GIS INTEROPERABILITY, FROM PROBLEMS TO SOLUTIONS

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Contents

Summary

Presently, a lot of Geographic Information Systems are operating all over the world, especially in administrations, and one of the problems is to make them cooperate, especially at the data level, such as an institution can profit from the data of another institution. This problem is identified as GIS interoperability since the idea is to share not only data but also programs and services. The goal of this article is to present the main issues that must be addressed to achieve interoperability among several GIS, and to discuss the variety of solutions proposed. Two main approaches have been distinguished: syntactic and semantic interoperability. As syntactic interoperability can be solved by extensions of CORBA, presently the proposed solutions of semantic interoperability are based on ontologies and mediators.

1. Introduction

Geographical information system design has evolved from isolated GIS to interoperability. During the last decades, local authorities, administrations, environmental agencies have developed geographic information systems to support various decision making tasks (see *Introduction to Spatial Decision Support Systems*). Initially, the overall scope is to store, manipulate and maintain data that are directly related to the mission of system users. But increasingly, the need to share information with other institutions and to reduce data cost has allowed the emergence of tools for the support of not only data sharing, but also interoperability between data and services. As it was said some years ago, whereas interoperability is a dream for users, it is a real nightmare for systems developers.

GIS interoperability is a necessity for applications that involve combining data from several institutions. Typical example of applications include: natural or technological risks, disaster management, street repairs, environmental monitoring and studies, international transportation, huge public works, marine cartography (navigation), etc (see *Advanced Geographic Information Systems*).

1.1 An introductory example

As an initial example, consider an application that is aimed at detecting and controlling pollution along the Rhine river in Europe (Figure 1). The Rhine takes its source in Switzerland, then flows along the boundary between France and Germany, traverses Germany, and it finishes in The Netherlands. Any comprehensive study must be based on several databases, located in different countries. The languages and scopes of the databases may be different. Their contents were not acquired with the same specifications, and their last updates do not coincide: in this example, interoperability must be ensured between four GIS (Swiss, German, French and Dutch), with perhaps the indication that some of them may be in reality a federation of different GIS subsystems.

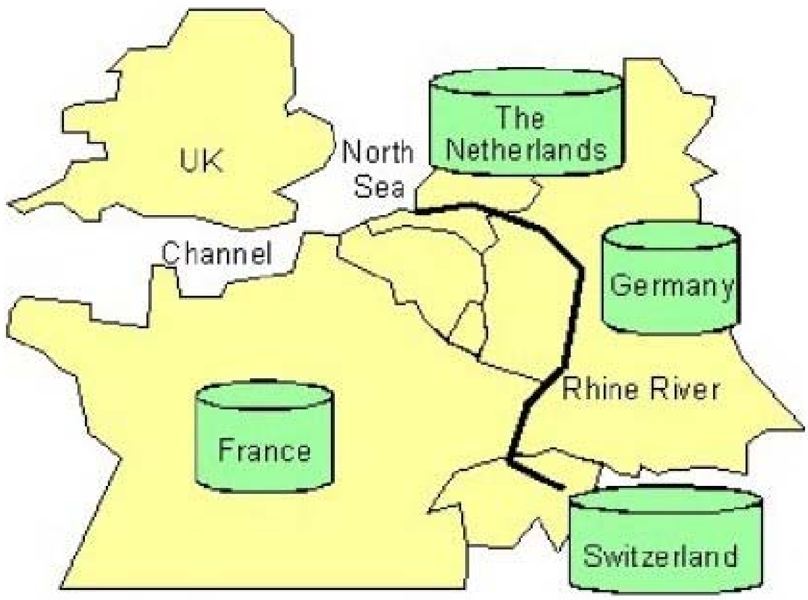

Figure 1. An introductory example about the Rhine river

1.2 Definitions

By definition, interoperability is "*the ability of two or more systems or components to exchange information and to use the information that has been exchanged*". More explicitly, interoperability can also be defined as the technical capacity of software applications for cooperating without conflicts neither of systems, nor of contents, between several organizations. As depicted in Figure 2, interoperability can be addressed in several ways. On the extremes, two solutions that are different in their scope have been identified. The first approach deals with interoperability of two sites, creating a sort of stovepipe system. This solution cannot easily be generalized or extended to more than two sites. The second approach is a more general interoperability solution that is aimed towards total integration of systems and data. Between these extreme approaches there are intermediate solutions with a different level of integration openness, i.e. the ease of integrating new sites. Connectivity solutions allow data transfer and management while inter-connectivity solutions allow data sharing over various domains.

