Information Rechnology for Web Application in Surveying

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Key words: Deformation measurement; Geoinformation/GI; On-line computing; Web application; WMS

SUMMARY

Fast development of new telecommunication technologies and on-line access to data by means of Internet provide a possibility for creation of new technologies in surveying. First of all these are web services based on standards and applications using these services. The article describes their main principles and presents the advantages and new possibilities coming up from their exploitation. Discussed are web application for analysis of deformations from repeated horizontal survey measurements based on the continuum mechanics and web application for processing of survey sketch.

In the XML Web Application to on-line calculation of deformations are derived and described parameters of deformation field (strain tensors, total dilatation) in quadratic network, covering the whole result obtained at individual points of the network in question. Vectors of displacement from repeated - and in several epochs observed - results obtained at individual points of this network are given as input values. The calculation is based on the theory of mechanics of continuum and its basic prerequisite is the homogeneity of the tested territory in question. Application uses Web Map Services (WMS) as its graphic representation of calculated results in the GIS format. Such services enable forming on-line of defined thematic maps in Internet viewer shown in its viewer from data obtained from servers with WMS by user. Thus no geographic data are needed by user to create GIS of his own. Results may be reproduced and observed on a digital terrain model. This makes better evaluation and analysis possible and takes spatial relation of given terrain in consideration, too. The application includes export of results to a series of formats to further using, e.g. as the KML format to Google Earth program. Such application is at disposal to be registered as on-line calculation using Internet to all interested persons.

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1. INTRODUCTION

Recently, we can follow very fast development of communication technologies that are used at management of national economics in the form of fast information provision. Nowadays, we cannot imagine some of the tasks, e.g. security systems, systems of environment monitoring, transport systems, armament systems etc. without developed system of geographic data (geodata). Should the data be accessible and operation with them, as well as their quality and access free, they have to use for their transfer, display, saving and cartographic visualization new information technologies. However, these technologies have been under fast development and have significantly influenced traditional ways of data mining, processing and distribution. Nevertheless, handing the data has required also new forms of their saving in databases, together with metadata. Under conditions of modern database technologies, to recognize geodata origin, their quality, way of original acquisition would not be possible without metadata (data on data).
During last years also web services and applications have been more and more discussed. We can follow diversion from understanding web only as a medium for information provision and information sources to using it as a tool for providing these services and applications. However, to use Web in this sense requires considering carefully the purpose for which Web should be used. Above all it means the goals that should be reached. The goals influence the basis for chosen tools that will be needed for the goals achievement. This trend is due to advantages and possibilities that web applications together with web services and released databases offer. In this article we will try to briefly describe general principles of web services and applications, their importance and advantages for the field of geodesy, surveying and cadastre. We will focus on Web Map Services. In addition, we will mention tools that may be advantageously used. Everything will be illustrated with examples of two web applications for surveyors.

2. TECHNOLOGIES FOR WEB SERVICES AND APPLICATIONS

2.1 Briefly about XML

XML – eXtensible Markup Language is one of the languages in the group of markup languages, similarly as language HTML. Unlike HTML, it may be easily extended. It means that author of XML documents and data sets can under certain conditions define which marks will his XML document used, exactly speaking he can create these marks himself. In this way authors of documents and data sets get in their hands a tool (language) with almost unlimited number of tags (marks) for more precise markup of specified information.

Language XML was created in the frame of consortium W3C (http://www.w3c.org), and is being further developed by this independent organization [1]. The language has got relatively simple syntactic rules, however compliance with the rules is more strictly required than it is in the case of language HTML. This enables cheaper and easier development of corresponding viewers that does not have to correct possible mistakes in XML documents syntax. It results in the possibility of displaying XML documents also on simplier devices, e.g. various mobile appliances and therefore, to make web information accessible at these portable devices.
It is simple open format independent on the operational system. The simplicity is based on text format (marked text) that uses simple syntax rules. Free displaying and access to language specification is realized on web pages of consortium W3C. This represents crucial difference when compared to company commercial products which are not at free disposal, and are bound with specified hardware or software; are very complicated and their specifications are often secret.

The principle of XML as a markup language is simply speaking based on the fact that marks encircling specified parts of the text in text XML document **mark** their **material sense.** Which marks and in which structure may be used is defined by the author himself in DTD (Document Type Definition); and how the document is displayed is defined with the help of XSL (eXtensible Stylesheet Language). Unlike HTML, this means that marks do not define the way of displaying marked part of text, but its material sense.

