INTERNATIONAL STANDARD

ISO 19101

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Geographic information — Reference model

Information géographique — Modèle de référence

Reference number
ISO 19101:2002(E)

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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.

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.

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.

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".

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.

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

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.

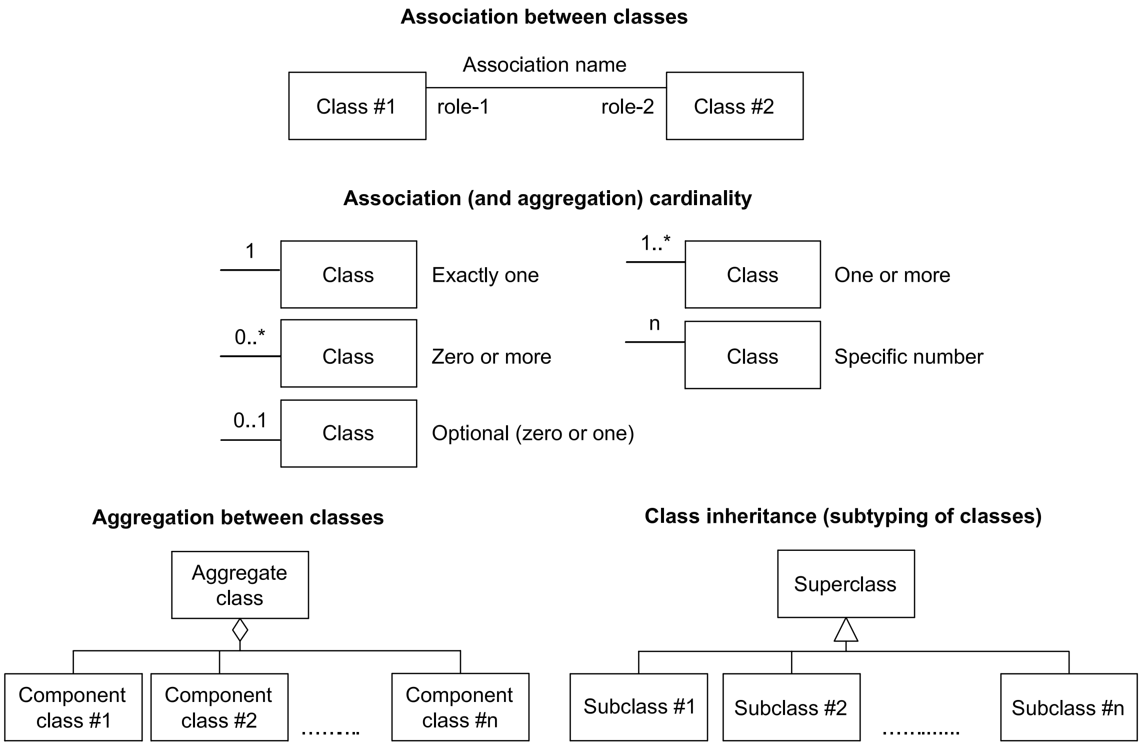


Figure 1 — UML notation

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.

