TECHNOLOGIES AND STANDARDS ON SPATIAL DATA SHARING

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Commission IV, WG IV/2

KEY WORDS: Spatial data, Sharing, Interoperability, Standards

ABSTRACT:

The issue of geo-spatial data sharing has long been a problem to be solved by experts in the field of geo-spatial information science and technology. Many studies have been carried out over the last years. With decades of efforts, this issue has basically been solved. This paper reviews the research course of technologies and standards on spatial data sharing and introduces the technical and standardization systems for spatial data sharing.

1. INTRODUCTION

With the development of geographic information technology, the geographic information system (GIS) is transiting from project application to organizational and social applications. A large number of GIS applications have been established by various organizations. At the same time, plenty of geospatial data have been collected as well. In many geo-spatial applications, it is necessary to transfer spatial data between different organizations, with different contents and in different forms for synthetic utilization. However, since the spatial databases of different organizations may have been established at different times, are based on different platforms, or have been made to fit different industries or departments, large differences exist between them. That is to say, they are largely heterogeneous. The differences are reflected in the following aspects.

1.1 Differences in Data Contents and Data Sources

Generally speaking, there are three types of spatial data.
Vector data – This may be the scanned map data after vectorization, or data obtained from digital surveying or other means.

Image data – The major sources are aerial photographs and satellite remote sensing. The data is stored in the format of raster data.

Topographic data – This type of data is generally used to describe the elevation of the Earth's surface. The sources are map scanning vectorization and digital photogrammetry. There are four forms including contour line, TIN, grid and the combination of TIN and grid.

1.2 Differences in Spatial Data Model

In general, different spatial database management systems support different spatial data models. For instance, there might be spatial data models with or without topology, supporting 2D, 2½D or 3D spatial data, or even spatio-temporal data.

1.3 Differences in Software Platform

For various reasons, different GIS software platforms are adopted by different spatial database management systems. Thus, these databases may have different data formats. Though the original data in the databases might be the same data set, the spatial database models may be different.

Since GIS came into being, the defects of GIS technology have becomie more apparent in spite of true improvements of the technology itself. Using their specific data formats, data storage and processing methods, traditional GISs are closed and isolated systems, without standards. The GISs and their application systems were based on dispersed, independent and closed platforms, causing substantial conflict in data semantics. Thus, they did not accommodate data sharing between application systems well. As a result, the development potential for geographic information processing technology was restricted to a large extent.

With the development of modern information technology, a great deal of geo-spatial data from different sources is produced almost continuously. With the development of computer networks and the growing popularity of the Internet, more and more information must be processed in different software packages to be distributed overthe network. Thus, the issue of how to acquire data rapidly from different sources, integrate the data for analysis, and realize heterogeneous spatial data interoperability in a distributed environment becomes very important.

As information sharing is an important requirement for the development of modern information society, GIS interoperability is an essential technology for information sharing. The geographic information sharing and interoperability has been an important direction in GIS.

A lot of research in geographic information sharing and interoperability has been carried out for decades. A series of methods for geographic information sharing and interoperability have been proposed. A number of standards have been constituted as well. This paper briefly introduces the methods for geo-spatial information sharing and interoperability. Then, the standards constituted by OpenGIS and ISO/TC211 are introduced in detail. The techniques to implement geo-spatial data sharing based on Web Service technology are introduced in the context of the accomplished researches and experiments.

2. BASIC METHODS FOR GEO-SPATIAL DATA SHARING

At present, there are three methods to realize geo-spatial data sharing, namely, through *data exchange mode*, *database direct access mode* or *database interoperability mode*.

2.1 Spatial data exchange mode

Each GIS software package has its own internal data format and data storage method. In the past, many GIS software manufacturers did not directly provide the functions to read/write internal data to their users. For data exchange with other GIS software, an external data exchange format was thus needed, such as DXF for AutoCAD, MIF for MapInfo and E00 for Arc/Info. Generally, the underlying data format is ASCII. Users can read/write such external data with use of the users' guide. However, the external data exchange formats were defined by each software manufacturer, respectively. Thus, the content and semantics would typically differ. Many countries and industries have constituted their own data exchange standards, requesting that other countries or other organizations use a mutual data exchange format, such as DLG and STDS in the USA, ASDTS in Australia, NTF in the UK, DIGEST with NATO, CNSTDF in China, and so on. Besides, some companies have developed specific geo-spatial data exchange software.

