Developing of A GIS Based Enviromental Monitoring System with Open Source Softwares

László KOTTYÁN, assistant professor, University of West Hungary, Faculty of Geoinformatics, Department of GIS, Székesfehérvár, Hungary
Gábor NAGY, assistant lecturer, University of West Hungary, Faculty of Geoinformatics, Department of GIS, Székesfehérvár, Hungary
András SZEPES, Dr. associate professor, University of West Hungary, Faculty of Geoinformatics, Department of GIS, Székesfehérvár, Hungary

Abstract: *The monitoring systems are widely usable, for example production systems, education systems and environmental systems. The environmental protection systems have significant function, in particular in industrial environment, where the chance of the pollution is remarkable.*

Keywords: *monitoring systems, GIS, open source softwares.*

1. Introduction

What kind of data need for this systems? The experts of environment protection could respond to this question: type, precision and period of their measures.

What is the optimal database structure for storing the environmental monitoring data? This is an information-technology related question, and one of the tasks of the writers.

What is the optimal user interface of an environmental monitoring system? This is another interesting question. The web-based systems do not require any GI software in the workstations and are nice for the centralized data store and process.

Many good commercial GI solutions are available for this challenge, but the cost of the software licensing may run up. With this object, we use open source software in each part of the system, from the database to the user interface. Our experiences are right, the quality of open source GI solutions is similar to the commercial programs.

2. Previous plan

After the first quests, we made a previous plan. This plan was not the final plan, because we did not know totally the parameters of the work. (For example: density of the measuring points, area of the inspected ground, types of the measurements) The steps of the previous plan:

Primary, we determined the entities of the database. What are the things, which will be the matter of the database.

In the next step, we analysed the attributes of the entities and determined the relationships between the entities.

In our conception, at an early stage we modelled a small area, which is usable for the compliance and discussion.

3. Map data

Many types of spatial data are usable in a environmental monitoring system. We probed and used the following maps:

- Cadastral maps: In Hungary the cadastral maps are available as digital maps for each settlement. The central area and the periphery are in different files. We used only the periphery data;
- Soil maps: a vector map for soil data of Hungary. They contain the soil type and other parameters of the soil;
- Digital elevation models: We studied the using of digital elevation models, but finally didn't use DEM.
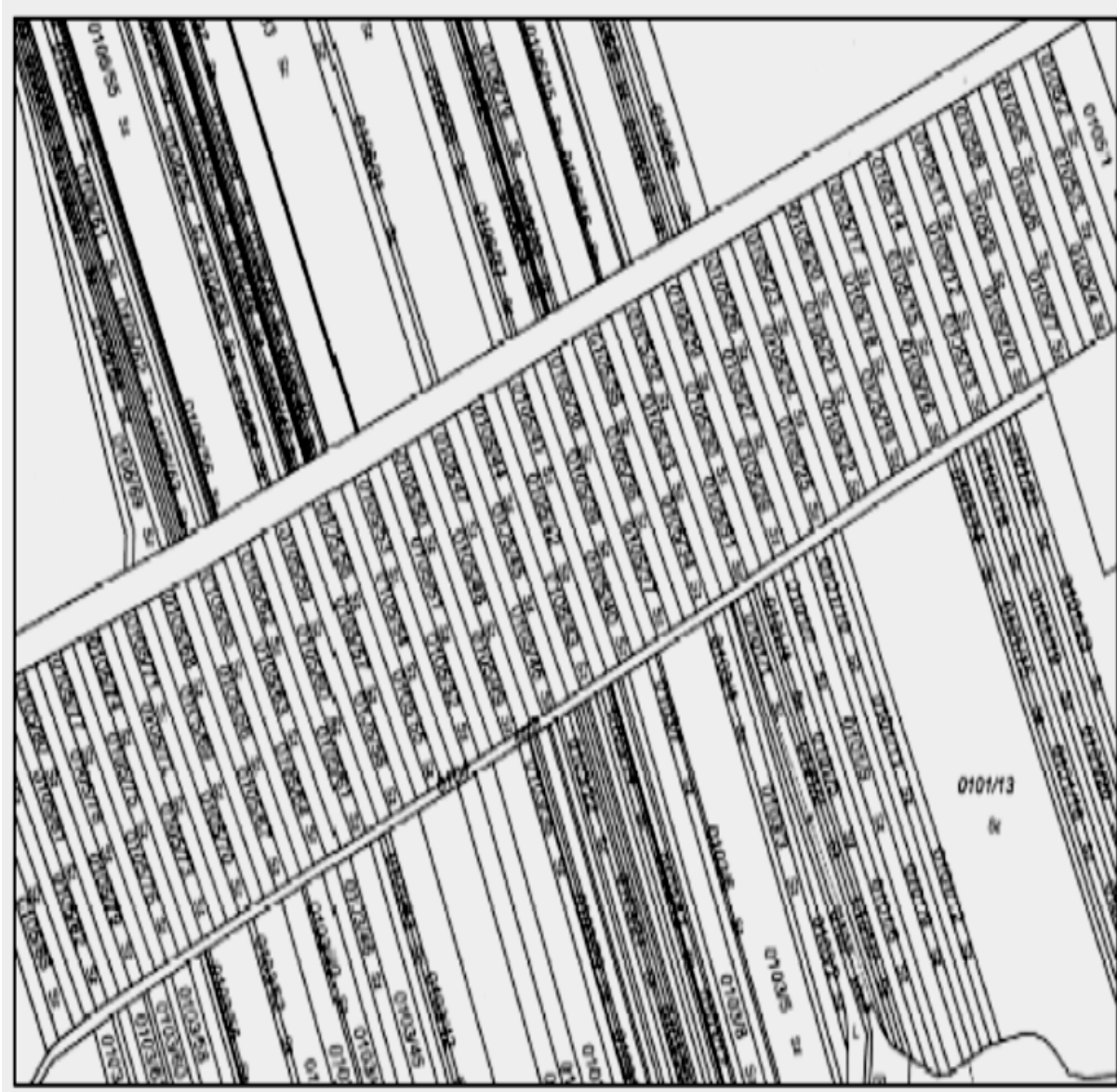

