# Some Problems Connected to Utilization of Internet Geographic Information Systems

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*Abstract:* - Geoenabling the Web and providing so called GIservices to the end users belong to the contemporary development trends in the field of geographic information systems (GIS). Today, four main kinds of Internet GIS users are usually distinguished. Their functional needs should be respected during the system analysis and design to provide satisfactory user-friendly environment. This is one of the reasons why so called user-centric design is more and more demanded and attention is paid to usability of provided Internet solutions. This article focuses on Internet GIS users and their needs so the state of art is described. Two case studies are briefly described to show the increasing importance of Internet GIS and their usability.

*Key-Words:* - Internet geographic information systems, Internet GIS, GeoWeb, GIServices

## 1 Introduction

A contemporary history of geographic information systems (GIS) themselves started in 1960s. They were used as a tool for environment protection in that time. Then, GIS have undergone a significant development and have become an important tool in many other branches as well. As a result of this development six main kinds of GIS are recognized today: professional, desktop, mobile, component, viewers, and Internet GIS. Internet geographic information systems represent a quite new branch of information and communication technologies – they have risen in the end of the 20th century and they undergo a rapid development. Their development has been driven by a wide spreading of Internet and increasing demand for easier access of regular and casual users to geographic information. Today, they have become an indispensable part of a variety of information systems used for supporting decision-making processes, e.g. in public administration, crisis management, military, farming, etc so an easy access of the users to provided information and services is required [1, 2].

Nowadays, many various technologies geoenabling the Web exist. They allow remote and easy access of end-users without special education in the field of geoinformation science to geographic information by means of variety devices, e.g. computers, notebooks, pocket PCs, mobile phones, etc. At the same time, one can find a lot of various terms which are used while talking about this kind of technology. Some examples are: GIS applications on Internet/intranet [2], GIS on-line, distributed geographic information [3, 4], Web-based GIS [5], Internet GIS, mobile GIS [1, 5] interactive mapping [6, 7], distributed GIservice [5], geo-enabled Web [8] GeoWeb, Internet map servers, and many others. These terms are sometimes understood as synonyms but it is not the best way of their understanding. For example, Internet does not provide only WWW service so Internet GIS has a different meaning from Web-based GIS. Mobile GIS is not the same as Internet GIS because mobile devices like PDA, and mobile phones use different protocols and technologies, and so on [5]. In the framework of this paper the term Internet GIS will be used although attention will be paid mostly to the Web-based solutions.

A significance of Internet and mobile GIS solutions continuously grows. It has become normal for many tourists, citizens, businessman to use their services, e.g. searching the shortest/fastest route, realty, sightseeing, camp, hotel, restaurant, and many others [1, 5]. Besides this mostly casual utilization, Internet and mobile GIS solutions have become a common software tool for regular utilization and an inherent part of institutional information systems. They are used by managers, traffic controllers, salesmen, civil servants, and many others. Intelligent transportation systems [9], facility management systems [10], geoenabled portals provided as a part of e-government services [11] can be randomly named as a very few examples.

A part of results of a research dedicated to the utilization of Internet GIS in the Czech public administration are described in the paper. In the next part of the paper there is a problem formulated. Chapter 3 deals with Internet GIS solution. Attention is paid especially to the system architecture, standardization, the users of Internet GIS, and functional requirements. In the

Chapter 4 there are given some examples of utilization of Internet GIS in a role of a tool for supporting decision-making process – a very brief description of two case studies. Conclusions are in the Chapter 5.

## 2 Problem formulation and methodology

Internet and mobile GIS have become an indispensable part of enterprises and governmental information systems so they are now regularly used as a working tool by many non-GIS specialists like local authority officials, government officials, managers, farmers, soldiers, etc. It means that all the services provided by Internet GIS solutions must be of an adequate quality, i.e. they must be of the same quality like services provided by the other information systems. For example, usability, reliability, security, trustworthy, interoperability, availability, fault tolerance, and adequately fast response are demanded.