The spatial data exchange standard or the spatial data exchange software has solved the problem of spatial data exchange between different GIS software. However, it is not an optimal method. This data sharing is based on files, which can be only used for data integration but cannot realize real-time data sharing at the feature level. Thus, the interoperation between two systems is not real interoperability. In one aspect, because of the lack of a unified description method for spatial objects, different data formats use different data models to describe the spatial objects. Thus, after data exchange, information of the original data cannot be expressed accurately, and information loss occurs. Moreover, real-time updating of spatial data and data consistency cannot be realized via external data exchange. For example, the planning bureau of a city may have several departments. Different departments purchase different software based on their own requirements. For example, the department of surveying and mapping may use GeoStar, while the department of pipeline network management may use Arc/Info, and still other departments may use MapInfo. The software packages may exchange data via external data exchange files. The problem is that the three databases are updating constantly and the update only is only reflected in its own database. If the administrator for urban planning does not exchange the spatial data from the surveying database or pipeline network database every day or every hour, the data he uses might be the data as current a few days or even months ago. Then, the spatial data for planning will not be current and accurate. As a result, it is necessary to study and constitute the methods and standards for spatial database online sharing.

2.2 Interoperability Based on Direct Access

Database direct access means that a GIS software package can directly access multiple databases using different data formats. Direct access not only avoids the fussy course of data exchange, but also allows users to obtain online data by accessing another database directly. Direct access provides a data-sharing mode for multi data sources with more economic and practical value.

Direct access assumes sufficient understanding of the data format and data model in the spatial database at hand. If its internal data format is not public, direct access to it is difficult. If the data format of the host software changes, any software package for data integration must re-address the changed format and then update its own. However, it is seldom publicly announced when this happens, which will lead to difficult to access the changed format of the database for data integration. If each GIS software package must interoperate with any GIS spatial database, interface functions to read/write different all their different formats must be developed, which is a vast body of work for developing the software package. If the API function can be implemented, data can be accessed directly, which will decrease the efforts of software development. Figure 1 shows the interoperability based on the direct access mode.

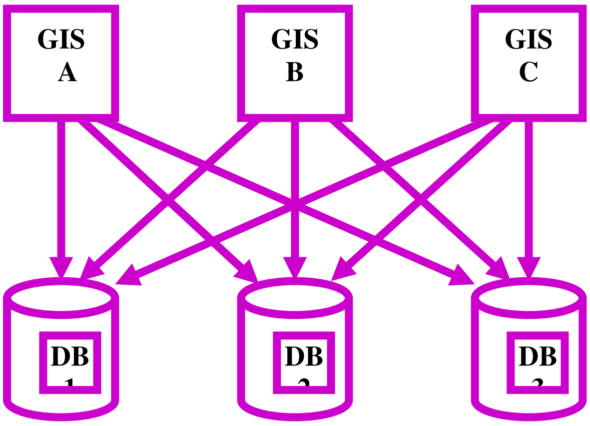

Figure 1 Interoperability Based on Direct Access to Databases

2.3 Interoperability Based on a Common Interface

If GIS software manufacturers develop modules to access spatial databases according to the interface specification constituted by international standardization organizations (such as ISO/TC211) or technical consortiums (such as OGC), heterogeneous spatial database interoperability can be realized. With regard to this interoperability in a distributed environment, the spatial data interoperability specification can be classified into two levels.

The first level is the API based on COM or CORBA standards or the interface specification of SQL. By constituting the common interface function form and parameters, different GIS software packages can directly access each other's database. This can be implemented in two ways. The first is one in which the data access interface of a GIS directly uses the standardized interface function. The second way is one in which a GIS has defined its own data access function. So as to realize interoperability, it wraps a standardized interface function on its own internal data access function. The interface based on API uses binary data with high efficiency, but is more complicated and difficult to implement. Figure 2 shows the relationship of specification interfaces for spatial data interoperability based on API.

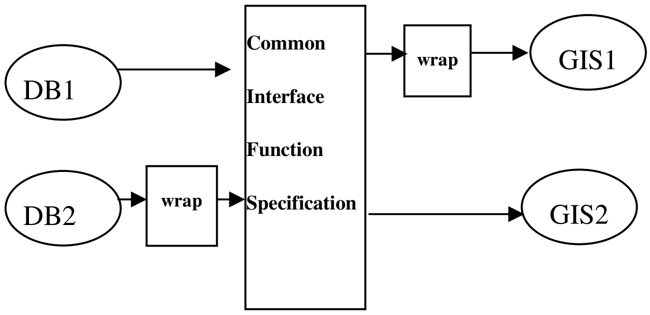

Figure 2 Relationship of Specification Interfaces for Spatial Data Interoperability Based on API

If middleware technology of CORBA or J2EE is adopted, interoperability based on common API can be realized on the Internet, and a triple level architecture or multi-level architecture can be easily constructed. The implementation method is similar to the previous one with additional middleware, as Figure 3 illustrates.