It results in **consistent differentiation of the information content from the graphical representation** under using different styles for the same XML file; it enables different representation of the same document. For example, this feature may be used when it is necessary to display the same data on different devices in different ways (e.g. as WAP pages for mobile phones, or as a printed brieflet, or as HTML or PDF document on Web etc.). Further, it is possible to use this feature advantageously for the same data input in different databases or applications independently on the platform used by the specific database or application. On the other hand, the feature of differentiating the information content from the graphical representation may be used in the case of different XML files containing different data (however accepting the same DTD) together with using one of the styles for the representation; it is possible to display these different data files identically. This is very handy for displaying outputs from different databases or applications, where it is possible to reach the same representation of the result.

Thanks to its features, generally speaking, XML is **very suitable format for data saving and exchange.** It is self-describing, independent on the platform with the possibility of data control, which is evaluated in particular by authors of information systems and programmers. Being based on the text format and the possibility of different language coding are very suitable features for being used in Internet, i.e. for the possibility of creating web information systems and web services and applications. The extensibility and possibility to define own marks and data structure means that XML is a very flexible and universal tool for data saving and exchange in almost all fields of human activities, i.e. also in surveying and cadastre.
Format XML is important in particular in situations where it is necessary to mine, process, save and provide data. XML will be suitable tool for work with these data. Openness of XML

then ensure that **information systems, applications and services based on format XML will have long operating life-cycle,** which will enable rapid decrease of costs of their creation and, above all, their maintenance.

2.2 Web services XML

During last years, transfer of many applications from "desktop" product environment to Internet in the environment of distributed management has been obvious. It has been the open standards that enabled and accelerated the development of web services. In fact, open standards are Alpha and Omega of the whole Internet with all its services. Without them Internet or any of its services would not exist, and this could not be changed by any rich or famous software company. The necessity of open standards mentioned above led, in fact, to creation of format XML. It is XML and, web services based on XML further become a tool for integration of web applications. Why this is true will be shown further.

First, let us clarify what we will understand under the terms web service and web application. **Web service enables interaction machine – machine.** This means that in this case it is two machines that communicate together under some standardized protocol. As an example we can use e-mail, during its way to the addressee e-mail has to go through a number of servers that communicate together in this way. Unlike this interaction **web application enables interaction man – machine.** As an example we can use Internet shop in which the customer fills in an appropriate form and consequently, he buys selected goods; or displaying output from a database after filling in filter criteria (e.g. the Business Register, excerpt from the Cadastre of Real Estate, etc.).

It is important that the existence of different web services enables the programmers and authors of the information systems to create web applications using these services. Provided the web services were based on XML formats for interface that enables access to the services it would be possible to create new applications using advantages of these XML interfaces, e.g. independence on the platform. In this way web services really become an integrating tool for creation of web applications. We can call them building blocks for web applications and distributed data processing. Processing is distributed because of the fact that one web application can at the same time use also other web services from different servers (possible also on different platforms) and these can address with their requirements other servers ensuring further web services etc. (the principle of cascading). Moreover, the application user does not have to know about all web services and servers that are used by his application; the user communicates only with the only one application.
For example, in the field of geodesy and surveying it is the three below mentioned development areas:

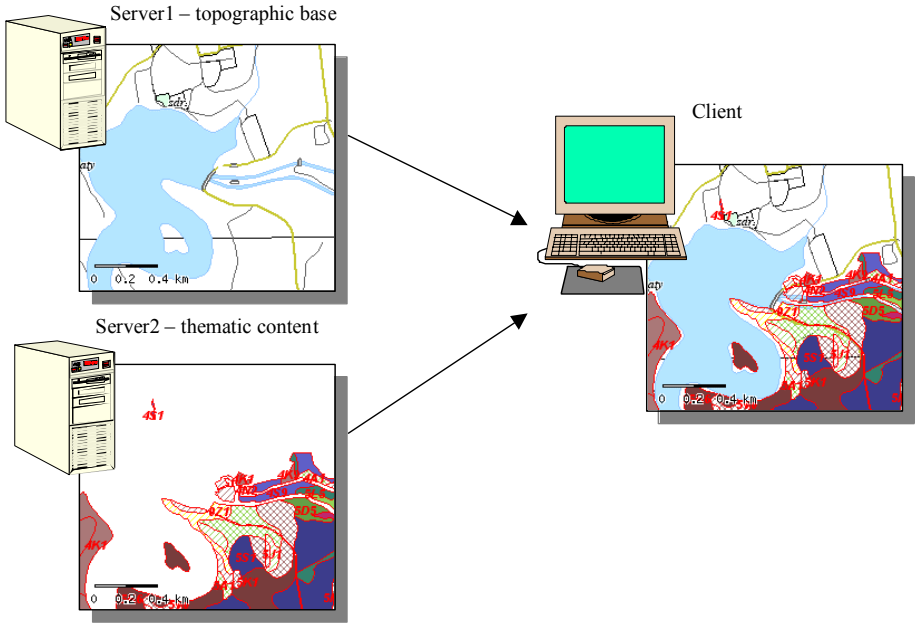
- Utilization of web services XML for **providing map data** in Internet or intranet environment that serve as a base for web applications requiring spatial component. E.g. as a topographical base for thematic GIS.

