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Geographic information — Reference model

Information géographique — Modèle de référence

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19101 was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Annexes A and B of this International Standard are for information only.

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Introduction

Every comprehensive standardization effort needs a reference model to ensure an integrated and consistent approach. This International Standard is a guide to structuring geographic information standards in a way that will enable the universal usage of digital geographic information. This reference model describes the overall requirements for standardization and the fundamental principles that apply in developing and using standards for geographic information. In describing these requirements and principles, this reference model provides a vision of standardization in which geographic information can be integrated with existing and emerging digital information technologies and applications. This International Standard is intended to be used by information system analysts, program planners and developers of geographic information standards that are related to geographic information standards, as well as others in order to understand the basic principles of this series of standards and the overall requirements for standardization of geographic information.

Beyond the needs within traditional applications of digital geographic information, there is a growing recognition among users of information technology that indexing by location is a fundamental way to organize and to use digital data. Increasingly, digital data from a wide variety of sources is being referenced to locations for use in a diversity of applications. Consequently, there is an increasing need for standardization of geographic information and services for processing this information. To meet this need, the ISO 19100 series standardizes relevant aspects of the description and management of geographic information and geographic information services. This standardization will:

— increase the understanding and usage of geographic information;

— increase the availability, access, integration and sharing of geographic information;

— promote the efficient, effective and economic use of digital geographic information and associated hardware and software systems;

— contribute to a unified approach to addressing global ecological and humanitarian problems.

To achieve these goals, standardization of geographic information in the ISO 19100 series is based on the integration of the concepts of geographic information with those of information technology. The development of standards for geographic information must consider the adoption or adaptation of generic information technology standards whenever possible. It is only when this cannot be done that geographic information standards need to be developed.

This International Standard identifies a generic approach to structuring the ISO 19100 series of standards. This reference model uses concepts obtained from the ISO/IEC Open Systems Environment (OSE) approach for determining standardization requirements described in ISO/IEC TR 14252, the IEC Open Distributed Processing (ODP) Reference Model described in ISO/IEC 10746-1 and other relevant ISO standards and technical reports. This International Standard does not prescribe any specific products or techniques for implementing geographic information systems.

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Geographic information — Reference model

1 Scope

This International Standard defines the framework for standardization in the field of geographic information and sets forth the basic principles by which this standardization takes place.

This framework identifies the scope of the standardization activity being undertaken and the context in which it takes place. The framework provides the method by which what is to be standardized can be determined and describes how the contents of the standards are related.

Although structured in the context of information technology and information technology standards, this International Standard is independent of any application development method or technology implementation approach.

2 Conformance

General conformance and testing requirements for the ISO 19100 series of geographic information standards are described in ISO 19105. Specific conformance requirements are described in individual standards in the ISO 19100 series.

3 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 19501-1:—[1], *Information technology — Unified Modeling Language (UML) — Part 1: Specification*

4 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply. Sources of term definitions not defined in this International Standard are provided.

NOTE Throughout this document, certain terms are italicized. These terms are defined either in this clause or in the terms and definitions clause of another part of ISO 19100, as indicated.

4.1
application
manipulation and processing of data in support of user requirements

4.2
application schema
conceptual schema for data required by one or more applications

1) To be published.

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4.3
conceptual formalism
set of modelling concepts used to describe a conceptual model

EXAMPLE UML meta model, EXPRESS meta model.

NOTE One conceptual formalism can be expressed in several conceptual schema languages.

4.4
conceptual model
model that defines concepts of a universe of discourse

4.5
conceptual schema
formal description of a conceptual model

4.6
conceptual schema language
formal language based on a conceptual formalism for the purpose of representing conceptual schemas

EXAMPLE UML, EXPRESS, IDEF1X

NOTE A conceptual schema language may be lexical or graphical. Several conceptual schema languages can be based on the same conceptual formalism.

4.7
dataset
identifiable collection of data

4.8
data level
level containing data describing specific instances

4.9
data quality element
quantitative component documenting the quality of a dataset

NOTE The applicability of a data quality element to a dataset depends on both the dataset's content and its product specification; the result being that all data elements may not be applicable to all datasets.