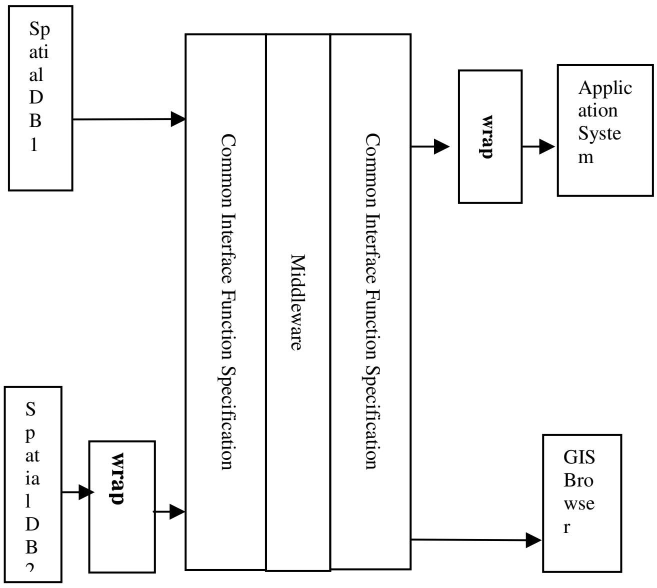

Figure 3 Interface Relationship of Spatial DB Interoperability Based on CORBA or J2EE

The second level is the implementation specification for spatial data interoperability based on Web Services. It follows the specification of spatial data sharing models and interoperation based on XML. When these are implemented among different GIS software packages, the internal spatial data is transformed into the data flow of the common interface description specification (the format is ASCII). The other system will read the data flow to itself system.

There are two forms of implementing interoperability specification based on XML. One is to transform one data set entirely into the data format described by XML.

Other systems can access the data set according to the defined specification and import it into the internal system. This method is similar to a data set transformation with a spatial data transformation standard. The other method is a real-time read/write transformation. When one system requests data from another system, it sends a massage to boot and start up the read/write and query method with the XML or SOAP protocol, to access spatial objects in the spatial database management system at real time, and then transforms the data into the data flow of the public format defined by XML. The system may acquire the object data at real-time, which results in the real-time online data sharing and interoperability. The data flow of interoperability specification based on XML has an ASCII format, which is easy to understand and to realize multi-hardware-software-platform interoperability. It can be used in many ways as spatial information distribution service and spatial information mobile service. At present, the spatial data interoperability based on XML is a hot research direction, which involves many concepts and mainly includes the related techniques of web services. OGC and ISO/TC211 have constituted spatial data interoperability specifications based on XML as Web Map Service Specification, Web Feature Service Specification, Web Coverage Service Specification and GML, a geographic information markup language used for spatial data exchange and online transformation. Figure 4 shows the spatial data interoperability implementation specification based on XML.

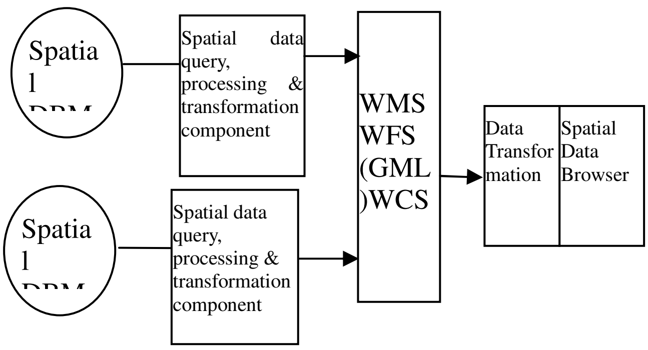

Figure 4 Spatial Data Interoperability Implementation Method Based on Web Service Technology (XML)

In the above two forms of spatial data interoperability, the efficiency of interoperability using an API is higher. The adaptability of interoperability based on XML is wider but has a lower efficiency. The interoperability system based on API is often used in the LAN of an organization, while the system based on XML is generally used on the Internet.

3. GEOGRAPHIC INFORMATION SHARING STANDARDS

3.1 Open Geographic Information Specifications

The Open GIS Consortium (OGC) is an industry organization with international members. It now has more than 220 members including software companies, governmental agencies, colleges and universities. Its major task is to develop Open GIS Specifications and enable them to transparently share heterogeneous geographic data and process resources in the network.

At present, the geographic data interoperability specification constituted by OGC is classified into *abstract specification* and *implementation specification*.