Fig. 1 A sample of cadastral map

The environmental expert groups could give the measurements in spreadsheet files, which contain the data in first normal form (1NF). We could process this data and determine the logical connections. Every spreadsheet contains one or more columns for the spatial identification of the place of measurements, which may be longitude and latitude (from GPS measuring), geodesy coordinates, parcel ID or name of the settlement.

4. Plan of the database, multidimensional data model

For the data handling (query, modify, delete etc.), we used Database Management Systems (DBMS). If this system allows to show the changes in the time of the data, the system is called monitoring system.

The data processing is based on the multidimensional data model, which is used in OLAP (Online Analytical Processing) technology. This technology allows the spatial and temporal analysis of the data. The temporal analysis is very important in the monitoring functions. The results may be visualised in maps, diagrams or charts.

The fact table contains the data of measuring in a multidimensional monitoring database. The data have three dimensions: type of measuring, time and location.

The OLAP technology provided the following simple operations:
- create cube: create an multidimensional array
- slice: a subset of the multidimensional array without one or more dimensions
- dice: a subset of the multidimensional array with more than two dimensions
- drill: navigates among levels of data ranging (drill up: to the most summarized, drill down: to the most detailed)

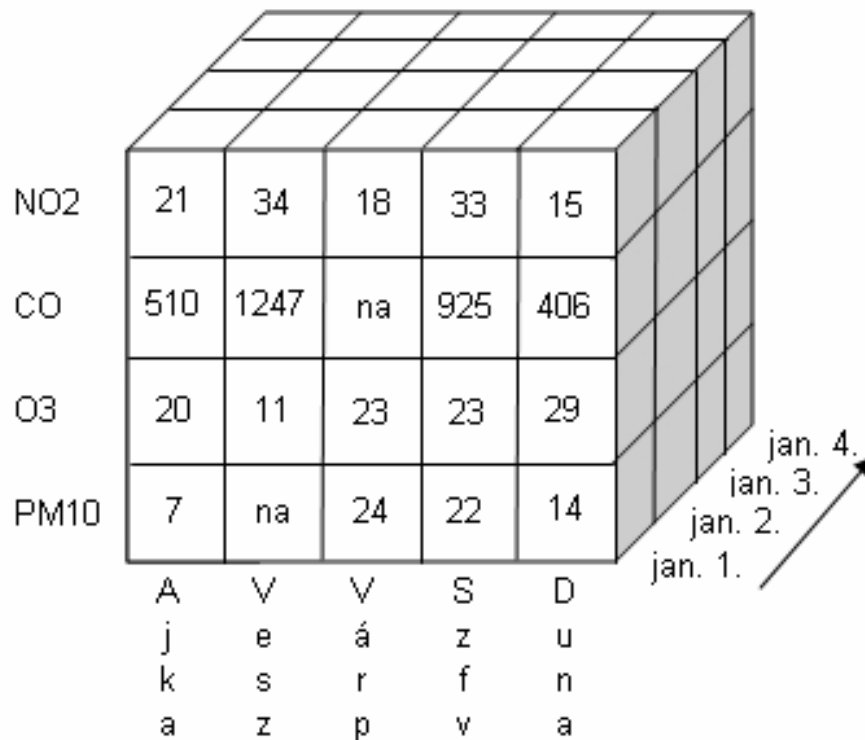The complex operations are constructed from several simple operations.