4.10
data quality overview element
non-quantitative component documenting the quality of a dataset

NOTE Information about the purpose, usage and lineage of a dataset is non-quantitative information.

4.11
feature
abstraction of real world phenomena

NOTE A feature may occur as a type or an instance. Feature type or feature instance shall be used when only one is meant.

4.12
feature attribute
characteristic of a feature

EXAMPLE 1 A feature attribute named "colour" may have an attribute value "green" which belongs to the data type "text".

EXAMPLE 2 A feature attribute named "length" may have an attribute value "82.4" which belongs to the data type "real".

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NOTE 1 A feature attribute has a name, a data type and a value domain associated to it. A feature attribute for a feature instance also has an attribute value taken from the value domain.

NOTE 2 In a feature catalogue, a feature attribute may include a value domain but does not specify attribute values for feature instances.

4.13
feature catalogue
catalogue containing definitions and descriptions of the feature types, feature attributes and feature relationships occurring in one or more sets of geographic data, together with any feature operations that may be applied

4.14
feature operation
operation that every instance of a feature type may perform

EXAMPLE 1 An operation upon the feature type “dam” is to raise the dam. The result of this operation is to raise the level of water in a reservoir.

EXAMPLE 2 An operation by the feature type “dam” might be to block vessels from navigating along a watercourse.

NOTE Feature operations provide a basis for feature type definition.

4.15
functional standard
existing geographic information standard, in active use by an international community of data producers and data users

NOTE GDF, S-57 and DIGEST are examples of functional standards.

4.16
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

4.17
geographic information service
service that transforms, manages, or presents geographic information to users

4.18
geographic information system
information system dealing with information concerning phenomena associated with location relative to the Earth

4.19
graphical language
language whose syntax is expressed in terms of graphical symbols

4.20
lexical language
language whose syntax is expressed in terms of symbols defined as character strings

4.21
metadata schema
conceptual schema describing metadata

NOTE ISO 19115 describes a standard for a metadata schema.

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4.22
profile
set of one or more base standards and — where applicable — the identification of chosen clauses, classes, options and parameters of those base standards that are necessary for accomplishing a particular function

NOTE A base standard is any ISO 19100 series standard or other Information Technology standard that can be used as a source for components from which a profile or product specification may be constructed (see ISO/IEC TR 10000-1).

4.23
quality
totality of characteristics of a product that bear on its ability to satisfy stated and implied needs

4.24
quality schema
conceptual schema defining aspects of quality for geographic data

4.25
schema
formal description of a model

4.26
service
capability which a service provider entity makes available to a service user entity at the interface between those entities

4.27
service interface
shared boundary between an automated system or human being and another automated system or human being

4.28
spatial object
instance of a type defined in the spatial schema

4.29
universe of discourse
view of the real or hypothetical world that includes everything of interest

5 Symbols and abbreviated terms

5.1 Abbreviations

CSMF Conceptual Schema Modelling Facility

ECMA European Computer Manufacturers Association

GIS Geographic Information System

IDL Interface Definition Language

IRDS Information Resource Dictionary System

ISP International Standardized Profiles

IT Information Technology

NIST National Institute of Standards and Technology

OCL Object Constraint Language

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ODP Open Distributed Processing

OMG Object Management Group

OSE Open Systems Environment

UML Unified Modelling Language

5.2 UML notation

The diagrams that appear in this International Standard are presented in accordance with the Unified Modelling Language (UML) specified in ISO/IEC 19501-1:—[1]. The UML notation is described in Figure 1.

