AN INTEROPERABILITY GIS MODEL BASED ON THE SPATIAL INFORMATION INFRASTRUCTURE

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Abstract: Increasing application of Geospatial information requires integration , fusion and interoperability of current monolithic GIS, especially more complex and multidisciplinary involved application. Interoperability is base for information integration and fusion. we give five-level GIS interoperability model(InteroModel5). The spatial information infrastructure(SII) provides a sharing spatial information framework , architecture and an interoperability platform for geographical information system. This paper studies architecture of spatial information infrastructure, and gives the relationship between GIS interoperability model and spatial information infrastructure architecture. We consider GIS interoperability model provide a theory base for SII, and SII provide an implementation platform for GIS interoperability model .

1. INTRODUCTION

The application of geographic information is increasing , accomplishing an mission relative to resource, environment, society and economy may requires multidiscipline knowledge. But current monolithic geographic information systems impede and restrict these requirement. Currently government, industry and academy are dedicating to develop project to resolve this problem. these projects include national spatial information infrastructure(NSII), OpenGIS specification and International Organization for Standardization(ISO) technical committee 211, Geographic Information/Geomatics, etc. the purpose is geographic information sharing, but the key approach is interoperability.

"interoperability" is the freedom to mix and match components of an information system without compromise of overall success. the components of an information system include: software, hardware, networks, data, workflows, process, human interfaces, users, and training [Cliff Kottman 1996]. It is communication and coordination between two or more entities which have heterogenous environment, different language and different model, in order to accomplish a special mission. These entities include application program, objects, and system environment[Junhua Ding, 1998].

Interoperability means many things to people. It means openness in the software industry, because open publication of internal data structures allows GIS users to build applications that integrate software components from different developers, and it allows new vendors to enter the market with competing products that are interchangeable with existing components, just as the concept of interchangeable parts helps competition in the automobile industry. In the past few years the Open GIS Consortium (OGC) has emerged as a major force in the trend to openness, as a consortium of GIS vendors, agencies, and academic institutions. Interoperability also means the ability to exchange data freely between systems, because each system would have knowledge of other systems' formats. Exchange standards such as the Spatial Data Transfer Standard have had a significant impact on the ease with which data can be transferred between systems. They allow a user of one vendor's products to make use of data prepared using another vendor's products, because data can be transferred in a standard format. Interoperability also means commonality in user interaction, as system designers build interfaces that can be customized to a 'look and feel' familiar to the user[Michael. F.Goodshild. 1997].

Incompatibilities in data formats, software products, spatial conceptions, quality standards, models of the world and whatever else make "GIS interoperability a dream for users and a nightmare for system developers"[Robert Laurini, 1998]. Interoperability is a complex problem. It needs research for base theory of geographic information and formalization system, coordinating and agreement between

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various department and disciplinary , opening their interior structure of software, and needs developers develop much complex interfaces and integration rules.

The communication between traditional GIS information islands is bottom level information transformation, the boat of interoperability wandering between information islands, lack of efficiency. Now we will build bridge and highway of interoperability between information islands. That needs a series of interfaces, specifications, and admittance. Spatial Information Infrastructure(SII) provides framework and architecture of interoperability for geographic information community. At the same time, interoperability technology can promotes SII, and provides base theory.

2. PRESUMPTION OF INTEROPERABILITY GIS

The issue of interoperability is different from distributed system, integration system and information fusion. But they are associated and mingled with each other, so essence of interoperability is not clarity. We describe the concepts of them, and then define six presumption of interoperability.

Distributed GIS or database has an “overall design” scheme. It is “up to down” globe schema, and should conform with C.J.Date’s twelve rules. Distributed system may be operation system, network, DBMS, they are always belong to single community or department.

Integration GIS or database is the compound or assemble of existed database for a special mission. It is considered by “bottom to top”, and builds an integration framework on the top. Integration focused on an objective, and an special task. It is synthesis of multi heterogenous database, others call it multi-database, in wide mining belongs to distributed database. Data warehouse is a special case of integration database.