- Web applications XML development for geodetic computing that will enable the users to compute on-line even **more demanding and less usual calculations** without special software and detailed theoretical knowledge of the exact calculation.
- Web applications XML development for geodetic **computing, that requires interactions with databases** of e.g. state administration, and whose results shall be given by stated procedures defined in regulations, with further output transfer into appropriate databases.

In general, we can find the development trend **towards using distributed services and data.**

2.3 Web services according to the standards of consortium OGC

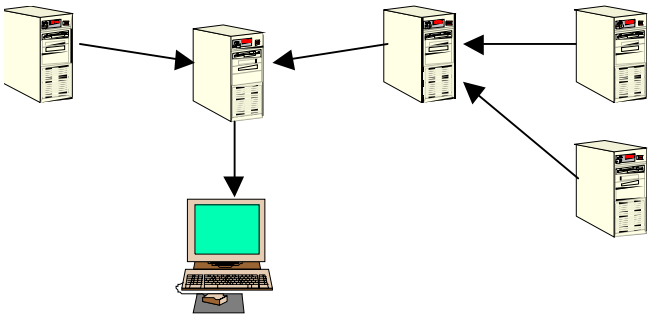
The above mentioned trend applies also to GIS, where it is represented by creation of web map applications. The applications use in particular Web Map Service (WMS). In most of the cases the services are defined by open standards of Open Geospatial Consortium. (OGC – http://www.opengeospatial.org/) [2].



Picture 1: example of Web Map Service WMS

The main contribution of web services defined in accordance with OGC consortium is the **possibility of GIS data sharing in distributed environment of Internet.** Users can share maps and applications without the necessity of having data on their own computer or server. The typical example is represented by displaying the complex thematic map containing data from different servers on-line in internet viewer (thin client) or in some desktop GIS programme (thick client). Just in this way it is possible to successfully create complex spatial data infrastructure in any scale, i.e. both national and international. In picture 1 there is a schematic example in which the client creates on-line his own thematic map using information from different servers via Internet or intranet.

Concerning the fact that some servers can services not only provide, but also process (require from other servers), it is possible to chain the services. This principle is called cascading. Schematically is the situation displayed in picture 2, where the client is addressing one server with the request for services, the server further gets required information from other servers providing partial services or data.



Picture 2: example of cascading the servers

2.3.1 Important specifications OGC for web services

Detailed overview of all specifications OGC for web services may be found on pages of consortium [2]. From many of the services we will briefly mention four services that are probably the most important:

- **Web Map Service (WMS):** provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc) that can be displayed in a browser application. The service is intended for displaying maps in raster format. 3 kinds of queries are defined in the specification:
    - GetCapabilities: it gives XML document describing all the service. Applications read from this document information for further cooperation with the server.
    - Get Map: it gives map in the form of a picture (PNG,...).
    - GetFeatureInfo: it gives map elements attributes at coordinates given by the user.
    - Using the thin client and e.g. cascading CSS styles the service enables displaying the complex map by overlapping pictures from map servers (see picture 1). Servers cascading is also possible (see picture 2).
- **Web Feature Service (WFS):** the service is intended for vector data displacement (in GML format). Because of the significant number of transferred data it is suitable rather for work with own data or for e.g. analyses. However, work with GML usually requires thick client.
- **Web Processing Service (WPS):** this interface standard provides rules for standardizing how inputs and outputs (requests and responses) for geospatial processing services, such as polygon overlay. The standard also defines how a client can request the execution of a process, and how the output from the process is handled. It defines an interface that facilitates the publishing of geospatial processes and clients' discovery of and binding to those processes. Please see more details at [3].

- **Catalogue Service (CSW):** supports the ability to publish and search collections of descriptive information (metadata) about geospatial data, services and related resources. Providers of resources use catalogues to register metadata that conform to the provider's choice of an information model; such models include descriptions of spatial references and thematic information. Client applications can then search for geospatial data and services in very efficient ways.

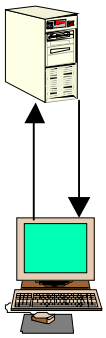
2.3.2 Main advantages of web services utilization in practice according to OGC

Main advantages of web services utilization according to OGC follows directly from its merit, i.e. on-line provided up-to-date data:

- The user does not have to have necessary map data on his computer, in the case of commercial approach it is possible to use other models, e.g. payment for data utilization using micropayments,
- Data maintenance at one place, preferably at the place of their origin, that means:
  - Each organization keeps only data it has in its management, other data may be accessed via web services, similarly as by everyone else,
  - It is not necessary to off-line transfer significant amounts of up-dated data to the final users,
  - data are always up-to-dated, the user does not have to take care of their updating,
- in the case of WMS, user can reach only the final picture consisting from data which can decrease the risk of abusment and unpermitted original data distribution,
- it is usually sufficient to use simple application for users access and data utilization (thin client, e.g. web viewer),
- the user uses only the services and data he really needs,
- with the assistance of catalogues the user quickly gets to the data he needs,
- the user is independent on any software platform, usually he does not recognize the operating software used by the server,
- WMS enables full interoperability – interconnection of applications of different producers. Each map servers may be based on technologies of different companies, but thanks to standardized interface they can communicate together.

