DISPOWER

Distributed Generation with high penetration of renewable energy sources

CONTRACT N°: ENK5-CT-2001-00522

Survey of the different Geographical Information Systems (GIS), standardised data structures and Databases.

A report prepared for Task 4.1b

Thierry Ranchin

Centre d'Energétique
ARMINES / Ecole des Mines de Paris
BP 207, 06904 Sophia Antipolis cedex (France)
Tel.: +33 4 93 95 74 53
Fax.: +33 4 93 95 75 35
thierry.ranchin@ensmp.fr

François-Pascal Neirac

Centre d'Energétique
ARMINES / Ecole des Mines de Paris
BP 207, 06904 Sophia Antipolis cedex (France)
Tel.: +33 4 93 95 74 08
Fax.: +33 4 93 95 75 35
francois.neirac@ensmp.fr

Michel Vandenbergh

Institut für Solare Energieversorgungstechnik (ISET) e. V.
Königstor 59
D-34119 Kassel (Germany)
Tel.: +49-561-7294-103
Fax.: +49-561-7294-100
mvandenbergh@iset.uni-kassel.de

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1. Introduction

It is the aim of the European Union to double the share in electricity production from renewable energy sources (**RES**) up to the year 2010. This involves the installation and operation of a high number of renewable energy plants for electricity production coming up to 22% (from 14% now). The installation of large capacities of renewable energy sources involves several financial and technical risks related to the intermittent nature of the resources and the geographical variation of the potential. Apart from the purely electric and electro-technical problems, there is a need for handling the geographical dimension of Distributed Generation.

This first report aims at fixing a set of information and vocabulary related to the GIS world. Even it seems general compared to the topics of DISPOWER, it is a need to establish the basis of our reflection on the potential of GIS tools for distributed generation through the basis of GIS tools.

After a short definition of GIS, enhancing the duality of the GIS, a short summary of the most used GIS tools is given. Hence a section describes the data structures used in GIS. A description of the different sort of Database Management Systems (DBMS) is then proposed. The topic of interoperability between GIS and through the Internet is evoked.