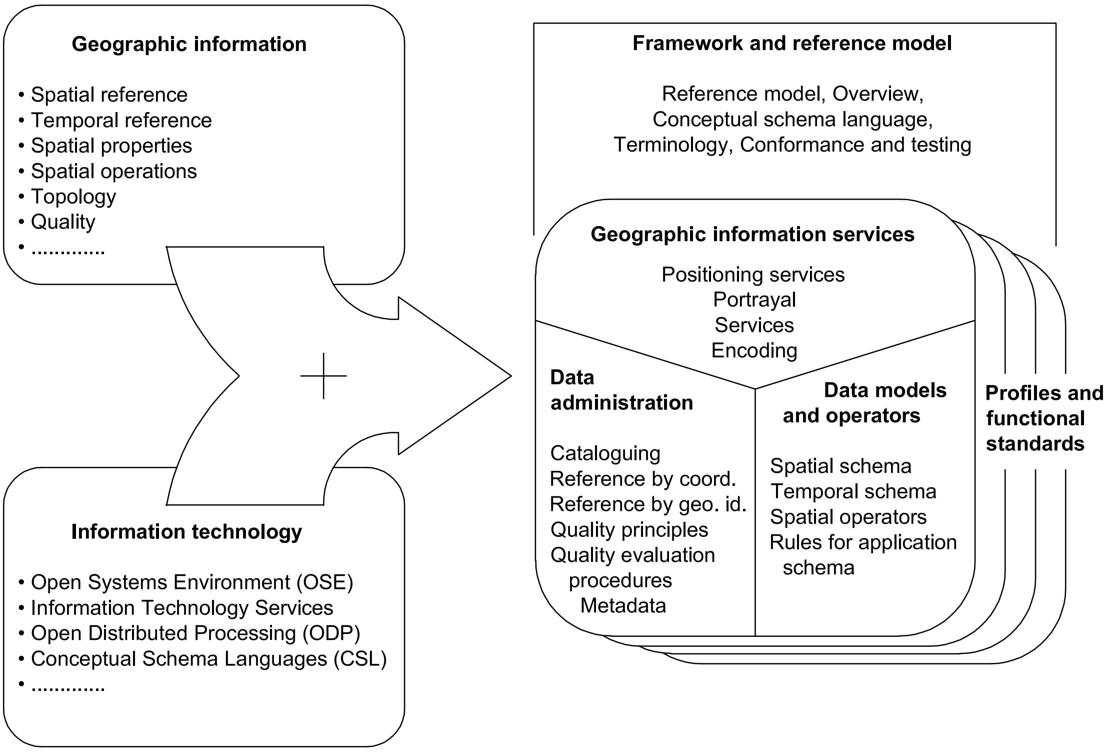


Figure 2 — Integration of geographic information and information technology

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 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.

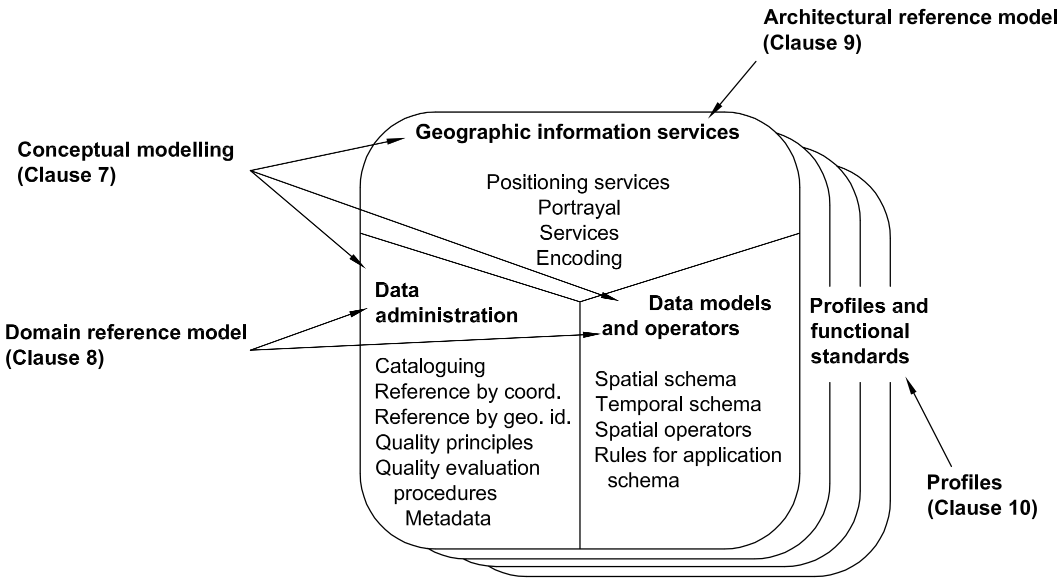


Figure 3 — Relationship of the Reference model to other standards in the ISO 19100 series of geographic information standards

<u>Conceptual modelling</u>. 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.

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.

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:

— Specification of conceptual schema languages for the ISO 19100 series create a framework to enable syntactic interoperability and to support semantic interoperability, while supporting multiple interchange formats and multiple service implementations, is discussed in 7.4 of this International Standard.

— Model integration, discussed in 7.7 of this International Standard ensures the meaningful exchange and sharing of geographic data by computing systems and provides a process for ensuring the consistency of two or more conceptual schemas in order to facilitate interoperability.

— Spatial objects and position can be related to more abstract concepts that may require standardization to ensure interoperability among computing systems. These concepts are directly related to ISO 19107, ISO 19108, ISO 19111 and ISO 19112.