Probably the only disadvantage may be the requirement of „on-line“connection to the map server, whose services are being used.

2.4 Web applications XML to calculations



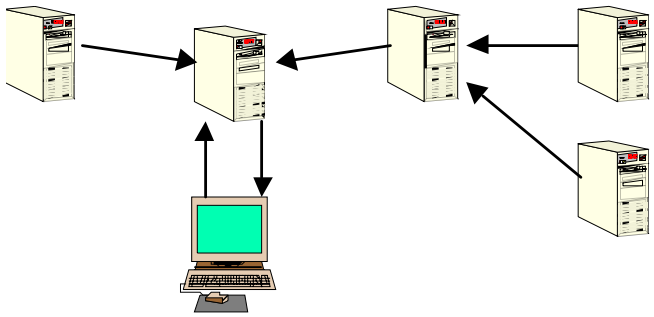
Picture 3: example of communication with web application

Previously mentioned trend of transition GIS applications from „desktop “to distributed Internet can be found even in the field of applications to calculations. Similarly, as in the field of GIS is the integrated element of Web Map Services open specification of the consortium OGC on the basis of XML, even here web applications to calculations are based on advantages and features of the format. Unfortunately, so far we cannot expect unification in formats for data processing. Although the unification would be one of the most important benefits.

Unlike web services with their interaction „machine – machine“, web applications represent the interaction „man – machine“. The principle of using web applications to calculations is that the user (client) has got on his computer some of his data (e.g. results of measurements or previous calculations); he transfers on-line the data to web application at the server; the application realizes stated calculations and gives the results back to the client. The interaction is schematically shown in picture 3. The result may be e.g. unknown coordinates by estimation of geodetic network with graphic representation of the selected output values (network configuration sketch, ellipses of errors, corrections of coordinates etc.) calculated by the application.

It is obvious that the server with the application may provide further services, e.g.WMS. Then it is possible to combine utilization of calculation application with these services. The result then may be e.g. displaying the output values into general topographic map base provided by the Web Map Service WMS.

However, it is not all, the application server may not only process applications and provide services as WMS, it is at the same time able to process the services, i.e. require them from other servers. In our case the result then is displaying the stated results not only in the topographic base from application server, but also in thematic map, content of which the user defines in advance using data from other servers providing these data in the form of service WMS. Providers of these data do not have to know anything about existence of the application. Interaction then works as it is schematically shown in picture 4.



Picture 4: example of communication with web application using other web services

And even more, the application is able to use other necessary data for own calculation from external databases, e.g. of state administration, international geodetic services or firm databases. The results are then automatically saved in similar databases together with protocols on computing procedure.

2.4.1 Main advantages of web applications utilization in practice

Main advantages of web applications utilization in practice follows again directly from the merit of providing the service transmitted by the application on-line. In particular, it is the following:

- on-line computing made by web application ensures compliance with the given methods of computing and processes of given applications that may result from required technological processes,
- in the case of necessity is possible to document executed computing steps with the inputs and outputs values,
- the user does not need to own software for less usual or more complicated computing,
- the user does not have to take care of updating the software because of technologies development or changes of computing (technological) processes and regulations,
- the user does not have to have detailed neither theoretical or programming skills for managing more difficult calculations, it is enough he is aware of principals of the solution, its material sense and restrictions for usage,
- in the case of commercial approach it is possible to require payment for services and applications, e.g. using micropayments,
- web applications XML may, similarly to web services WMS, enable full interoperability – interconnection of applications of different producers. Each application servers may be based on technologies of different companies, but thanks to standardized interface they can communicate together.

The disadvantage, similarly as in the case of web services, is the requirement of on-line connection during the time of using the application. Nevertheless, currently this is not a real problem.
Regarding the stated advantages we would like to stress the first two. The last of the list enables to build whole infrastructure from web applications and consequently, to solve even very difficult tasks based on the distribution.
In conclusion, we would like to remind that at suitable combination of web applications with web services, user enters the application only with his own input data (e.g. measured values or statistical data) and; user´s result can get not only values from the calculation (that may be very difficult), but in addition, appended with graphical output in the form of thematic map from geographic data defined by him; he does not have to own the data and the data are always up-to-dated.