2. Geographical Information Systems

Definition

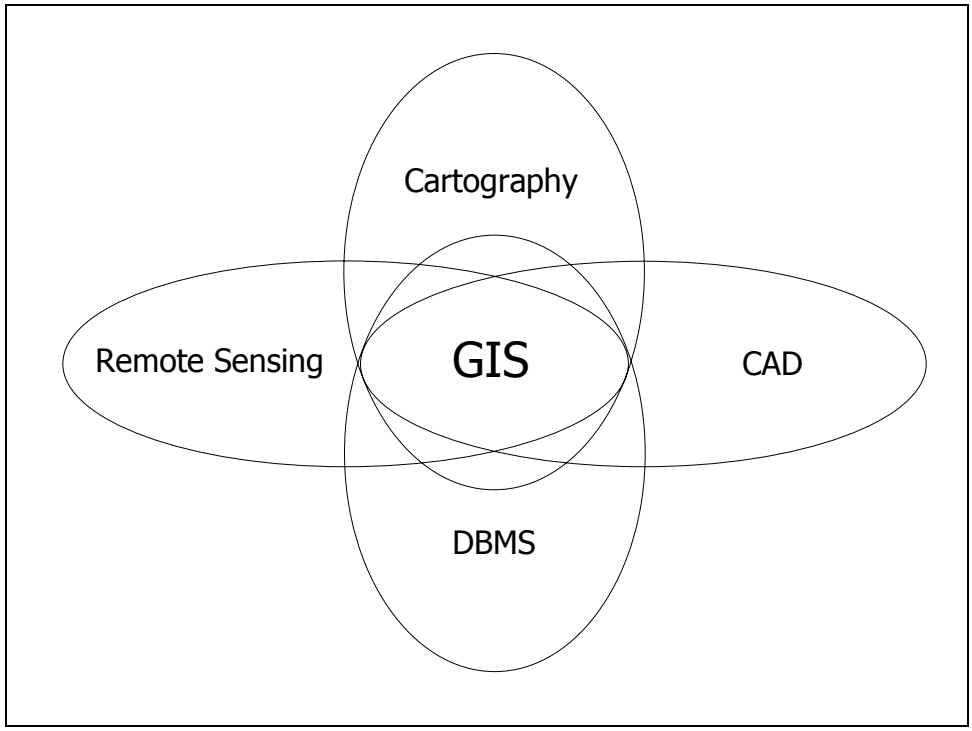

Figure 1. Different domains of a GIS

A Geographical Information System (GIS) is an organised set of hardware, software, geographical data and of people. It allows capturing, storing, updating, analysing and displaying all types of referenced geographical information. A GIS can be exploited at two levels: a management level and a decision-maker level. Within the Distributed Generation, the merging of technical, socio-economic and environmental aspects and the analysis of impacts can be addressed within the network through the use of GIS. Figure 1 presents the different fields included in a GIS. A GIS is at the crossroad of Remote Sensing, Data Based Management System (DBMS) Computer Aided Design system (CAD) and Cartography.

A GIS is an information system designed for spatial analysis. This means that it can be used for analysis combining different parameters, including the geographical constraints. As an example, renewable energies sources (wind, sun, water and biomass) are not geographically independent. A day-to-day management of the production of electricity by the different RES needs an accurate knowledge of their spatial repartition.
GIS will not replace Energy Management Systems (EMS) or Distribution Management Systems DMS). But in the framework of Distributed Generation, they can complement in a useful way the present approach use in the management of electricity networks. This point will be explored in the following report.

Review of the main GIS tools.

There is a large range of existing GIS. They constitute the core of management system or of Decision Support System (DSS). Most often, they are customized for a specific approach. The main GIS tools are presented in table 1.

The set of GIS tools is much more important than those proposed in Table 1. But this table proposed the more professional and most used GIS. The last three (STAR GIS, Geoconcept and APIC 4) are more "European" than the others, in the sense they are programmed and sell by European companies.

The most used GIS tools in the world are presently those proposed by ESRI. They represent around 30 % of the world market of GIS. Of course this position is due to the anteriority of this company. ESRI was the historical designer of GIS.

The different GIS tools can be classified in three general kinds of tools. Table 2 proposed this classification.

Products	Editors
Arcview, ArcInfo, ArcGIS	**ESRI** 380 New York Street, Redlands, CA 92373-8100,USA Web: http://www.esri.com/ see local ESRI Distributors
MapInfo	**MapInfo Corporation** One Global View, Troy, New York 12180, USA Web: http://www.mapinfo.com/ see local Mapinfo distributors
AutoDesk Map AutoCAD 2002	**EMEA Headquarters** (Europe, Middle East and Africa) Autodesk S.A., 20 Route de Pre-Bois, Case Postale 1894, Geneva 15, CH-1215, Switzerland Phone: +41-22-929-75-00 Fax: +41-22-929-75-01 Web: http://www.autodesk.com
MicroStation Geographics MicroStation GeoOutlook	**Bentley Systems Europe B.V.** Europe, Middle East, Africa Headquarters Wegalaan 2, 2132 JC Hoofddorp, The Netherlands (+31) 23 5560560 Web: http://www2.bentley.com/
Geomedia	**Intergraph Corporation** One Madison Industrial Park, Huntsville, AL 35894-0001, USA Web: http://www.intergraph.com/ See local Intergraph distributors
STAR GIS	**STAR INFORMATIC s.a.** Avenue du Pré Aily, 24, 4031 Angleur, (Liège - Belgique) Web: http://www.star.be/
GeoConcept	**GeoConcept SA** 25/27, rue de Tolbiac, 75647 PARIS Cedex 13, France. +33 (0)1 53 94 57 00 +33 (0)1 53 94 57 99 Web: http://www.geoconcept.com/
APIC 4	**Apic-Arcueil** (siège) 113, avenue Aristide Briand, 94117 Arcueil Cedex, France +33 (0) 1 49 08 83 00 +33 (0) 1 49 69 92 93 Web: http://www.apic.fr/

Table1. Main GIS products and editors.

	GIS data viewers	Desktop GIS	Complete GIS
Computer hardware required	Desktop personal computer, some can be run from a single compact disk without installing new software on the computer itself	Desktop personal computer, colour printer	Workstation (more powerful than a typical personal computer) and frequently a separate database server, digitising hardware, high-end printer or plotter
Primary users	Non-GIS staff, the general public	Full- or part-time GIS specialists, often in smaller organizations, and non specialists (for applications customized from standard software)	Full-time GIS specialists
Major uses	Querying and displaying a specified data set provided by a public agency or other organization, sometimes even by a software company; usually cannot be further customized by users, or accept additional data	Database management, queries, and display, often at a project level	Full-fledged data & and application development, statistical analysis, and high-quality map production, often enterprise-wide or over a network

Table 2. Classification of GIS tools

In the context of Distributed Generation of main interest will be the complete GIS solutions. All the companies referred in table 1 are selling such a kind of software suite. But the GIS Data viewers can be interesting for the consultation of the products defined in a complete GIS.