Interoperability GIS or database is the connection and exchange each other between existed system or database. Existed databases are differ in thousands way, have different goals, and different in content, model, platform, and community which belong to. Interoperability systems are equal and exchange resource horizontally, share information each other. Interoperability relies on interfaces and standard specification. It is base for integration or contributed system. Integration is a special and concrete application based on interoperability which has the property of base and generality. The research for Interoperability usually be found in the procedure of distributed system and integration system. The following is six presumption we defined:

a) Equality Each system is equal and autonomy, has right to control its information and processing. Has its independence schema rules. There has no center control.

b) Reciprocity There is broad mutual benefit between interoperability, export of one system is input of another system. They have different roles in application. A GIS in one domain may needs spatial data and processing from the GIS in other domain to accomplish a stride disciplinary task.

c) Sharing There is an intersection set between different GIS systems, they need share some fundament spatial information, such as fundament framework data set. They can also share other resource through special protocol.

d) Diversity Each system has its own disciplinary rule, on behalf of diversity of real world. Each system has its own model content and cognizance field, and different aspects of real world.

e) Independence Each system is complete, and integrity entity, has system boundary differing from other system.

f) Belongingness Each system belongs to one community or department, and has its own institution, policy, culture and value viewpoint.

The meaning of interoperability is communication and collaboration between different disciplinary or department, expends knowledge boundary of their domain, and innovates new domain to resolve the problem continuously emerged about resource, environment, society and economy, accomplish information integration and fusion based on SII.

3. GIS INTEROPERABILITY LEVEL MODEL

According to presumption defined above, we need interoperability at different levels between systems, level models in literature [Goodchild 1997,Yaser 1998] are loosely structured and do not consider all level as a whole. We take into account SII architecture , then give five-level interoperability model(InteroModel5). List as table 1.

Table 1 five-level interoperability model (Interomodel5)

System A	Method of interoperability	System B
Institution	Policy, Culture, Value	Institution
Semantics	Semantics translator , metadata Geographic information formalization system	Semantics
Application service	Distributed Object Agent Trader, CORBA OpenGIS	Application service
Resource transformation	Virtual Database, MultiDatabase OGM SDTS Data Warehouse Framework	Resource transformation
Resource discovery	Metadata, Digital libraries, Catalog, Clearinghouse	Resource discovery

First , we want to find interoperability objects. Resolve what needs interoperability and in where. In resource discovery level , we define these objects and the method of how to find them. The problem of this level have already resolved. There are many method, such as United States Federal Geographic Data Committee (FGDC) developed metadata standards Clearinghouse in the project of National Spatial Data Infrostructure (NSDI) . Matadata provide the description of spatial information, including content, quality, position, recommend application, etc. Clearinghouse provide a list of geographic data server node and relative matadata entries. Open GIS Consortium(OGC) provide Catalog server specification similarity with Clearinghouse.

Second , data from different source are different in data structure and schema. In resource transformation level, interoperability needs to resolve heterogeneity of data. FGDC gives Spatial Data Transformation Standard(SDTS). OpenGIS gives simple feature specification(OGM) which is a big contribution to this level. In the research area of database, there are many significative advances , including object oriented database, integration database and multi-database.

Different information communities have different special analysis model. In third level , application service interoperability provides exchange of geoprocessing and analysis function between different communities or departments. In this level , we can adopt distributed object computing. The existed standards include CORBA of Object Management Group and OpenGIS distributed computing service specification.

Many issues of society and economy needs knowledge from different disciplinary or community. In semantics level , interoperability provides semantics exchange between different communities. Using special information standards and corresponding rules of a special community , and the cognition for common fundament geographic information and its theory, the semantics interoperability is possible. But currently there are many technical issues need to be resolved.

In institution level, interoperability is a big problem, because we do not know whether a department desire exchange of information with other, different communities have different policy, culture and value, have their own benefits and privacy. It needs coordinating of policy, culture and value between different communities.

The implementation of the interoperability model is more difficult than network protocol level. How to effectively connect different level of interoperability as an organic body, ensure low level interoperability harmonize and comport with high level interoperability, coordinate interaction and promote each other, the SII is necessary. SII will provide a platform for implementation of each level interoperability.

4. THE IMPLEMENTATION OF INTEROMODEL5 ON SII

Different system needs different level interoperability. In order to implement each level interoperability , provide broad geographic information service for society, many country and department put forward the plan about spatial data or information infrastructure (SII). We define the architecture of SII, and think the InteroModel5 have an corresponding relation with SII architecture.

Interoperability GIS model provide a base theory for SII, and SII architecture provides a platform and environment for implementation of interoperability GIS.

4.1 the architecture of SII

Spatial information infrastructure is the collection of people, doctrine, policies, architectures, standards, and technologies necessary to create, maintain, and utilize a shared geospatial framework. The architecture is the logic modal of SII. From different dimension of architecture we can derive data, technical, operational, and institutional architecture.