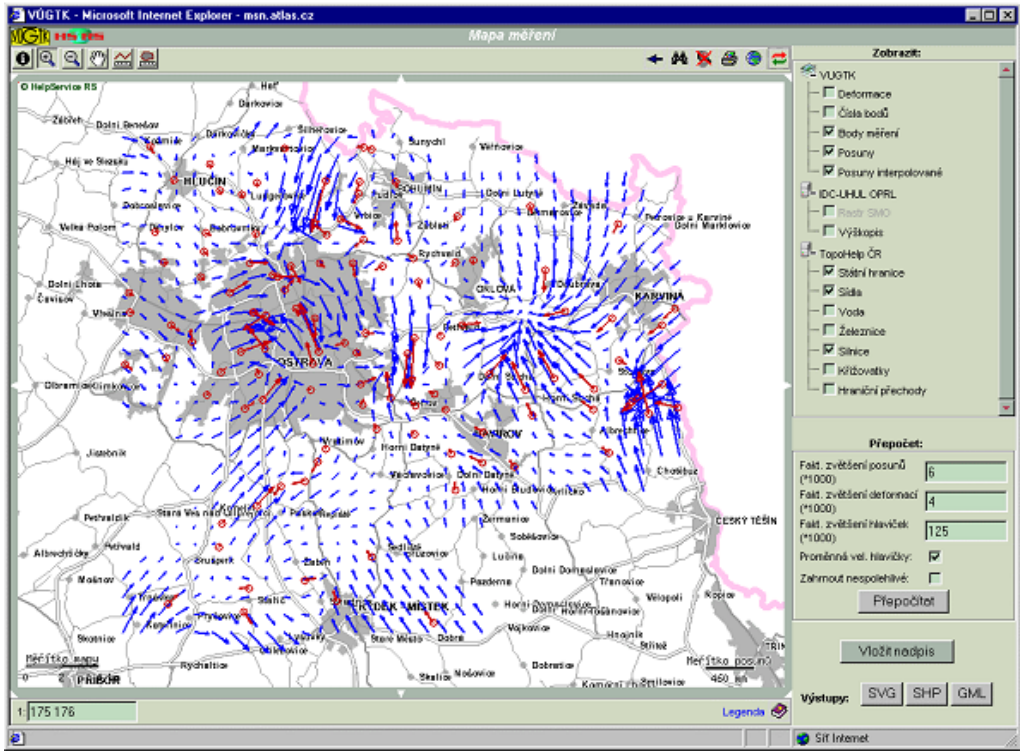
3. EXAMPLES OF WEB APPLICATIONS FOR SURVEYORS

3.1 Deformation analysis calculation

As the first example we can use application for on-line computing of deformation analysis based on the theory of mechanics of continuum from repeated measurements of geodetic network with graphic representation of the results in the topographic or thematic base (GIS) [4], [5]. Fully operating software application shows the possibilities of web applications XML for geodetic computing with simultaneous utilization of Web Map Services. As it is not usual task, probably there is no commercial software to solve it. That is why we can expect even its use in practice, together with improving exactness of geodetic techniques and technologies (especially GPS) and the need to monitor geodynamic changes in stated localities (nuclear power stations, deposits of nuclear waste, undermined territories, tectonic faults etc.). The application is accessible at URL: http://www.vugtk.cz/~deformace.

The main principle of application utilization is based on the fact that from the input values, i.e. movements (displacements, velocities) of given points of the geodetic network from repeated measurements (in pictures 5 and 7 they are represented with red darts), are derived output values in the form of movements in the quadratic network (in the pictures represented with blue darts), and above all, parameters of deformation (strain tensors) field in the quadratic network. As the parameters, main axes of strain tensors are used. In pictures 6, 8 and 9 they are represented with blue or green crosses, where the blue colour represents the main direction of compression, while the green extension.