3. Data structures in GIS

Raster versus vector format.

The data in GIS are stored in different formats. The geographical information is usually stored in raster and/or vector formats.

Raster format is also known as image format. Even if the data stored is not an image or a remotely sensed image, a set of information should be stored in such a format. As an example, digital elevation models (DEM) representing the elevation of any point in a geographical area can be stored in a raster format. A result of a classification process applied to a satellite image of an area can be stored as raster data. Of course additional information on an area (such as photographs) can also be stored in such a format.

Vector format is the most used format for storing geographical information. Three types of vector data are used in GIS: points, lines and polygons. They are usually stored in a so-called layer. Layers are containing only one type of data. They allow to store efficiently, complex information and to apply complex spatial processing in this data. Figure 1 proposes a representation of the real world through a vector modelling such as the one use in a GIS.

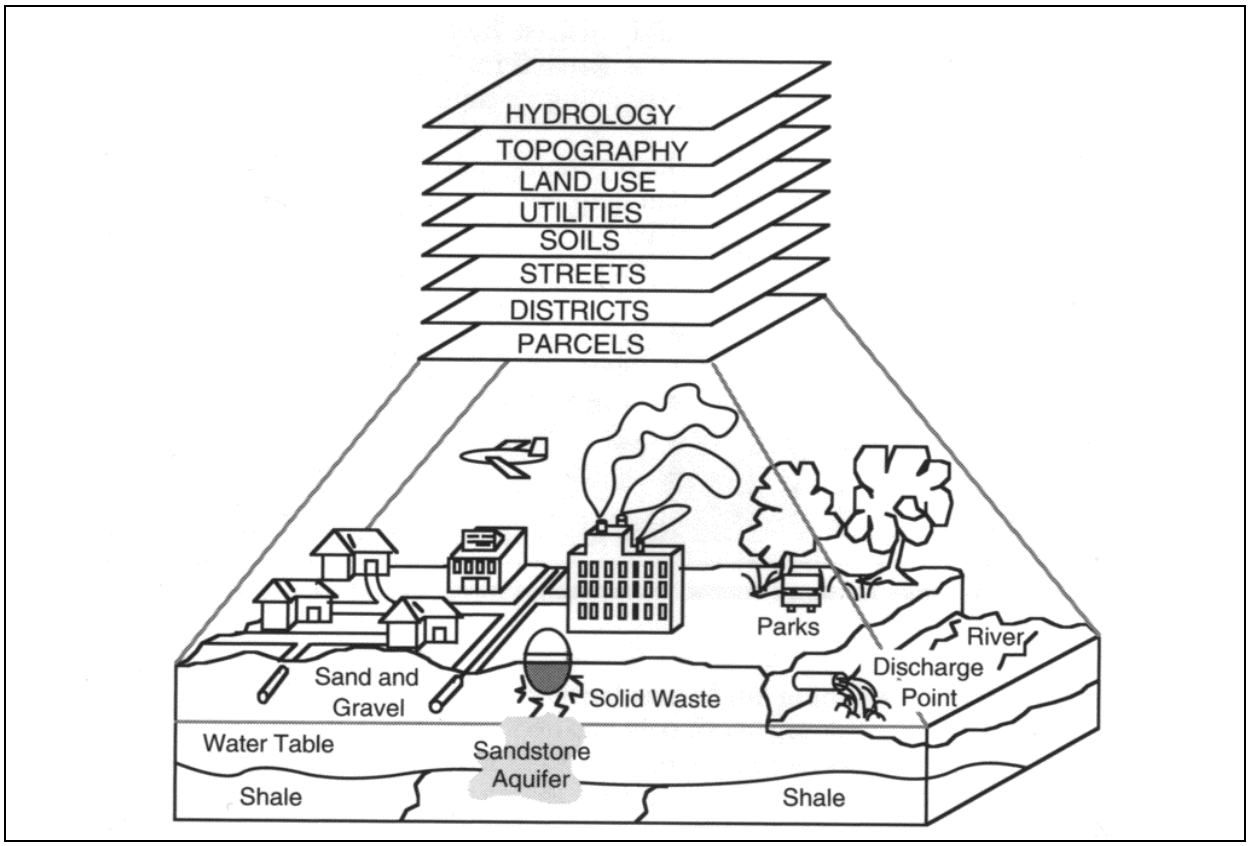

Figure 1. Representation of the real world through a vector modelling

In the context of Distributed Generation, the representation of the geographical component of the network and of the different means of production can be achieved through a vector representation. As a full GIS contains tools for modelling, a link with the complex model describing the behaviour of the network and of the different elements can be added.