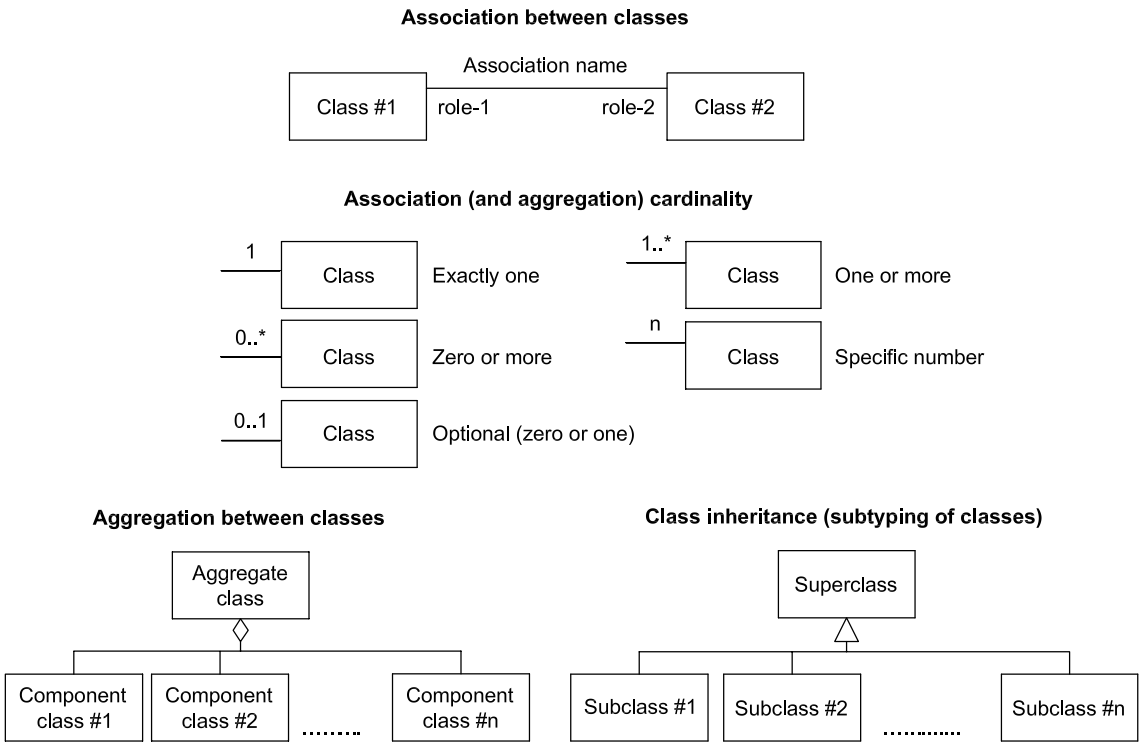

Figure 1 — UML notation

6 Concepts and organization of the reference model

6.1 Integration of geographic information with information technology

The ISO 19100 is a series of standards for defining, describing and managing geographic information. This International Standard defines the architectural framework of the ISO 19100 series of standards and sets forth the principles by which this standardization takes place.

Standardization of geographic information can best be served by a set of standards that integrates a detailed description of the concepts of geographic information with the concepts of information technology. A goal of this standardization effort is to facilitate interoperability of geographic information systems, including interoperability in distributed computing environments. Figure 2 depicts this approach.

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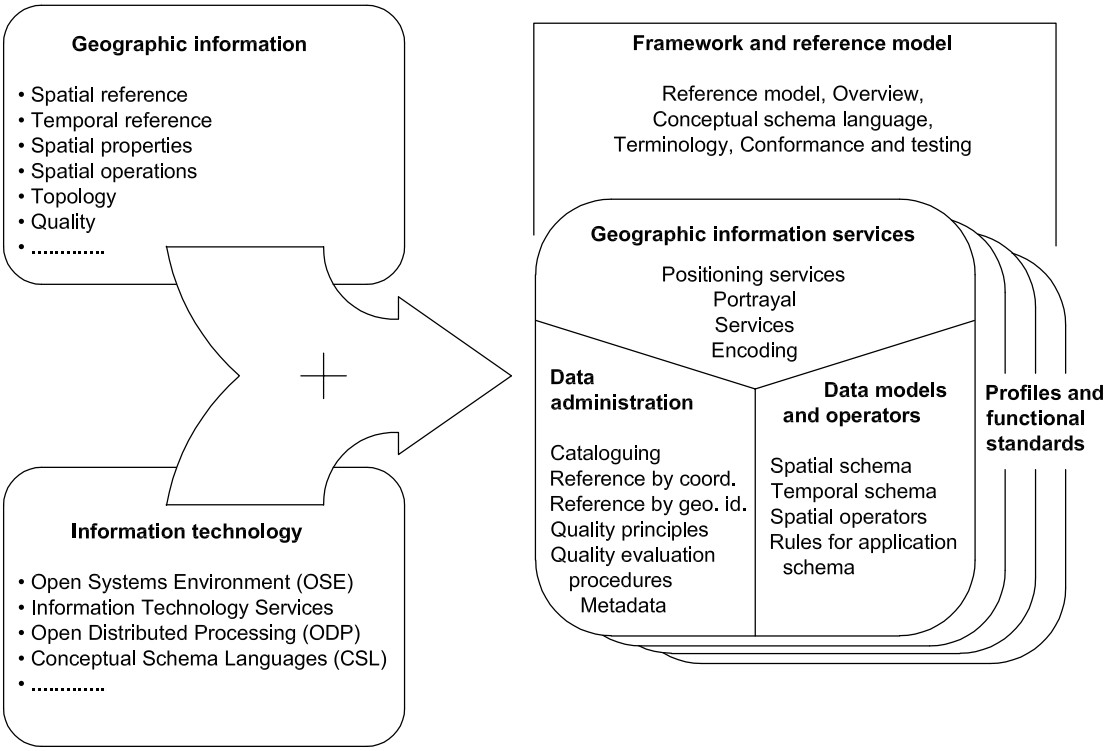