Usability and data quality are very important requirements on Internet GIS. But there is one significant problem connected to the utilization of spatial data in general. Needed data are usually available from various sources – producers. It means that they are available in different formats, different quality, different scale, and different coordinate systems. But in the end they must be used all together in the framework of one information system, i.e. by means of one software tool. An example of two data sets from two various sources is given on Fig. 2. Further, collected data and provided services are usually used by various types of users and for various purposes, e.g. for strategic and tactical planning, operational decisions (executing), and controlling [9, 12]. It means that there must be very user-friendly GIServices available as well. This is one of the reasons why today so much attention is paid to software usability and user-centric design [13]. The following problem is connected to another significant contemporary requirement – a fast search for information on Internet. Agent technologies have been more and more used for this task. Unfortunately, Czech language uses many specific features (e.g. some characters are used with special signs and there are more Czech language codings available) which must be considered [14]. So there is a large set of problems connected to pre-processing of data, design of the entire Internet GIS solution including databases, data models, and user's interfaces, respectively, and their maintenance.


**Fig. 1 – Differences between two data sets coming from various sources (source: authors)**

The paper deals with state of art in the field of utilization of Internet GIS as a regular working tool used by various types of users. Selected topics are discussed in more detailed way. Then, two examples of utilization of Internet GIS as a kind of decision support system are provided.

## 3 Internet Geographic Information Systems

As it was mentioned above, geographic information and GIServices are a requisite for everyday work and life of many people. Thus, geographic information and GIServices have even become a necessary part of some decision support systems. The problem is that many potential users have any special education neither in geoinformation science nor in computer science. They need very user-friendly environment, mobile and flexible access on one hand and powerful functionality on the other hand. Internet GIS if properly designed can provide all the users what they need [1].

In any case, design of Internet GIS solution should respect needs of target users, functional requirements and assumed utilization of the solution.

The basic idea of system architecture and functionality is given on the Fig. 2. Because of the difference and importance both of data and user's queries they are uncommonly shown as two different inputs of the system.

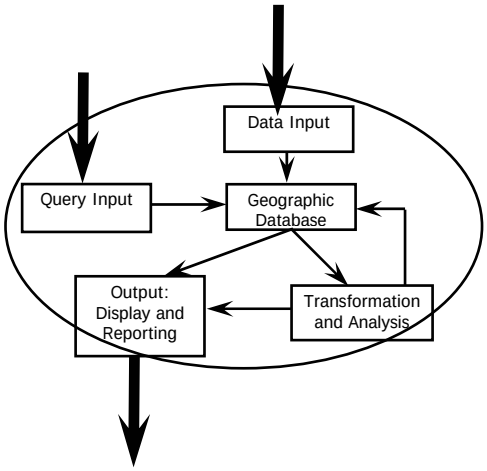


**Fig. 2 – Basic idea of Internet GIS solution architecture and functionality (source: authors, based on [1, 2])**

Many standards have been developed for Internet GIS solutions thanks to rapid wide spreading of Internet GIS, and necessity of data sharing. There are two significant standardization organizations on the field of Internet GIS. The Open Geospatial Consortium, Inc. (OGC) is the first one. It is a non-profit, international organization. Companies, government agencies and universities are its members. OGC develops OpenGIS® Specifications which "...support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT" [8]. These standards are highly respected by software producers including e.g. ESRI, and Intergraph.

The second important standardization activity is done by the ISO Technical Committee of Geographic Information/Geomatics ISO/TC 211 [5].

## 3.1 System Architecture of Internet GIS

Architecture of Internet GIS is usually based on n-tier client/server architecture. It means that at minimum next parts can be usually recognized [5, 12]:

- *Data layer* – data management system which is able to store and provide both spatial and non-spatial data.
- *Application logic* (business logic) – processing functionality (at least map server and Web server in this case).
- *Presentation layer* –interface provided to the users.

Internet GIS are supposed to quickly provide a large amount of data from various sources including terabytes of data from remote sensing. Thanks to an existence of interoperability standards which are accepted by wide community, Internet GIS were found as a suitable domain for application of ideas of parallel and distributed computing [5, 17].

In the framework of Internet GIS the attribute 'distributed' means that there is a distributed platform available for storing, processing and accessing geographic information on the Internet [5].

In according to [5] an Internet GIS solution must meet following characteristics to be qualified as a true distributed system:

- It must be composed of distributed components which work separately and which have different functions.
- The components are distributed. Each component can be installed on different computer but they must cooperate.
- The components are mobile so they can be moved from computer to another one.
- The components are open and interoperable. The components have to follow standards to be able to interoperate with any new component.
- Data are distributed. Data stored anywhere on the Internet can be accessed.
- Data are interchangeable. It means that it is possible to integrate data from various different sources.