3.1.1 Abstract Specification

1. Objectives

The objective to compose an abstract specification is to build a concept model and prove that the model can be used to establish the implementation specification. The abstract specification includes two models derived from Syntropy object analysis and design.

The first model is a basic model. It is simple and is used to establish the conceptual links between the software or system design with the real world. The basic model is to describe how the real world works or how the real world should work.

The second model is an abstract model. It is the essence of abstract specification, which is used to define the final software system of the implementation middleware. The abstract model is to describe how the software should work. The objectives to develop this abstract specification include:

- Relate the software and system design with the real world;
- Acquire and accurately state demands and field knowledge, so that the risk bearer can understand and make decisions;
- Consider the system design;
- Acquire the design decisions in indefinite forms. The forms and the demands are separate;
- Produce useable working products (such as certification of prototype and concept implementation);
- Organize, discover, screen, index, check and edit the information of the related large systems;
- Seek for various economical solutions;
- The abstract specification, especially the abstract model can be applied for all the mentioned objectives. In addition, it provides sets of “languages” for interoperability.

2. Topics

The central topic of OGC is to share information and provide service. Thus, it has two central technical topics, i.e., to share geo-spatial information and provide geo-spatial service. There are 17 topics in the OGC abstract specification (see Table 1). Figure 5 shows the relationship.

No.	Name
Topic 0	Abstract Specification Overview
Topic 1	Feature Geometry
Topic 2	Spatial Reference System
Topic 3	Locational Geometry Structures
Topic 4	Stored Functions and Interpolation
Topic 5	The OpenGIS™ Feature
Topic 6	The Coverage Type
Topic 7	Earth Imagery Case
Topic 8	Relationships between Features
Topic 9	Quality
Topic 10	Feature Collection
Topic 11	Metadata
Topic 12	The OpenGIS™ Services
Topic 13	Catalog Exploitation
Topic 14	Semantics and Information communities
Topic 15	Image Exploitation Services
Topic 16	Image Coordinate Transformation Services

Table 1 Abstract Specification

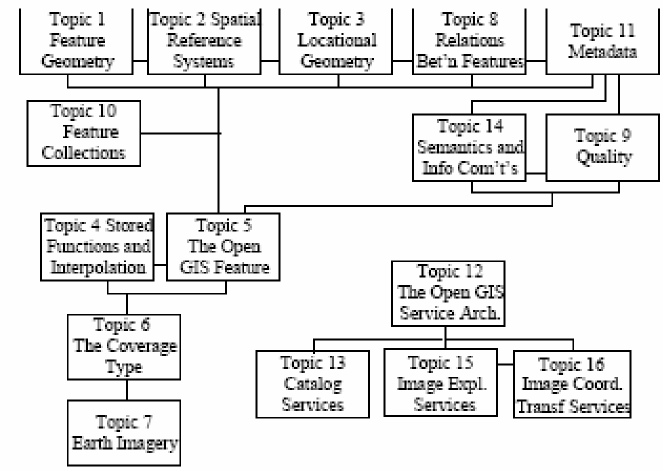

Figure 5 Abstract Specification Topic Dependencies

The relations of these topics are shown in Fig. 5. Topics 5, 6, and 7 are centered on sharing geospatial information. These topics are the OpenGIS™ Feature, the Coverage Type, and Earth Imagery. Each of these topics (5,6 and 7) is fundamentally concerned with the handling and exposing of Geospatial information, whether it is modeled using Features With Geometry, Coverages, or with the Imagery information type.

Topics 1, 2, 3, 8, and 11 directly support topics 5, 6, and 7. Topic 1 provides the Geometry structures for Features With Geometry. Topics 2 and 3 deal with the same subject (geo-location), but in two different technology domains. Topic 2 provides the Spatial Reference Systems by which features are related to positions on the surface of the Earth in the discipline of Geodesy. Topic 3 adds tools for providing geospatial referencing to image coordinates, raster coordinates, and indirect referencing systems that are not found in Geodesy texts. Topic 8 provides for the modeling and exposure of relationships between features. Topic 11 provides for the modeling and querying of metadata. Each of these topics is essential before any geospatial information is shared.

Topic 4, on Stored Functions, is necessary to support Topic 6, Coverages. Most Coverages depend on two stored functions. The functions map respectively "to" and "from" a mathematical coordinate space called the Coverage Extent, or a Spatial Domain.

Topics 12,13, 15 and 16 are concerned with providing geospatial services. The remainder is centered on sharing geospatial information. Topic 12 specifies a comprehensive set of geospatial services. Topics 13, 15 and 16 describe, in greater detail, specific categories of geospatial service.