Figure 2 — Integration of geographic information and information technology

The ISO 19100 series of geographic information standards establishes a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. This standard specifies methods, tools and services for management of geographic information, including the definition, acquisition, analysis, access, presentation and transfer of such data in digital/electronic form between different users, systems and locations. In Figure 2, the ISO 19100 series of geographic information standards can be grouped into five major areas, each of which incorporate information technology concepts to standardize geographic information. These major areas describe:

— The framework for the ISO 19100 series of geographic information standards including this International Standard. The framework and reference model cover the more general aspects of the ISO 19100 series of standards. The reference model identifies all components involved and defines how they fit together. It relates the different aspects of the ISO 19100 series of standards together and provides a common basis for communication.

— Geographic information services define the encoding of information in transfer formats and the methodology for presentation of geographic information that is based on cartography and the old traditions of standardized visualisations. This area also includes the field of satellite positioning; together with the formats and interfaces necessary to utilize modern navigational satellite systems.

— Data administration is concerned with the description of quality principles and quality evaluation procedures for geographic information datasets. Data administration also includes the description of the data itself, or metadata, together with feature catalogues. This area also covers the spatial referencing of geographical objects — either directly through coordinates, or more indirectly by use of, for instance, area codes like postal or zip codes, addresses, etc.

— Data models and operators are concerned with the underlying geometry of the globe and how geographic features and their spatial characteristics may be modelled. This area defines important spatial characteristics and how these are related to each other.

— Profiles and functional standards consider the technique of profiling. Profiling consists of putting together “packages/subsets” of the total set of standards to fit individual application areas or users. This supports rapid

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implementation and penetration in the user environments due to the comprehensiveness of the total set of standards. Equally important is the task of “absorbing” existing de facto standards from the commercial sector and harmonizing them with profiles of the emerging ISO standards.

6.2 Focus of standardization in the ISO 19100 series of geographic information standards

The focus of this family of standards is to:

a) define the basic semantics and structure of geographic information for data management and data interchange purposes and

b) define geographic information service components and their behaviour for data processing purposes.

These two focus points are compatible with the information viewpoint and computational viewpoint of ISO/IEC 10746. See Annex B for an overview of RM-ODP.

6.3 Reference model organization

The major clauses of the Reference model are Conceptual modelling (clause 7), the Domain reference model (clause 8), the Architectural reference model (clause 9) and Profiles (clause 10). These clauses are related to the major areas of the ISO 19100 series of geographic information standards (described above at the beginning of clause 6). These relationships are summarized in Figure 3 and explained in the paragraphs that follow.