Web Services technology is used to ensure interoperability of proprietary Internet GIS solutions. But, along with implementing principles of Web services by Internet GIS, a quality of services should be considered too [18].

Distributed architecture of Internet GIS can easily allow utilization of various regional data repositories and warehouses. As it was found warehouses are suitable even for smaller municipalities and they can provide a fuzzy approach in enquiries [19].

## 3.2 Target User's Groups

Wide spreading of Internet GIS is one of the reasons why some ways of classifications of Internet GIS users are needed. These classifications vary from author to author and they are dependent on the purpose of classification too. Anyway, following basic types of users are usually distinguished [1, 5, 15]:

- *High-end users*, e.g. data treatment specialists (GIS specialists), who can run spatial analyses as well and provide the results of their work to the other users.
- *Regular users*, e.g. civil servants, managers, controllers, regular customers, cooperating partners, etc. Regular, everyday use of Internet GIS is typical for this group of users. They

usually need only several functions too. All needed functions are known in advance and are used repeatedly. It can be supposed that they access Internet GIS by means of appointed Web browser or other defined client. It means their working environment is known in advance as well and can be influenced in the case of necessity.

- *Casual users*, e.g. tourists, residents, businessmen, etc. They use Internet GIS solution irregularly and casually. They are usually not educated in computer science and their skills how to use computer, may be very low. On the other side, only a few functions are interesting for these users. They usually need to select region of interest, select appropriate data layers, view geographic information, change scale, run very simple queries, and print outputs or save result maps. It is supposed that they can use various Web browsers, they may not be able to install any software, and their Internet connection can be slow.
- *Mobile users*, i.e. people who usually use wireless technologies and mobile devices like PDA or mobile phones to connect to a server and access geographic information and/or GIS functionality provided by the server. The users can vary from casual low-end users to high-end users. Utilities management (e.g. water, electrical utilities) can be given as an example of a branch where mobile GIS solutions are very often used as a regular tool by non GIS specialists.

### 3.3 Functional requirements

Functional requirements on Internet GIS are of course based on the aim of the whole process where Internet GIS are used as an information system. Both geographic data and results of their analyses can be used in many different functions in the framework of decision-making process. Functional requirements are shown on a real example of transportation data here. Data can be divided into following types in according to the way of their usage [9]:

- *Planning data*, i.e. data which are used for long-term planning, e.g. estimation of environmental impacts, and planning of infrastructure.
- *Engineering data*, i.e. data which are used for shorter-term planning, e.g. signal timing planning, and freeway management.
- *Operational data*, i.e. real-time data from on-line sensors which are used by traffic operators and other people for operational decisions.

In more general view planning, executing (operating), and controlling phases can be distinguished during each business process. During each of these phases different data and analyses (functions) are needed [12, 16].

## 4 Case studies – Utilization of Internet GIS as a Decision Support Tool

Internet based GIS solutions have become widely used to support decision-making processes in many branches. Following two case studies are very briefly described just to show an importance of easy access to geographic information by non-GIS specialists. Both studies are a part of on-going research.

The first case study which is a part of ESPON project is dedicated to analyzing an influence of cultural heritage on regions and their development. In this case Internet GIS systems are used to provide available data and analyses results to both local authority officials and government officials to help them with policy-making in wide area and local government as well. Following Fig. 3 shows comparison of all regions of the Czech Republic. Number of overnight guests and percentage share of cultural heritage are compared. Comparison between Gross Domestic Product (GDP) and overnight guests is given on the Fig. 4.