Attribute tables

The data linked to the vector or raster representation of the elements constituting the world are usually stored in attribute tables. These tables contain data relate to the geographical elements represented in the vector layers. As an example, the description of the physical and technical characteristics of an electric line (voltage, load, connections,...) will be stored in such a kind of tables. Then, it will be possible through the exploitation of these links between attributes and representations to obtain an analysis that cannot be reached easily without such a combination of sets of information. Table 3 presents an example of an attribute table for tubes. Each row represents a geographic feature. Each column represents one attribute of a feature, with the same column representing the same attribute in each row. This table linked with the geographical description of the water tubes allows, for example, the planning of an intervention. The knowledge brought by the link between this table and the geography permits to know what type of tools will be needed and what sort of problems can be encountered.

N° MAT	MATERIAL	DIAMETER
1	concrete	1000
2	concrete	600
3	pvc	150

Table 3. Example of an attribute table

Topology

Topological organisation of the graphical features in a GIS is of tremendous importance for simplifying their use. It simplifies the acquisition of data, avoids redundancy in the representation and allows the use of spatial analysis. It allows the manipulation of complex geographical objects such as networks or surfaces. The application of graph theory is supported by a topological organisation of the data. This point will be of particular interest fro the exploitation of electricity utilities in the context of Distributed Generation.
The main GIS tools are now topologic and they favour the exploitation of geographical data when there is a need of planning, simulation, or operational use.

4. DataBase Management System (DBMS)

The main objective of a DBMS is to collect and manage the sets of information. It is defined as a set of computer programs for organizing the information in a database. A DBMS supports the structuring of the database in a standard format and provides tools for data input, verification, storage, retrieval, query, and manipulation. Different models of DBMS exist:

- hierarchical.
- network
- relational
- object

The actual models of DBMS in the main GIS tools are relational and/or objects. In the following are presented the different models of DBMS and their advantages and drawbacks.

Hierarchical DBMS

In a hierarchical DBMS, data are represented as records associated with relationship or links. The database is in this case represented as a tree of data. The first drawback of this model consists in the difficulty for updating the database. This update implies to redefine the tree and to reconsider the different relations between the elements. The second one is due to the structure of the tree of relations, which implies to replicate the data on each needed leaf. Hence the storage of the database is not optimal.

Network DBMS

Similarly to the hierarchical DBMS, in the network DBMS data are represented as records associated with relationship or links. The scheme of relations is not so structured compared to the hierarchical one. But the organisation of the database implies to define a scheme that will be fixed for a specific exploitation. In this model, the data are organised for a specific aim. If a new exploitation is planned, it is mandatory to re-organise the database. An additional drawback is the complexity of the scheme when the database is large. It can be rapidly difficult to read and understand.

Relational DBMS

In relational DBMS, data are structured in two-dimensional tables. The lines represent the records and the rows, the attributes. The relationships are also represented in two-dimensional tables. The main advantage of this kind of representation is its flexibility. Its use and evolution are simple then the two previous models. One can easily add new tables, attributes to a table or new relations between tables through attributes. In this case data and processing are dissociated. A relational algebra exists allowing complex processing on the database based on operators such as union, difference, restriction, projection, junction, ... Additionally some constraints on the integrity of the data are existing in such a DBMS.

Object DBMS

In object DBMS, the only element is the object. An object contains its properties and the processes allowing its manipulation. The conception of the database is very easy and the complexity of the database can be very high. The consistency of the data is very simple to define and as in object programming the notion of inheritance allows the deduction of properties and processing for the entities.

5. GIS and Interoperability

The development of GIS and of internet lead to the problem of interoperability between tools. As GIS use heterogeneous data and as databases are more and more distributed a consortium was built to tackle these issues. The OpenGis Consortium is an international industry consortium of more than 220 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications. Open interfaces and protocols defined by OpenGIS® Specifications support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT, and empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.

