin or thick client from a technological point of view. The level of functionality is crucial. Thin client is the client that does not contain any application logic. The application logic is provided by the application server. Every operation and request is managed on the server in the case of a thin client (Pinde & Jiulin 2011). Usually, the web browser is used for visualization purposes. Therefore, any installation process is not required. The thin client technology allows the user to significantly reduce costs. On the other hand, a thick client deals with a wide functionality and performs the application logic. There is only a service that processes client requests on the server side. The thick client is usually a robust desktop or server application that requires installation (e.g. ArcGIS for Desktop, Quantum GIS, ArcGIS for Server, MapServer etc.). The application based on the concept of Rich Internet Application allows to create a smart client (Meier 2008; Johansson 2010). It is an extension of the thin client, hierarchically located between thin and thick client. It provides the functionality and features of a thick client but still in a web browser environment. The interactive map application is stored in the form of an HTML document,
thus is platform independent (Voženílek 2009). Compared to the thin client, the smart client provides higher technical and performance options.

**Application concept.** The pilot application is based on WebGIS 2.0 concept - the combination of RIA and SOA. A Smart Client (RIA) provides the functionality. Transactional Web Feature Service (SOA concept) enables map content editing. Based on situation of the Fire Brigade of the Olomouc region the pilot application has been built as well as on ArcGIS Viewer for Flex technology. It is a duplicate of central map client (available from http://gis.izscr.cz/map2/) with common visualisation tools: zoom in/out, interactive legend, on-screen identification, print, full text searching, measuring, StreetView. All these functions are basic widgets available for public. The map client content two kinds of data: basemaps and operation layers. There are three default basemaps:

- **ZABAGED®** – Czech national topographic basemap, provided by Czech Cadastral Office (public);
- Satellite images – Alternative of Czech national basemap, provided by Czech Cadastral Office, spatial resolution 0.25m/px, (public);
- Basemap of Fire brigade of Czech Republic – specialized topographic basemap (non-public). Basemaps are loaded into map by WMTS standard. Operation layers handle with WMTS of WFS according to their character. There are about 25 layers divided into two groups:

  - basic thematic layers (Geonames, Rivers, Streets, Regions etc.),
  - specialized POI (trauma points, city lights, railway crossing, rocks, flood zones, evacuation points, traffic signs, etc.).

All data are stored in Czech local coordinate system (S-JTSK/Krovak East North; EPSG 5514). Due to the fact that most of Czech spatial data support Krovak as well as WGS84 coordinate system, data are visualised precisely, no transformation is required. The application support web-browser cache. If background layers are loaded once, than another loading of the same data is managed by cache. The same data are not downloaded several times which effects into faster loading.

The unique is extension by WFS-T widget. The widget has been especially developed and implemented, it consists of two files. The editation.swf file is a compressed Flex file that enables communication with WFS-T server. The editation.xml is a file used for the set up of the parameters. It provides editing requests by eight parameters (true or false):

```xml
<addfeatures> <deletefeatures>
<updategeometry> <updateattributes>
<toolbarvisible> <toolbarcheckvisible>
<toolbarmergevisible> <toolbarcheckshapevisible>
```

Edit widget allows three basic kind of operation: add new, edit and delete events. In case of new event four kinds are predefined: the fire, the accident, the damage and the other. Operator selects kind of event and locates position into the map by click on-screen. Then info window with attribute information (kind, date, title, description) is shown (Figure 4). Any photo or text document could be added into the pop-up window as an attachment. In case of existing event can be edit by click on icon. Attribute data can be modified by same way as new one. Spatial location can be changed by move icon into the appropriate position. When info window is closed, changes are automatically saved and immediately updated.

All displayed spatial data are available through the principle of smart client. It is possible to conduct an analysis on-screen or identify the attribute element linked to its spatial localization. The solution allows visualization, publication, editing and deletion of both spatial and attributes data in real time. The data security is provided by two level accesses. Both spatial and attribute data can be edited only by an authorized user, typically by an operator on the base or incident commander in the field. Authentication by name is required. If any change is made by operator, then time and initiator of event are recorded into database.
In fact, the client could be divided into two levels of access (Figure 5). Operators have full rights to edit when editing widget is activated. Otherwise, if the editing widget is switched off, geodata are available for visualization only. All data are available as a mapping service through WFS-T interface. Non-editable mode is suitable for firemen in the field for event localization. On the other hand, if the editing widget is switched on, then the operator can record events directly into the map. Every single change is updated in the live application immediately in real time, any reloading or webpage refresh is not required.