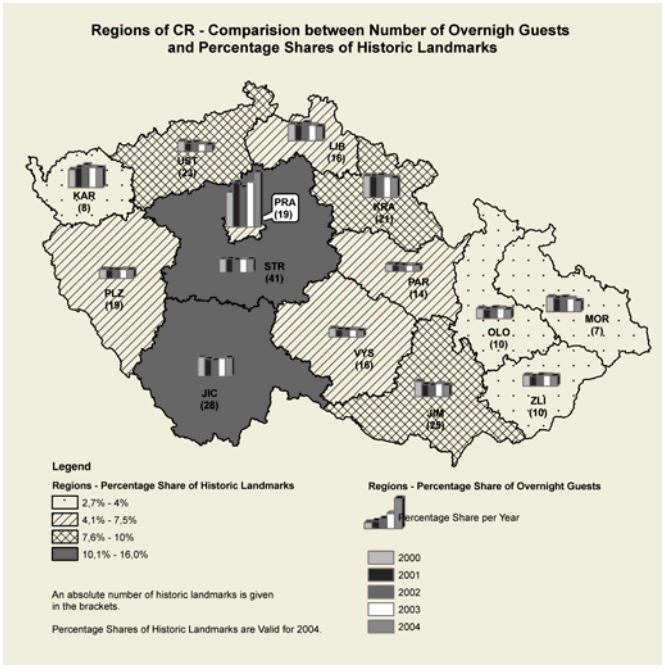


**Fig. 3 – Comparison between number of overnight guests and percentage share of cultural heritage (source: authors)**

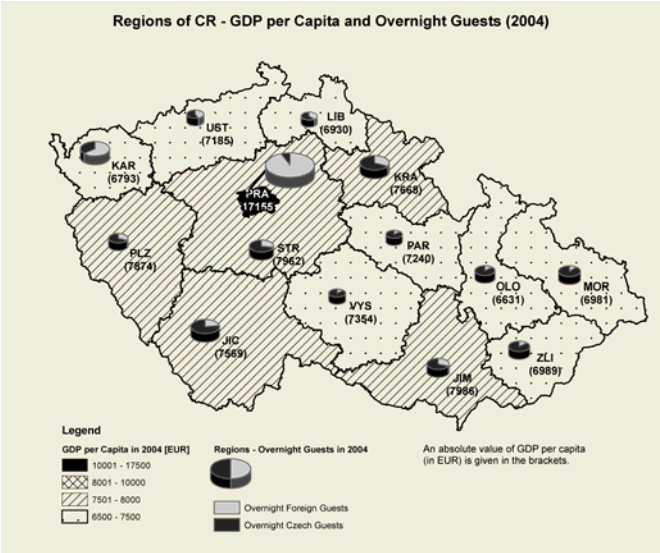


**Fig. 4 – Comparison between GDP and number of overnight guests (source: authors)**

The second case study documents a possible way of use of Internet GIS by local authority to improve transport services in Pardubice region. The target aim of the research and project is to optimize transport services in the whole region. In this project, transport specialist and local authority officials play main role. They need a lot of information about transportation flows in the region to be able to optimize transportation lines in the region. There is an example of transportation flows in Pardubice region given on the following Fig. 5 used by local authority officials for planning the lines for the next year.

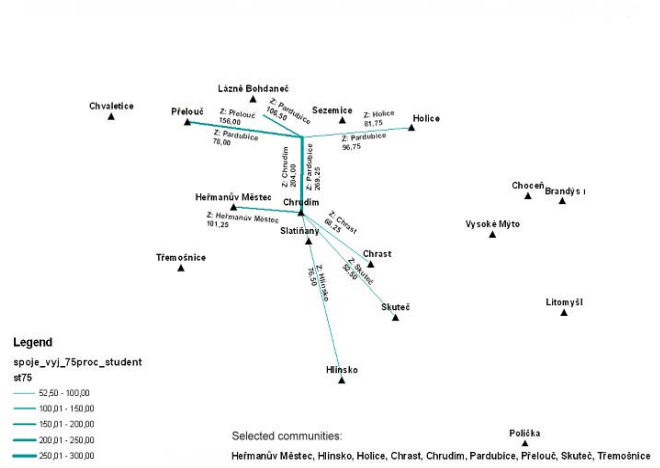


**Fig. 5 – Number of commuting students – a base for planning number of lines in region (source: authors)**

# 5 Conclusion

Expansion of Internet GIS solutions is driven by the increasing demand for geographic data and GIS services by the end-users because geographic information let them improve and speed up their work. End-users can use Internet GIS regularly or casually but in both cases they need only some functions and they do need a very user-friendly environment to be able to explore geographic information. Two cases studies document an importance of easy and fast access of end-users to geographic information.

Different kinds of users of Internet GIS solutions and their needs must be taken into account during system analysis and design. It highly corresponds with today's trend of user-centric system design.

Although Internet GIS can be very helpful, it is necessary to deal with the quality of used data. Data from various sources can quite differ, e.g. in their accuracy, as it was shown on Fig. 1.

Regardless of all above mentioned problems, Inetrnet GIS can be used as a decision support tool in everyday work of non-GIS specialist it he system is well designed so it provides user-friendly environment.

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