OpenGIS is defined as transparent access to heterogeneous geodata and geoprocessing resources in a networked environment. The goal of the OpenGIS Project is to provide a comprehensive suite of open interface specifications that enable developers to write interoperating components that provide these capabilities. Figure 2 presents the topics of interest for the OpenGIS consortium.

As this interoperability is a tremendous importance for the diffusion and the use of GIS, most of the GIS editors are participating to this consortium. From Table 1, only Geoconcept and Apic are not participating to this initiative.

In these specifications, a large use of Unified Modeling Language (UML) is made. As this language is used in Common Information Model (CIM) used for representing the major objects in an electric utility enterprise, these two sets of specification should be joined in the context of Distributed Generation.

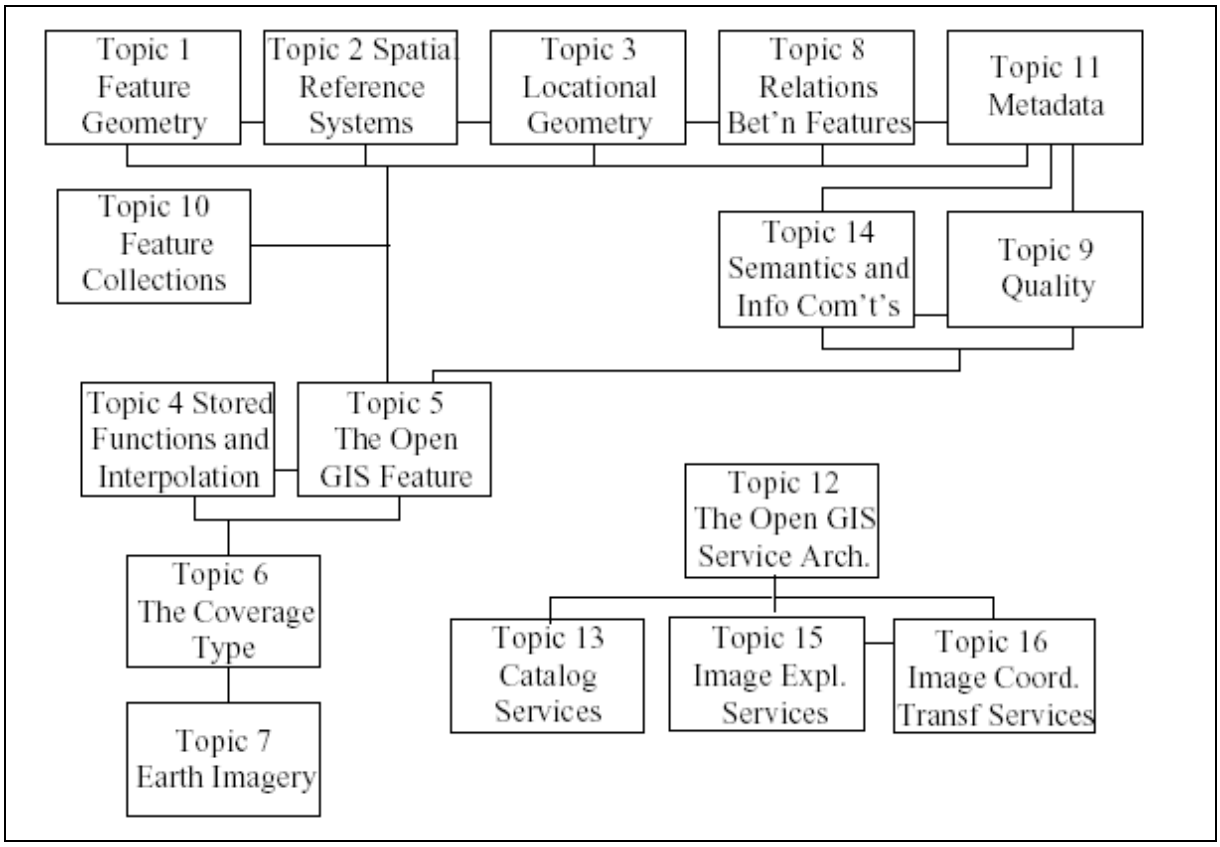

Figure 2. Topics of interest for the OpenGIS Consortium.

6. Conclusion

This short document tries to present a synthetic view of the present state of GIS. It sets vocabulary and ideas on this domain. It will help the DISPOWER project to focus on the potential of these tools in the context of Distributed Generation.

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