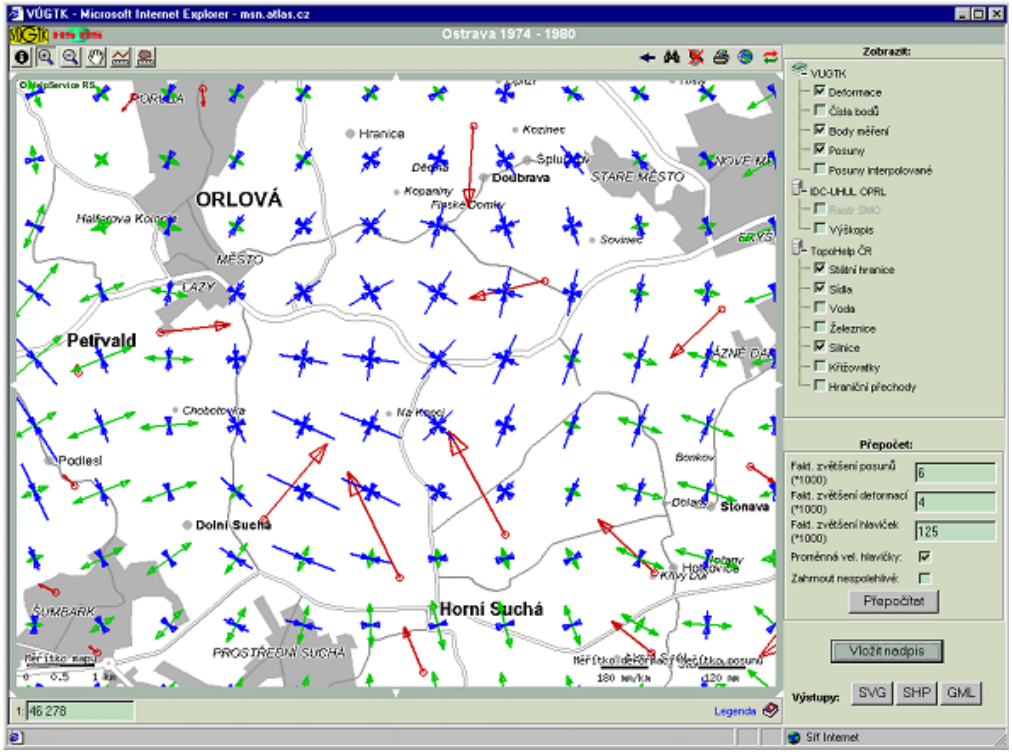
It is the parameters of deformation field that are independent on coordinate frames and enable matter-of-fact examination of geodynamic activities of the given territory. These output values are then graphically illustrated, using base maps obtained from the service WMS at Internet. In the same way it is possible to display results in 3D models, or to export output values in format KML for the purpose of displaying in SW Google Earth. Besides well arranged tables, the output values are in format GML (Geographic markup language) [6] and SVG (Scalable Vector Graphics) [7], i.e. in formats XML. Pictures 5 to 9 show only some of versions from many possible graphic representations.



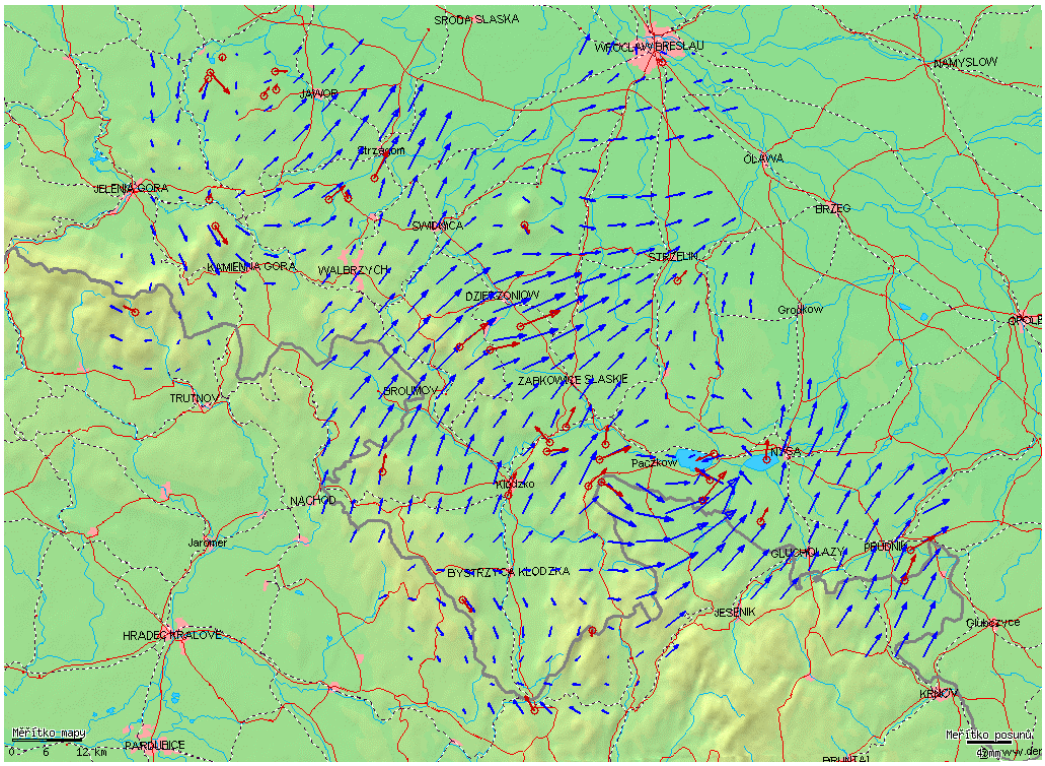
Picture 5: given and output movements for network Ostrava incl.the base map