Fig. 2 An OLAP cube

5. Used standards

The using of standards used widely is very expedient, when we want to build an information system, because the collaboration with other systems will be simple.

We use the following standards:
- SQL (Structured Query Language): The famous query language of relational databases. Every relational database server can use it.

- Simple Feature Specification for SQL (OGC 99-049, OGC 05-134): An OGC (Open Geospatial Consortium) standard for adding GIS function to SQL. It contains for example the binary (WKB) or text (WKT) description of the geometry element and spatial operations and functions.
- GML (Geographic Markup Language, OGC 02-023r4): XML based language for description the spatial data.
- WMS (Web Map Services, OGC 06-042): Transfer raster GI data over http protocol, which uses various raster formats for the description of the data.
- WFS (Web Feature Services, OGC 06-042): Transfer vector GI data over http protocol, which uses GML (Geographic Markup Language, OGC 02-023r4) to description the data.

6. Software

We would like to make a web based GIS application, because we:
- needn't install and upgrade any special client software to the client computers (need only a web browser in the clients)
- could storage and process the data on a central computer (server)
- This technology has some weaknesses:
- needs internet connection for the work
- a web based application is not so interactive as a native application

The solution to the second problem is the AJAX (Asynchronous JavaScript and XML) technology. The AJAX technology uses JavaScript programs to provide a more interactive web-based user interface.
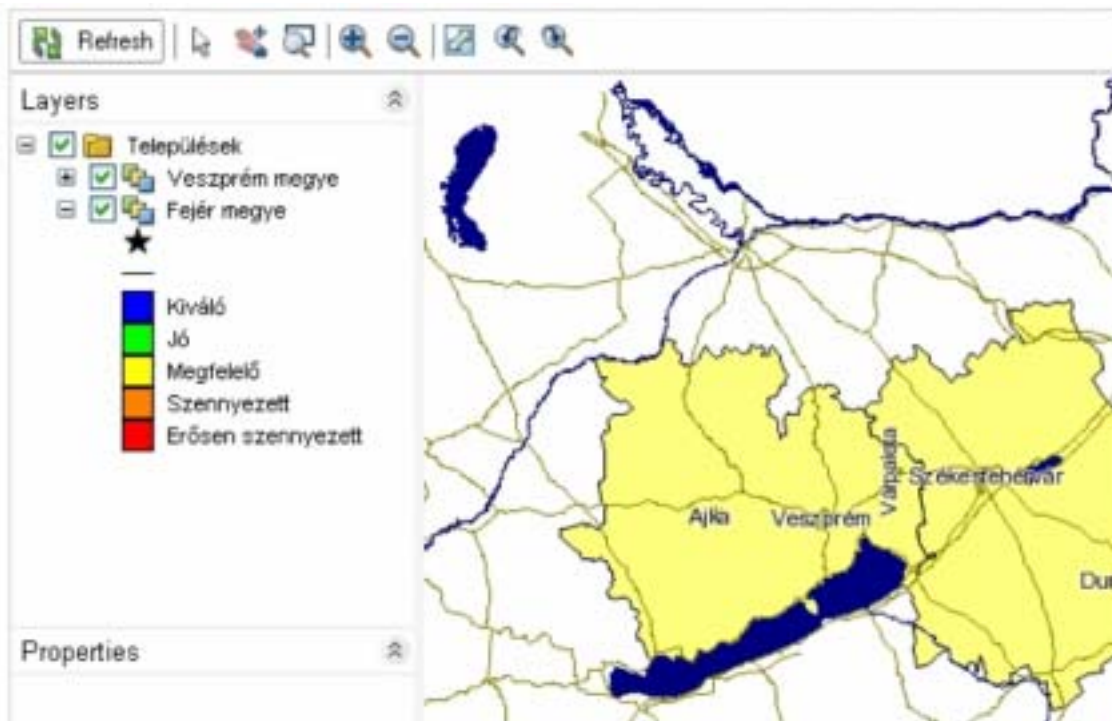

Fig. 3 The MapGuide based user interface

We studied the availability of many open source GIS softwares for data storage (PostgreSQL, PostGIS, MySQL), data conversion (OGR, GDAL), desktop client (uDig, QGIS) and web mapping (UMN Mapserver, GeoServer, MapBuilder).