3.1.2 Implementation Specification

The abstract specifications (interface and protocol) constituted by OGC provide solutions for geographic data interoperability based on Internet, wireless communications, LBS and main-stream information technology, meeting the demand of all applications. However, these specifications can only be implementation specifications by programming, testing, modifying and perfecting. The accomplished specifications include Simple Feature Access Specification for OLE/COM, Simple Feature Access Specification for CORBA, Simple Feature Storage Specification for SQL, Catalogue Interface, Grid Coverage, Coordinate Transformation Service, Web Map Server Interface, Web Feature Service Interface, Web Coverage Service Interface, GML and so on.

3.2 International Standard for Geographic Information

3.2.1 Study Status of International Standard for Geographic Information

According to the real requirements of geographic information industrialization, the international standardization organization founded ISO/TC211 in 1994, being specifically responsible for the study and constitution of geographic information standards. By May 8, 2004, there were 57 members (countries and areas), among which 28 have the right to vote (P-Member), 29 are observation members (O-Member). In addition, there are 22 external liaison members (outside ISO), such as OGC and DGIWG; and 11 internal liaison members (within ISO), such as ISO/TEC.

There are nine working groups since the foundation of ISO/TC211. With the task development, WGs1, 2 and 3 have finished the tasks and have been cancelled. At present, six WGs are responsible for drafting geographic information standards. And six special WGs are responsible for the study of strategy and quality of the standards.

By May 8, 2004, there were more than 40 working projects. Table 2 shows the progress status of the projects. The projects can be classified into four groups according to their status: international standards or technical reports (IS or TR), draft international standards (DIS), working group draft (WD) or committee draft (CD). Among these, there are 12 standards related to access and service, 21 related to data content and seven related to organization and management.

No. and Name	Status					Types
	IS/TR	FDIS	WD or CD	Storage	Content	Organization & Managment
ISO 19101 – Reference model	* /					*
ISO 19102-Overview (deleted)					*	
ISO 19103-Conceptual Schema Language (CSL)			*			
ISO 19104-Terminology			*			*
ISO 19105-Conformance and testing	*					*
ISO 19106-Profiles		*				*
ISO 19107-Spatial schema		*			*	
ISO 19108-Temporal schema		*			*	
ISO 19109-Rules for application schema		*			*	
ISO 19110-Feature cataloguing methodology		*			*	
ISO 19111-Spatial referencing by coordinates		*			*	
ISO 19112-Spatial referencing by geographic identifiers		*			*	
ISO 19113-Quality principles		*			*	
ISO 19114-Quality evaluation procedures					*	
ISO 19115-Metadata		*			*	
ISO 19116-Positioning services				*		
ISO 19117-Portrayal		*		*		
ISO 19118-Encoding				*		
ISO 19119-Services		*		*		
ISO 19120-Functional standards	/ *					*
ISO 19121-Imagery and gridded data	/ *				*	
ISO 19122-Qualification and certification of personal			*			
ISO 19123-Schema for coverage geometry and functions			*		*	
ISO 19124-Imagery and gridded data components			*		*	
ISO 19125-Symbol feature access Part1: Common architecture Part2: SQL option Part3 :COM OLE		* *		* * *		
ISO 19126-Profile – FACC data dictionary			*		*	
ISO 19127-Geodetic codes			*		*	

and parameters						
ISO 19128- Web map server interface			*	*		
ISO 19129- Imagery and gridded and coverage data framework			*		*	
ISO 19130- Sensor and data model for imagery and gridded data			*		*	
ISO 19131- Data Product Specification			*		*	
ISO 19132- Location-based services possible standards			*	*		
ISO 19133- Location-based services tracking and navigation			*	*		
ISO 19134- Multimodel location-based services for routing and navigation			*	*		
ISO 19135- Procedures for registration for Geographic information items			*			*
ISO 19136- Geography Markup Language (GML)			*	*		
ISO 19137- Generally used profiles of the spatial schema and of similar important other schema			*		*	
ISO 19138 – Data quality measures						
ISO 19139 - Metadata – Implementation specification						
ISO 19140 – Metadata – Implementation specification						

Table 2 Number and Name, Status and Types Fit for Spatial Data Infrastructure

3.2.2 The Scope of ISO 19100 series of Geographic Information Standards

ISO 19101 Reference model: It describes the environment within which the standardization of geographic information takes place, the fundamental principles that will apply, and the architectural framework for standardization. The reference model defines and relates all concepts and components needed for this standardization. Structured within information technology standards, the reference model is to be independent of any application, methodology, and technology.

ISO 19102 Overview (Currently it is deleted.)

ISO 19103 Conceptual schema language: Adoption of a conceptual schema language (CSL) for use in development of conceptual schemata in the field of geographic information.