Regarding software tools, besides the kernel of computing application that is written using more programming and script languages, the key is the utilization of freeware (Open Source license) Mapserver at University Minnesota [8] together with the library MapScript on server with operational system Linux and web server Apache. It can be also shown that even more difficult and complicated web applications may be build with the assistance of software with

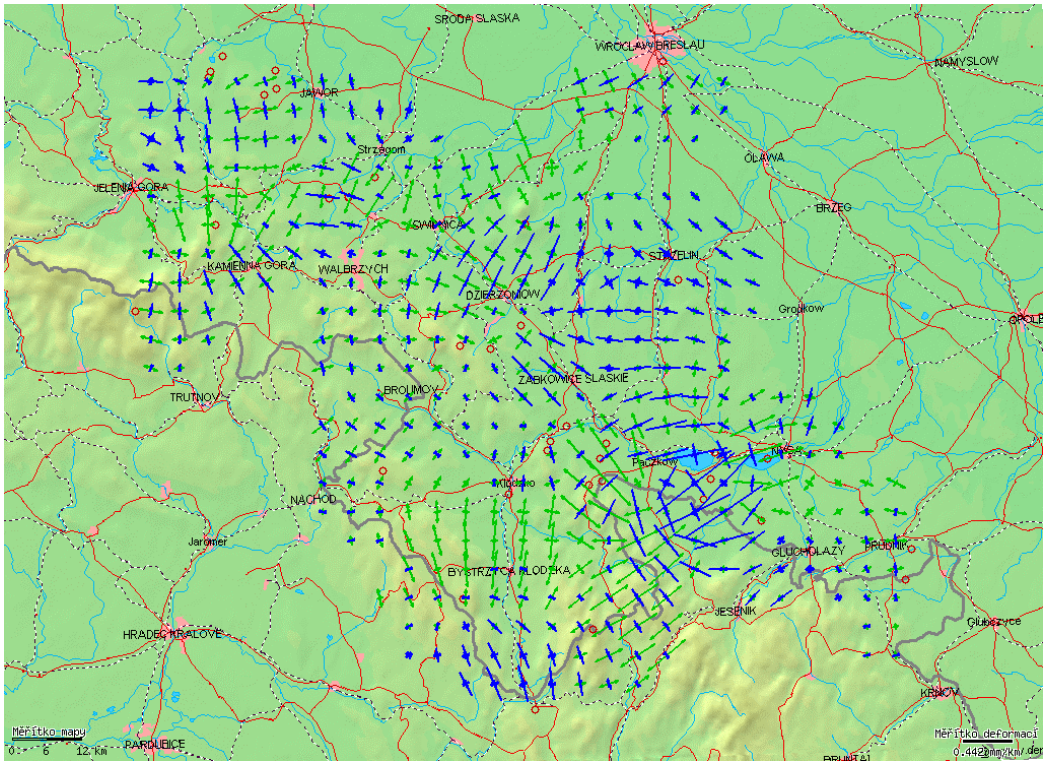
open source license, i.e. with minimal software costs. In this case, it is not necessary to consider number of licenses in order to use at the same time WMS services. Strict keeping of the standards represents the condition of successful and long-term solution.
Further details on the application may be found in [4] or [5].



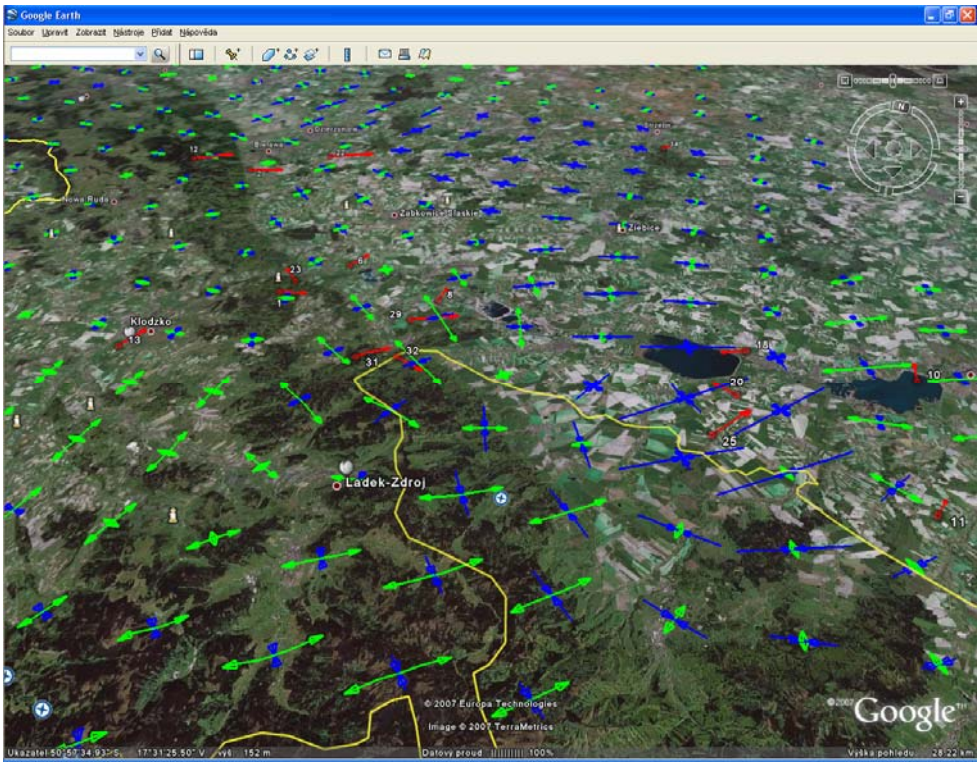
Picture 6: cutout with given movements and specified deformations for network Ostrava incl.the base map