We decided that we would use the MapGuide Open Source, because it is a complete software package for a web based GIS application and has simple administration interface.

The MapGuide Open Source (MGOP) is a client-server based, open source GIS software, which has been made by Autodesk, the creator of the AutoCAD. The MGOP has many components:

- MapGuide Server: attends the requests of clients. Use seven services (site service, resource service, drawing service, feature service, mapping service, rendering service, tile service).
- MapGuide Web Server Extension: provides the programming interface to the development in various web server environment (Apache, IIS) and programming languages (PHP, ASP.NET, Java/JSP).
- MapGuide Viewer: DWF or AJAX based client with customizable user interface.
- MapGuide Web Studio: web based editor tool for the data sources, maps and layers.
- MapGuide Site Administrator: web based tool for the server administration.

7. Possibilities of improvement

An improvement may be the using of the automatic systems for the measuring and sending the results of measurements to the server.

The location of the measuring points may be surveyed by GPS technology, because the precision of the point location became uniformly good.

8. References

1. *Cox, S. et al.(2005), OpenGIS® Geography Markup Language (GML) Encoding Specification, OGC 02-023r4, Open Geospatial Consortium, http://www.opengeospatial.org/standards/gml , (2007.05.11)*
2. *GeoServer Home, http://docs.codehaus.org/display/GEOS/Home, (2007.05.08)*
3. *Halassy B. (1994), Az adatbázis-tervezés alapjai és titkai, IDG Magyarország*
4. *Halassy B. (2002), Adatmodellezés, Universitas - Nemzeti Tankönyvkiadó*
5. *Herring, J. R.(2006), OpenGIS® Implementation Specification for Geographic information - Simple feature access - Part 2: SQL option, OGC 06-104r3, Open Geospatial Consortium, http://www.opengeospatial.org/standards/sfs , (2007.05.11.)*
6. *Kanellopoulos, I. (2005), Nature-GIS Guidelines, GISIG, Italy*
7. *Kottyán L. (2004), Space – Time Dimensions of Decision Support, poszter, GeoCAD '04 International Scientific Symposium, Gyulafehérvár, Románia*
8. *Kottyán L. (2005), Decision support in land consolidation, Cadastral development – the contribution of scientific enquiry, Aalborg, Dánia*
9. *Kottyán L. (2005), A birtokrendezés UML modellezése (használati esetek), Kutatási beszámoló előadás, NyME GEO, Székesfehérvár*
10. *Kottyán L.-Nagy G.-Szepes A.: Kutatási jelentés I., Székesfehérvár, 2005.*
11. *Kottyán L.-Nagy G.-Szepes A.: Kutatási jelentés II, Székesfehérvár, 2006.*
12. *Kottyán L.-Nagy G.-Szepes A.: Kutatási zárójelentés, Székesfehérvár, 2007.*
13. *Lalonde, W.(2002), Styled Layer Descriptor Implementation Specification, OGC 02-070, Open Geospatial Consortium, http://www.opengeospatial.org/standards/sld , (2007.05.11)*
14. *Mapbuilder Home, http://communitymapbuilder.org/, (2007.05.08.)*
15. *MapGuide Open Source, http://mapguide.osgeo.org, (2007.04.13.)*
16. *MySQL, http://www.mysql.com/ , (2007.05.08.)*
17. *OLM, Országos Légszennyezettségi Mérőhálózat, http://www.kvvm.hu/olm, (2007.06.08.)*

18. *Pájer J. (1994), A környezeti hatásvizsgálat. I rész. Általános módszertani ismeretek (oktatási segédlet). EFE Erdőmérnöki Kar, Sopron*
19. *PostGIS, http://postgis.refractions.net/, (2007.05.08.)*
20. *PostgreSQL, http://www.postgresql.org/ , (2007.05.08.)*
21. *Vretanos, A. P.(2005), Web Feature Service Implementation Specification, OGC® 04-094, Open Geospatial Consortium, http://www.opengeospatial.org/standards/wfs , (2007.05.11.)*
22. *W3 Schools, AJAX Tutorial, http://www.w3schools.com/ajax/default.asp, (2007.03.19.)*