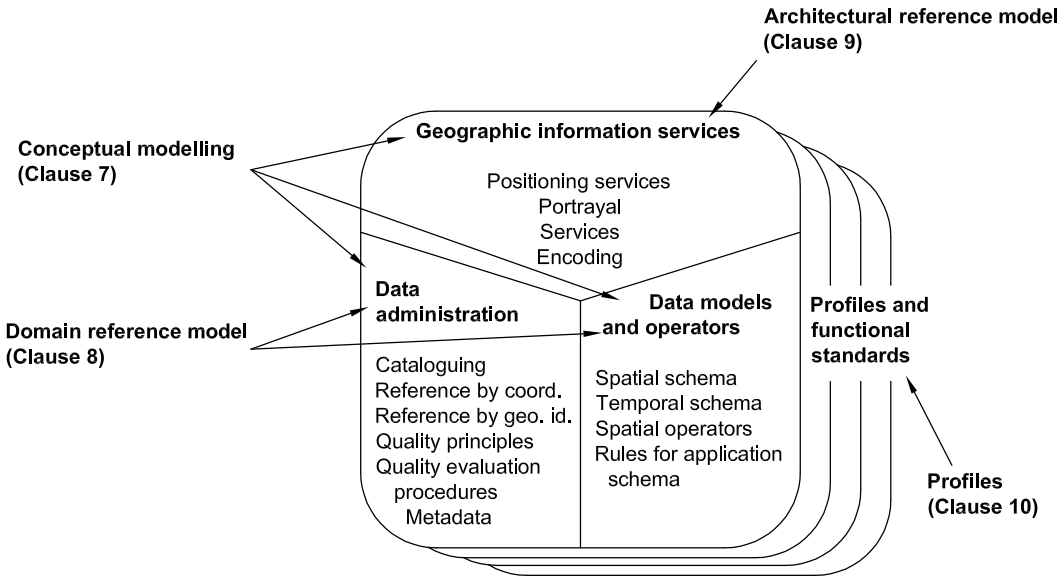

Figure 3 — Relationship of the Reference model to other standards in the ISO 19100 series of geographic information standards

Conceptual modelling. Conceptual modelling is critically important to the definition of the ISO 19100 series of geographic information standards. It is necessary for both the information and computational viewpoints (see Annex A). This family of standards uses conceptual modelling to rigorously describe geographic information. Conceptual modelling is also used to define services for transformation and exchange of geographic information. Conceptual modelling is used to describe both geographic information and geographic information services in profiles and functional specifications that specialize the ISO 19100 standards for particular purposes. A consistent application of conceptual modelling is necessary to assure that the standards in the ISO 19100 series are integrated with this reference model and with each other. The approach to conceptual modelling in the ISO 19100 series is based on the Open Distributed Processing (ODP) Reference Model and the principles described in the Conceptual Schema Modelling Facilities (CSMF). Conceptual Modelling is described in clause 7 of this International Standard. The Open Distributed Processing (ODP) Reference Model is described in ISO/IEC 10746-1. The CSMF is described in ISO/IEC 14481.

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Domain reference model. The *Domain reference model* in clause 8 provides a high-level representation and description of the structure and content of geographic information. This model describes the scope of the standardization addressed by the ISO 19100 geographic information series and identifies the major aspects of geographic information that will be the subject of standardization activity. The *Domain reference model* encompasses both the information and computational viewpoints, focusing most closely on those standards in the ISO 19100 series of standards that standardize

— the structure of geographic information in data models and definition of operations and

— the administration of geographic information.

The *General feature model* defines a metamodel for features and their properties.

The *Domain reference model* uses concepts of the *Information Resource Dictionary System (IRDS) Framework* in ISO/IEC 10027, the *Conceptual Schema Modelling Facilities (CSMF)* in ISO/IEC 14481 and applies concepts from the *Unified Modelling Language (UML)* specified in ISO/IEC 19501-1:—[1]. In order to provide more precise definition and understanding, the *Domain reference model* is described using graphical notation of UML. This is intended for developers of geographic information standards who will use or extend the ISO 19100 series as well as for those who wish to have an in-depth knowledge of this family of standards. 5.2 summarizes the UML notation.

Architectural reference model. In clause 9, the *Architectural reference model* describes the general types of services that will be provided by computer systems to manipulate geographic information and enumerates the service interfaces across which those services must interoperate. This model also provides a method of identifying specific requirements for standardization of geographic information that is processed by these services. Standardization at these interfaces enables services to interoperate with their environments and to exchange geographic information. The *Architectural reference model* is based on concepts of (1) the *ISO Open Systems Environment (OSE)* approach for determining standardization requirements, described in ISO/IEC TR 14252, and (2) the *Open Distributed Processing (ODP) Reference Model*, described in ISO/IEC 10746-1. The *Architectural reference model* focuses primarily on the computational viewpoint (see Annex A).