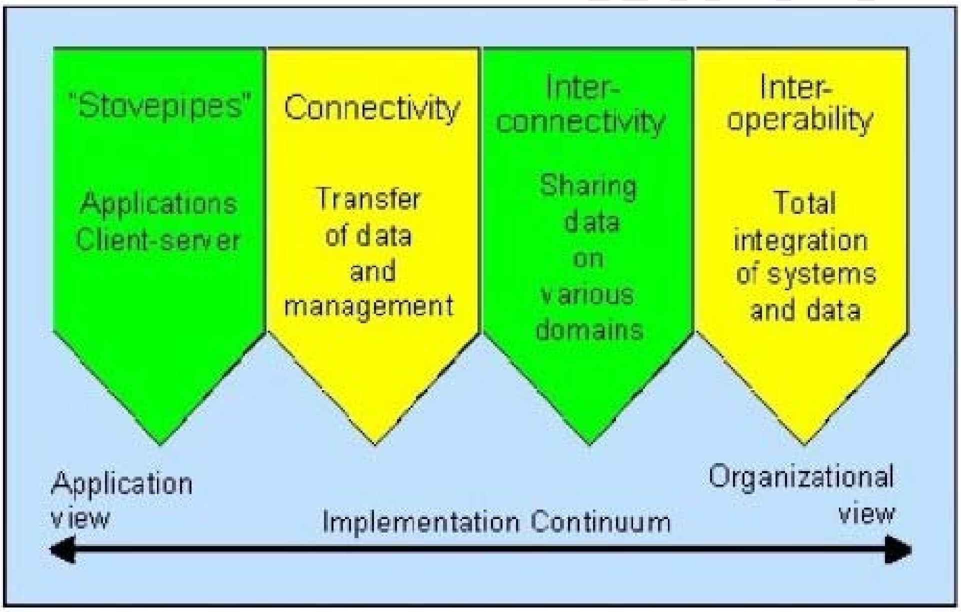

Figure2. The implementation continuum to ensure interoperability

1.3 Levels of interoperability

Different classifications of interoperability approaches have been proposed. Figure 3 illustrates the different levels of interoperability, ranging from the lowest level devoted to network protocol interoperability to the highest level of applications interoperability. In this paper the focus is on the highest level of interoperability, assuming that problems at other levels are solved. (For some details on lower level approaches, see *Interaction Issues and Decision Support in Intelligent GIS*, and *Web Based Spatial Decision Support: Technical Foundation and Applications*; for a discussion on geographic data integration see *Advanced Geographic Information Systems*) In the application level two sub-levels devoted to the resolution of data conflicts are usually distinguished: syntactic and semantic levels. The first sub-level resolves syntactic data conflicts to allow data sharing in a common representation. Syntactic conflicts occur when different spatial databases use different data models to represent information. The semantic sub-level is dedicated to the resolution of semantic conflicts. It provides tools to create and use global view on distributed databases according to the context of application. Data access to various databases is carried out in a transparent manner. Semantic conflicts arise when the different databases present differences in spatial data representation, spatial scale, spatial fragmentation, geometric coordinate systems and the interpretation of the same real entity (see *Spatial Data Quality*). The remainder of the paper is devoted to an extensive description of the main issues related to these sub-levels.

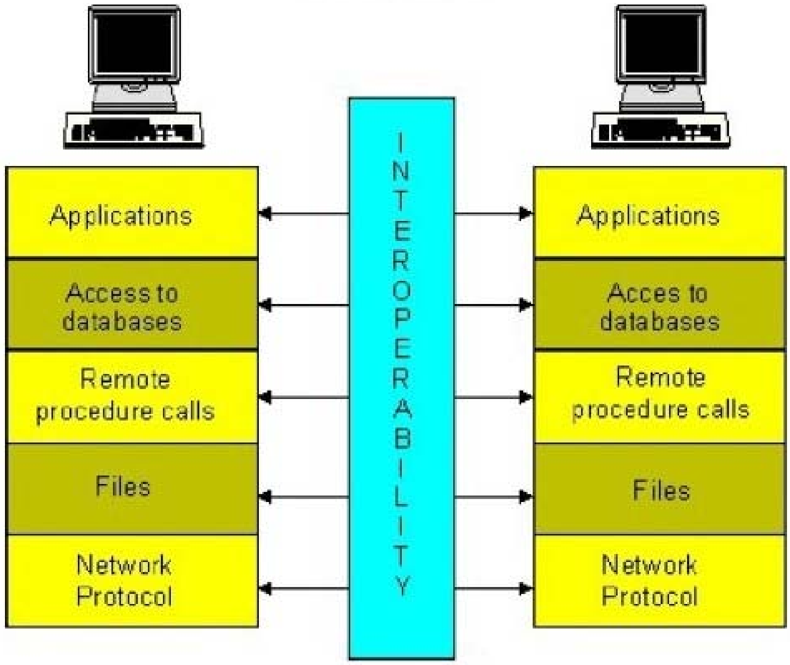

Figure 3. Interoperability levels

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Biographical Sketches

Robert Laurini is presently head of the Laboratory for Information System Engineering (LISI), shared by to the National Institute for Applied Sciences (INSA) and Claude Bernard University of Lyon, France, and head of SIGMA / CASSINI, the French CNRS Research Group on Geographic Information Systems. He received his doctorates (docteur-ingénieur 1973, and doctorat d'état in 1980) from Claude Bernard University of Lyon.
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His main interests are spatial and multimedia information systems with applications to urban and environmental planning, together with telegeoprocessing (GIS + Telecom). He has authored or co-authored more than 150 refereed papers. Prof. Laurini is also vice-president of Urban Data Management Society), associate editor of "Journal of Visual Computing and Languages", "Computers, Environment and Urban Systems", and member of scientific committees of several journals.

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Kokou Yétongnon received his BS degree in mathematics from the university of Bénin, Togo, in 1974; his MS and PhD in computer science and engineering from the university of Connecticut in 1981 and 1985 respectively. He joined the university of Bourgogne in Dijon, France as an assistant professor in 1985. He is currently a professor in the computer science department at the university of Bourgogne. He was the director of the Laboratoire d'Ingéniérie Informatique from 1991 to 1995. He currently heads the database and information technology research group. The research of the group involves distributed computing systems and databases. His research interests include databases, object oriented information systems, cooperative systems, image database, spatial database systems, distributed information systems, semantic data models and performance analysis.

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