Picture 7: given and specified movements in GPS network on Polish – Czech border



Picture 8: given points and specified deformations in GPS network on Polish – Czech border



Picture 9: given movements and specified deformations in GPS network on Polish – Czech border, 3D visualization in Google Earth

3.2 Processing of survey sketch

Processing of survey sketch by means of web application of the Research Institute of Geodesy, Topography and Cartography (VÚGTK) is one of the new technologies. The technology took the resources of the „Information System of the Cadastre of Real Estate in the Czech Republic"(ISKN) that for the purpose of up-to-dating process uses text exchangable data format not only for files of described information (SPI), but also for files of geodetic information (SGI) in one text format marked VFK.

Web application for processing of survey sketch and exchangeable format contains entirely new way of drawing the survey sketch, which is made directly in the environment of Internet. At the same time, it is possible to use data in format of DGN files, that were created in the environment of conventional and „desktop"application. Web application can be described as conventional software application on personal computer with its functionality transferred into network environment (Internet).

The technology uses standardized components as JavaScript, SVG on the side of the client, and communication in XML between the server and client. Application functionality on the server creates universal environment that may be implemented using web application.
An example of such technology is AJAX (Asynchronous JavaScript and XML), that are marked as Web 2.0 technologies and enables to create new web application for surveying work as well.

Interactive technologies, that are users more friendly, enable web applications using JavaScript on the side of the client. Under provision of asynchronic communication client-server on the basis of XML language, the necessity of re-reading and re-drawing of the whole web page at each operation, as it is on the model of static HTML pages, is removed. New application for processing of survey sketch on the Web is fully effective GIS application with its own difficult inner logic. The application with more details description is accessible at URL: http://www.geometrplan.cz/ but only in Czech language.

Picture 10: The introductory page of web application for processing of survey sketch

4. CONCLUSION

During last years, the effort to intensively use web as a tool for providing services and applications based on them, and not only as a medium for providing and searching data and information, has been definitely demonstrated. Therefore, the need of unifying tool for web applications that would enable their easier and faster integrity becomes more and more important. Currently is such a tool represented by web services with XML interface independent on platforms and firm formats. It means that information systems, services and applications based on the interface will have long operating life-cycle provided the standards are kept. At the same time, we can say that the development trends to utilization of distributed services and databases that use such XML interfaces for the access. As an example of such trend in the field of geodata, above mentioned web services in accordance with specifications of OGC consortium may be mentioned.
These services have been used for providing geodata more and more often.
The future is definitely in web applications that use the mentioned services based on the standards. In this connection we would like to bring reader´s attention in particular to specification of Web Processing Service (WPS), see [3].

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BIOGRAPHICAL NOTES

Milan Talich was graduated from the Czech Technical University in Prague, Faculty of Civil Engineering, Department of Geodesy and Cartography. Then he was engaged in the Research Office of Geodesy, Topography and Cartography (VÚGTK), working since 1987 in the International Centre on Recent Crustal Movement (ICRCM) at geodetic networks processing and geodynamic problems. In 1992 - 1993 he was at one-year stage in the Institute of Applied Geodesy in Frankfurt/Main (IfAG), where he compiled the Czech, Slovak and Hungarian parts of the European Reference System (EUREF) GPS network. Then he was engaged in solutions of GPS processing oriented to geodynamic applications and to questions related to deformation analysis of those data. Since 1995 he solved some problems of informatics in the Branch Information Centre (ODIS) of the VÚGTK. At present he works at information systems oriented to web information as a leader of ODIS. In 2002, Milan Talich presented his doctorial thesis "Information Systems to On-Line Providing of Geodetic Information and Their Creation".

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