Due to WFS-T approach the data are still centralized at one place, but wasteful data duplication and redistributing process is eliminated. That is the reason why WebGIS 2.0 is suitable for analogous purposes. It is not required to download any data, software or any other tools into users’ computer. Moreover, sharing data via WFS-T provides the benefit that any data change is reflected immediately into the application; the application is still up-to-date.

**Testing and evaluation.** The application has been tested several times by author during the development. Complex testing process followed immediately after launching. First of all it is necessary to mentioned: the pilot application has been tested and evaluated by operator in real situation but as an alternative (second) way only. During the testing it
was not a primary tool for crisis management decision. It only supported operator to recording events. The testing process has been divided into three steps.

**Step 1** – Stress test on the desktop. Ten clients have been simultaneously launched on 10 personal computers (HP Elite 8300 CMT (i7-3770, 8 GB, 500GB, W7 Pro) with cable Internet connection (70 Mbit/s)). Stress test took place in the Computer laboratory at Dept. of Geoinformatics. No significant decrease of loading or response speed. First loading 5.5 sec. Ten repetitive loading: ca. 2 sec in average due to cache, editing response immediately.

**Step 2** – Testing on the desktop with cable Internet connection (> 100 Mbit/s). Made by fire operators at the fire station, ca. 30 hours in total (5 x 6 hours). It has been tested during five relays by two operators. Short discussion has been made with both operators after relays. The aim was to evaluate interface and managing. According to operators the application was stable and intuitive. But they did not use it during stress situation (e.g. during more simultaneous accidents) because it did not play fundamental role for them in emergency situation.

**Step 3a** – Testing on the mobile device with WiFi connection at the fire station. Failed. Neither Android platform nor iOS (iPad) does not support Flex/Flash. Application did not launched at all.

**Step 3b** – Flex support has been restored additionally - non-supported crack into Android tablet has been necessary to launch. WiFi connection, single client, no significant decrease of loading or response speed. First loading time ca 12 seconds. Ten repetitive loading, ca. 3-5 sec in average due to cache, editing response immediately.

**Step 4** - Testing on the mobile device with mobile internet connection, in the field during real events. One fireman (volunteer) took Android tablet into the field. Similarly to step 2 he did not utilize it during stress situation. He up-dated data in non-stress situation e.g. in the car during free time. Remarks to button sizes. He has not been able to control screen in the moving car and in the gloves because of very small buttons. Response in dependence on strength of signal connection.

In general, two major problems have been indicated during testing and evaluation steps. Unfortunately Flex is not supported on mobile platform such as Android or iOS. That problem has been fixed in very operative way by minor crack. That has been appropriate solution on single pilot study. Definitely it is not suitable for wide use. That is the main reason why ArcGIS Viewer for Flex is probably going to die. On the other hand applications built on HTML5 (e.g. Leaflet or any JavaScript API) becoming popular because of responsive and adaptive design. The second problem detected due to real implementation was insufficient size of control elements, especially zoom buttons and select-boxes. Originally, any usability experiment was not scheduled by author. The experience confirms that real evaluation in the field brings unexpected results. The pilot application has been reworked including bigger buttons. Currently it is again used and tested at the fire station, obviously by operator at the desktop computer only. On the other hand there is a new idea given by operators - use the application for monitor fire machinery in the field, e.g. cars or trucks.

Based on mentioned evaluations it is under the discussion design of a quite new version suitable for mobile devices. According to the first research a Leaflet library seems to be a perfect solution for it. The other question for future discussion is an ensure of adequate signal of internet connection.

**Conclusions**. The design of a web client for the requirements of the Fire Brigade of the Olomouc region utilizes WebGIS 2.0 concept - the combination of the Rich Internet Application and Service-oriented architecture. The application framework is built on ArcGIS Viewer for Flex platform extended by WFS-T client. It enables visualization as well as editing of both spatial and attribute data directly in the environment of a web browser. On-screen, in the real time. Any installation process or desktop software is not required. Described solution provides benefits of web services that allow the centralization and standardization any process. Data editing and/or update based on the described solution is faster and more effective than previous solution. The advantage is that it ensures that
the program is running smoothly while the content is updated. On the other hand it is
tested and discussed that chosen technology is not suitable for mobile devices.

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