ISO 19104 Terminology: A harmonized set of all specific terms that relate to the ISO/TC 211 family of standards.

ISO 19105 Conformance and testing: The framework, concepts, and methods for testing and criteria to be achieved to claim conformance to the ISO/TC 211 family of standards.

ISO 19106 - Profiles: Definition of guidelines for defining a profile/product within the ISO/TC 211 family of standards.

ISO 19107 Spatial schema: Definition of the conceptual schema defining the spatial characteristics of object types.

ISO 19108 Geographic information - Temporal schema: Definition of the conceptual schema defining the temporal characteristics of object types.

ISO 19109 Geographic information - Rules for application schema: Definition of the rules for defining an application schema, including the principles for classification of geographic objects and their relationships to an application schema.

ISO 19110 Feature cataloguing methodology: Definition of the methodology for creating geographic object, attribute and relationship catalogues and the determination of the feasibility of setting up a single international multilingual catalogue and its administration.

ISO 19111 Spatial referencing by coordinates: Definition of the conceptual schema and guidelines for describing geodetic reference systems. This work will include references to selected international reference systems.

ISO 19112 Spatial referencing by geographic identifiers: Definition of the conceptual schema and guidelines for describing indirect spatial (non-coordinate) reference systems.

ISO 19113 Quality principles: Definition of the schema for quality applicable to geographic data.

ISO 19114 Quality evaluation procedures: Development of guidelines for the methods of specifying/evaluating data quality.

ISO 19115 Metadata: Definition of the schema required for describing geographic information and services.

ISO 19116 Positioning services: Definition of a standard interface protocol for positioning systems. A standardized interface of geographic information with position will allow the integration of position data into a variety of geographic information applications.

ISO 19117 Portrayal: Definition of a schema describing the portrayal of geographic information in a form understandable by humans, including the methodology for describing symbols and mapping of the schema to an application schema. This work does not include the standardization of cartographic symbology.

ISO 19118 Encoding: Selection of encoding rules compatible with the conceptual schemata that apply to geographic information and definition of the mapping between the conceptual schema language and the encoding rules.

ISO 19119 Services: Identification and definition of the service interfaces used for geographic information and definition of the relationship to the Open Systems Environment model.

ISO 19120 Functional standards: To develop a taxonomy, in the form of a Type 3 report, of recognized functional standards in the field of geographic information developed in other international or multi-national standardization fora. To identify the components of those recognized functional standards and to identify elements that can be harmonized between these standards and with the TC211 base standards. To provide assistance with the development of profiles, when the base standards of ISO/TC211 are available, which correspond to these recognized functional standards. The actual development of profiles is not included in this scope.

ISO 19120 Functional standards - Amendment 1: The ISO TR 19120 Functional standards report seeks to identify areas where the developing ISO 15046 base standards should be influenced or guided by the experience of the functional standards communities. A functional standard has been identified as the existing geographic information standard, in active use within the international community. National standards have not been considered within scope. This initial edition of ISO TR 19120 provides a starting point for a feedback cycle between the functional standards communities and the ISO/TC 211 component project teams.

ISO 19121 Imagery and gridded data: To develop a Type 3 report, which addresses the manner by which TC211 should handle imagery and gridded data in the context of the field of geographic information. To identify those aspects of imagery and gridded data that have been standardized or are being standardized in other ISO committees and external organizations that influence or support the establishment of raster and matrix data standards for geographic information. To identify the components of those identified ISO and external imagery and gridded data standards that can be harmonized with the TC211 Geographic information standards. To develop a plan for TC211 to address imagery and gridded data in an integrated manner, within the suite of TC211 base standards.

ISO 19122 Qualifications and Certification of Personnel: To develop a Type 3 report, which describes a system for the qualification and certification, by a central independent body, of personnel in the field of Geographic Information Science; to define the boundaries between Geographic Information Science and other related disciplines and professions; to specify the technologies and tasks pertaining to Geographic Information Science. To establish skill sets and competency levels for technologists, professional staff and management in the field. To research the relationship between this initiative and other similar certification processes performed by existing professional associations; to develop a plan for the accreditation of candidate institutions and programs, for the certification of individuals in the workforce, and for collaboration with other professional bodies.

ISO 19123 Schema for coverage geometry and functions: Definition of a standard conceptual schema for describing the spatial characteristics of coverages.