Profiles. Profiles and functional standards combine different standards in the ISO 19100 series and specialize the information in these standards in order to meet specific needs. Profiles and functional standards facilitate the development of geographic information systems and application systems that will be used for specific purposes. Clause 10 describes the approach to profiling the ISO 19100 series of standards.

To be complete, the reference model must provide an understanding of how it relates to other ISO reference model standards that describe key aspects of information technology upon which the ISO 19100 series is based. Clause 9 describes the relationship between the ISO 19100 series and the Open Systems Environment Reference Model.

6.4 Interoperability of geographic information

6.4.1 Definition of interoperability

Interoperability is the ability of a system or system component to provide information sharing and inter-application co-operative process control. Standardization of geographic information can best be served by a set of standards that integrates a detailed description of geographic information concepts with the concepts of information technology. A goal of the ISO 19100 series standardization effort is to facilitate interoperability of geographic information systems, including interoperability in distributed computing environments. Interoperability provides the freedom to mix and match information system components without compromising overall success. Interoperability refers to the ability to:

a) Find information and processing tools, when they are needed, independent of physical location.

b) Understand and employ the discovered information and tools, no matter what platform supports them, whether local or remote.

NOTE Data exchange is a special case of this level of interoperability.

c) Evolve a processing environment for commercial use without being constrained to a single vendor's offerings.

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d) Build upon the information and processing infrastructures of others in order to serve niche markets, without fear of being stranded when the supporting infrastructure matures and evolves.

e) Participate in a healthy marketplace, where goods and services are responsive to the needs of consumers and where commodity channels are opened as the market expands sufficiently to support them.

6.4.2 Aspects of interoperability

Interoperability between systems has several aspects:

a) Network Protocol interoperability describes basic communication between systems. Communication occurs on two levels. At the higher level, there is the communication between applications. The lower level describes the transmission of signals. Interoperability is required at this level to ensure signals can be sent and received, signals are timely, networks are expandable and security is intact.

b) File System interoperability requires that a file can be opened and displayed in its native format on another system. This includes interoperability for transfer and access of files, as well as naming conventions, access control, access methods and file management.

c) Remote Procedure Calls refer to a set of operations that execute procedures on remote systems. This form of interoperability standardizes how programs run under another operating system.

d) Search and Access Databases provide the ability to query and manipulate data in a common database that is distributed over different platforms. Interoperability challenges include the location and access to the stored data.

e) Geographic Information Systems (GIS) are specific to the geographic community. Interoperability between GIS implies transparent access to data, the sharing of spatial databases and other services regardless of the platform. To achieve interoperability between GIS, a geodata model, service model and information communities model must be utilized. Syntactic interoperability refers to the ability for different systems to interpret the syntax of the data the same way.

f) Application interoperability refers to the ability for different GIS applications to use and represent data in the same manner. To do this, semantic interoperability is required. Semantic interoperability refers to applications interpreting data consistently in the same manner in order to provide the intended representation of the data. Semantic interoperability may be achieved using translators to convert data from a database to an application. The schemas and implementations described in the ISO 19100 series of standards support this level of interoperability.

6.4.3 Interoperability in the ISO 19100 series of geographic standards

In order to support the goal of interoperability in the ISO 19100 series of geographic information standards, the following use of conceptual schema language applies:

— For application schema: An application schema shall either exist or be derivable. Any suitable conceptual schema language can be used, in principle. An application schema shall be created using rules defined in ISO 19109, for the specific conceptual schema language that assure that the application schema conforms to the relevant standards in the ISO 19100 series of standards.

— For data interchange: A generic data interchange mechanism is described in ISO 19118. Another interchange mechanism may be used, in which case a two-way mapping with the relevant ISO 19100 standards shall be provided.

— For service implementations: Supporting service implementations and associated data descriptions, can be based on various platforms such as COM/MS-IDL, CORBA/ISO-IDL, ODBC/SQL, SDAI/EXPRESS, ODMG/ODL and shall then conform to and have two-way mapping with the relevant standards in the ISO 19100 series of standards.

The ISO 19100 series of geographic information standards addresses interoperability in the following standards:

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