Data architecture is aspect of geospatial data structure and model in SII. SII data model provide different views for different users. In a large-scale system, the “data model” is really a set of models which may include an enterprise-wide logical model, subject-specific logical models, as well as physical models to support specific system installations. The views of SII include metadata view which provides data reference, data quality, spatial reference, feature content, and information distribution; Feature subject view provides nature resource feature, environment and culture feature; Imagery view provides imagery type and description.

Operational architecture is observed from data flow which includes five components, requirements management, data acquisition, information production, information management and dissemination, and information application.

Technical architecture is technical method and its component to implement SII. We adopt distributed object computing to inter-operate and share information and processing of framework. Object method has property of reuse, component, and interoperability. The CORBA and DCOM are significative advance.

Institution architecture is the collection of participants and their responsibility which create and maintain SII. The plan and implementation of SII needs state level group or board which leads and coordinates other participants. The participants include mapping communities, nature resource, environment, utilities, and facility community, etc. they are important factors to discuss semantics interoperability and coordinate relation.

4.2 the relationship between InteroModel5 and SII architecture

The implementation of Interoperability GIS model based on SII. The relationship between InteroModel5 and SII architecture show as figure 1.

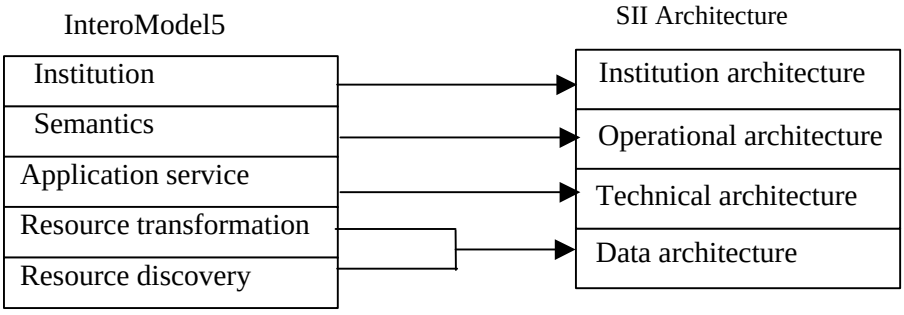

Figure 1 InteroModel5 levels corresponding to SII architecture

Resource discovery and Resource transformation levels of InteroModel5 relating to data architecture of SII. Application service corresponding to technical architecture. Interoperability Semantics level based on Operational architecture which process information flow across different communities. Institution level of InteroModel5 relating to Institute architecture.

Resource discovery and Resource transformation of interoperability can be implemented on Data architecture of SII. Most of problems in this have already been resolved. Data architecture provides base of interoperability and integration for discovery, access, and dissemination of geographic data in different type of single repository and different model in multi-repository. Matedata and catalog services provide method to discovery data. Spatial data transformation standards provides an middle bridge to transform different data. OpenGIS provides a middleware for different information resource.

Multi-database, federal database, virtual world database, and model integration also provides way to transform data. But in resource transformation level , we must consider consistency of horizon and vertical, and integration of spatial database.

The interoperability of Application service based on technical architecture which computing technology will adopt. Distributed object computing can resolve interoperability of application service object. Application services include spatial query, spatial analysis , mapping, and spatial information management. OGC has already provided OpenGIS service specification.

Semantics interoperability based on Operational architecture which is process information flow across different component, such as information flow from providers to users, and users to users. In the flow the coordination and agreement between two participant are necessary. The information flow and exchange between different communities need semantics exchange. Operational architecture of SII include requirements management, data acquisition, information production, information management and dissemination, and information application. From these five component we can extract semantics item, define semantics translator. Information standards in a community is necessary, then different standards between communities can be translated each other. An common geographic information formalization system is necessary.

Institution architecture of SII is organizational structure and participant, and their responsibility, coordinating relationship. The interoperability of institution is most difficult, because we do not know whether a community desires to share and inter-operate. In this level interoperability relies on many factors. Policy factor includes desire of open and exchange. We can persuade and propagandize to eliminate tradition and protection of benefit, in order to boom together. Law factor includes copyright and privacy. Institution architecture of SII can provide a forum to discuss and resolve these problems.

5. CONCLUSION

The model of interoperability is a complex issue. Its content is enough and different researcher has different aspect about it. In application of GIS, the interoperability is implemented in different level. The InteroModel5 based on SII connects all levels of interoperability together and forms an entire system. But the detail of each level of the model needs a lot of research. In the low level , such as resource discovery and transformation, many problems have already been resolved. But in high level , semantics and institution interoperability need technical programme are in exploring.

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