ISO 19124 Imagery and gridded data components: To standardize concepts for the description and representation of imagery and gridded data in the context of the ISO 15046 suite of standards. This includes new work on the following aspects of such data: Rules for application schemas, Quality principles and Quality evaluation procedures, Spatial reference systems, Visualization, and Exploitation services. The work will also identify aspects of existing parts of the family of standards that need to be expanded to address imagery and gridded data. New metadata elements will be defined using the extension mechanism of ISO 15046-15. Methods of encoding imagery and gridded data will be identified for inclusion in ISO 15046-18.

19125-1: Geographic information - Simple feature access - Part 1: Common architecture and 19125-2: Geographic information - Simple feature access - Part 2: SQL option: They will provide an implementation specification for the SQL environment conformant with the Simple feature access; specify an SQL schema that supports storage, retrieval, query and update of simple geospatial feature collections; establish an architecture for the implementation of feature tables; define terms to use within the architecture; apply to both SQL Components and SQL with Geometry Types Components; describe a set of SQL Geometry Types together with the SQL functions on those types; and not attempt to standardize any part of the mechanism by which the Geometry Types are added to and maintained in the SQL environment.

19125-3 Simple feature access - Part 3: COM/OLE option: It will provide an implementation specification for the COM/OLE environment conformant with the Simple feature access - SQL ISO 19125; specify a COM/OLE schema that supports storage, retrieval, query and update of simple geospatial feature collections; establish a architecture for the implementation; and define terms to use within the architecture;

ISO 19126 Profile - FACC Data Dictionary: This International Standard is a profile. It is based on rules and methods defined in ISO CD 19110 Feature cataloguing methodology, in the context of DGIWG. It defines a Data Dictionary and includes the definition of Features and Attributes only, which may be of use to the wider international community.

ISO 19127 Geodetic codes and parameters: To develop a Technical Specification on geodetic codes and parameters that defines rules for the population of tables of geodetic codes and parameters and identifies the data elements required within these tables, in compliance with ISO 19111, Geographic information - Spatial referencing by coordinates, and makes recommendations for use of the tables. These recommendations should address the legal aspects, the applicability to historic data, the completeness of the tables, and a mechanism for maintenance.

ISO 19128 Web Map server interface: It will describe a Web Map Server (or just Map Server). A Map Server can do three things. It can produce a map; answer basic queries about the content of the map; and tell other programs what maps it can produce and which of those can be queried further.

ISO 19129 Imagery, gridded and coverage data framework: To standardize concepts for the description and representation of imagery, gridded and coverage data in the context of the ISO 19100 series of standards. This New Work Item Proposal is for a Technical Specification to define the framework for imagery, gridded and coverage data and those elements that require standardization that are not identified in other ISO 19100 standards.

ISO 19130 Sensor and data models for imagery and gridded data: It will specify a sensor model describing the physical and geometrical properties of each kind of photogrammetric, remote sensing and other sensors that produces imagery type of data, and define a conceptual data model that specifies, for each kind of sensor, the minimum content requirement and the relationship among the components of the content for the raw data that was measured by the sensor and provided in an instrument-based coordinate system, to make it possible to geo-locate and analyze the data.

19131 Data product specifications: It will provide requirements for the specification of geographic data products. These will include the application schema, spatial and temporal referencing systems, quality and data capture and maintenance processes.

ISO 19132 Location based services possible standards: This Stage 0 report will investigate the need for the following LBS standards: Format for the expressions of location (including orientation), Coordinates, Addresses, Route "mile markers"; Format for the expression of routes, Segment sequences and Turning instructions; Formats and rules for the expression of navigational "commands"; Format for the expression of choice by clients of forms of commands, potentially expression of personal preferences; Format for the expression of traffic conditions; Format for the transfer between client and servers of request and responses for each of the above applications. The scope will include the consideration of both local (server side) and client aspects of cultural and linguistic adaptability.

ISO 19133 Location based services tracking and navigation: It will specify 'web' based services in support of (mobile) clients that will enable: Route finding or traversal (navigation) between two targets; Route as conditions along the route, or nearby alternate routes change; Route Instruction traversal; ability to synchronize the target's position through its network; to allow scrolling through route commands as appropriate. How to maintain a tracking database in support of this application, including conditions along potential routes such as Traffic Monitoring

ISO 19134 Multimode location based services for routing and navigation: It will specify: Route finding or navigation between two targets using two or more modes of transportation, i.e. finding the most desirable route from an origin to a destination using various available modes of transportation; and calculating a set of procedural "navigation decisions" or route following commands that will execute that route on a single network or on multimode networks.

ISO 19135 Procedures for registration of geographical information items: The development of a single standard or multi-part standard, which specifies procedures to be followed in preparing, maintaining, and publishing a register or registers of unique unambiguous and permanent identifiers, and meanings that, under the direction of ISO/TC 211, are assigned to geographic information items.

ISO 19136 Geography Markup Language (GML): The Geography Markup Language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modeled according to the conceptual modeling framework used in the ISO 19100 series and including both the spatial and non-spatial properties of geographic features. This specification defines the XML Schema syntax, mechanisms, and conventions that provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects; Allow profiles that support proper subsets of GML framework descriptive capabilities; Support the description of geospatial application schemas for specialized domains and information communities; Enable the creation and maintenance of linked geographic application schemas and datasets; Support the storage and transport of application schemas and data sets; and Increase the ability of organizations to share geographic application schemas and the information they describe. Implementers may decide to store geographic application schemas and information in GML, or they may decide to convert from some other storage format on demand and use GML only for schema and data transport.

ISO 19137 Generally used profiles of the spatial schema and of similar important other schemes: Develop a set of profiles of the spatial schema to provide a minimal set of geometric elements necessary for an efficient creation of application schemata.

These profiles will include components from ISO 19107 Spatial schema, ISO 19108 Temporal schema, ISO 19109 Rules for application schema development, ISO 19111 Spatial referencing by coordinates and shall clarify the corresponding encoding rules in ISO 19118 Encoding. The profiles shall support many of the spatial data formats and description languages already developed and in broad use within a group of nations or liaison organizations.

ISO 19138 Data quality measures: This Technical Specification will define a set of measures for the data quality sub-elements identified in ISO 19113 Geographic information - Quality principles. A registry of data quality measures will be established, to include for each measure, an identifier and a code. The measures will be applicable when evaluating the quality of geographic datasets and assessing their fitness for their intended purpose. Multiple measures will be defined for each data quality sub-element, and the choice of which to use will depend on the type of the data and its intended purpose.

ISO 19139 Metadata - Implementation specification: This technical specification will define a UML implementation model that is based on the ISO 19115 abstract UML model. This specification and the associated implementation model will be used in conjunction with an XML schema that will also be defined in this document to describe digital geographic datasets. The implementation described in this document can also be used to describe many other forms of geographic data such as maps, charts and textual documents. It will illustrate how to provide information about the identification, the quality, the spatial reference, and the distribution of digital geographic data.

ISO 19140 Technical amendment to the ISO 191** Geographic information series of standards for harmonization and enhancements: Technical amendments to the ISO 191** Geographic information series of standards to achieve harmonization between them. This will include issues of consistency, cross-references, terminology, data model and presentation. Other amendments necessary to achieve the objectives of these standards will also be included subject to ensuring consistency with the other standards.

4. CONCLUSION

With years of efforts by experts and scholars worldwide, especially the efficient work by OGC and ISO/TC211, the technologies and standards on geographic information sharing have been defined in theory, and addressed in techniques and major standards. Efforts still should be made in the implementation and promotion of these standards. In the past few years, though some standards (such as spatial data transfer standard, Simple Feature Access Specification based on OLE/COM, CORBA or SQL) for spatial data sharing have been forwarded, there are still problems in the pursuit of their implementation. Many GIS software packages do not support them in a complete way. Recently, OGC and ISO/TC211 have started to promote spatial data sharing and interoperability specifications based on Web Services, such as Web Map Service Specification, Web Feature Service Specification, Web Coverage Service Specification and GML. These are easy to implement and have gained support from many GIS manufacturers. They have solved the problem of spatial data sharing in the network. Figure 6 illustrates the result of data overlapping from two different spatial databases based on Web Map Service Specification by using ArcIMS and Web Feature Service Specification by using GeoStar. The result shows that the interoperability specification based on Web Service is easy to realize web spatial data service and interoperability with a bright application prospect.

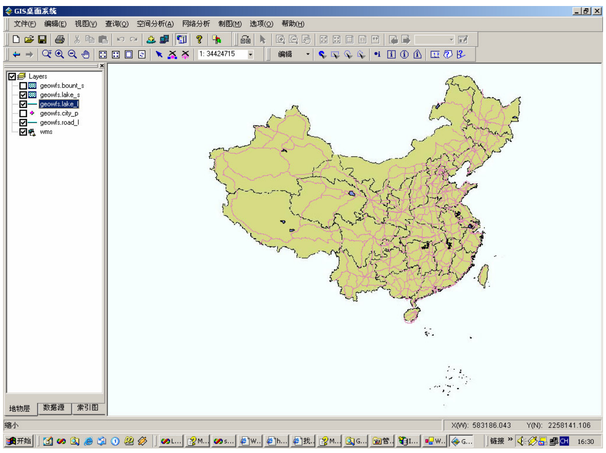

Figure 6 The integrated data from ArcIMS with WMS and GeoStar with WFS

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