— Service interfaces provide access to geographic information services and enable exchange of data between services and service users, information storage devices and networks. The Architectural reference model identifies general types of interfaces that are used by geographic information services. Clause 9 of this International Standard provides a method for identifying standardization requirements for those interfaces to enable the interoperability of GIS in distributed computing environments.

— The purpose of an encoding standard is to enable interoperability between heterogeneous geographic information systems. To achieve interoperability between heterogeneous systems two fundamental issues need to be determined. The first issue is to define the semantics of the content and logical structures of geographic data. This shall be done in an application schema. The second issue is to define a system and platform independent data structure that can represent data corresponding to the application schema.

7 Conceptual modelling

7.1 Content of this clause

This clause describes the concepts that underlie conceptual modelling in the ISO 19100 series of geographic information standards and identifies the conceptual schema language used to describe geographic information. 7.2 provides a definition of conceptual modelling. 7.3 describes how to use the information provided in this clause. 7.4 identifies the conceptual schema language that is used in the ISO 19100 series for describing models of geographic information and geographic information services. 7.5 provides a description of the approach to conceptual modelling used in the ISO 19100 series. 7.6 identifies the underlying principles used in conceptual modelling. These principles are compiled and defined in ISO/IEC 14481. Finally, 7.7 describes the concept of Model Integration that is fundamental to the effective use of the ISO 19100 series for integrating geographic information in distributed computing environments. More detailed information is also provided in ISO/TS 19103.

Two standards, ISO/IEC 10746-1 and ISO/IEC 14481, provide a framework for the use of conceptual modelling in ISO standards and ensure an implementation-neutral specification and modelling approach. ISO/IEC 10746-1 and ISO/IEC 14481 provide a basis for this clause.

7.2 Definition of conceptual modelling

Conceptual modelling is the process of creating an abstract description of some portion of the real world and/or a set of related concepts. As an example, a set of features such as watercourses, lakes, or islands might constitute a portion of the real world being modelled. A set of geometric constructs, such as points, lines and surfaces, used to describe the shape of these features might be a set of related concepts. The abstract description of these real-world features is called a *conceptual model*. Conceptual models may exist only in the minds of people who communicate them to each other verbally and often imprecisely. They may also be written down and stored for wider dissemination. A *conceptual schema language* provides the semantic and syntactic elements used to describe the *conceptual model* rigorously in order to convey meaning consistently. A *conceptual model* described using a *conceptual schema language* is called a *conceptual schema*. Because a *conceptual schema language* provides a uniform method and format for describing information, it is possible to read and update the resulting *conceptual schema* by computer systems as well as human beings. The use of conceptual schema languages to develop conceptual schemas is thus fundamental to the standardization of geographic information. The ISO 19100 series of geographic information standards employs conceptual modelling for two purposes:

1) to provide a rigorous definition of geographic information and geographic information services.

2) to standardize the definition of geographic information and geographic information services so that software systems interoperate in distributed computing environments.

To achieve the second purpose, standardized schemas for the standards in the ISO 19100 series of standards should serve as a basis for deriving consistent schemas for inter-communicating geographic information services and software systems. The process by which consistency between schemas is achieved is referred to as *Model integration*. The definitions given in this subclause are detailed in 7.5, 7.6 and 7.7.

7.3 Use of this clause

The information contained in this clause is intended for developers of standards in geographic information, for users of the ISO 19100 series of geographic information standards who wish to understand how conceptual modelling is used in this family of standards and for developers of GIS software.

Developers of the ISO 19100 series of standards and developers of standards intended to be consistent with the ISO 19100 series should follow recommendations in this clause on the use of conceptual schema languages for geographic information. Users and developers will need to understand the use of conceptual schema languages in the ISO 19100 series in order to properly use this family of standards and its associated profiles and product specifications to develop GIS software and GIS applications.

7.4 Specification of conceptual schema language for the ISO 19100 series of geographic information standards

ISO/TS 19103 provides a set of requirements for representing the structure of geographic information and for specifying the behaviour of geographic information services. To meet these requirements, the following languages should be used.

The ISO 19100 series of standards shall use the Unified Modelling Language (UML) static structure diagram shown in ISO/IEC 19501-1:—[1)] with UML Object Constraint Language (OCL) as the conceptual schema language for specification of the normative parts of the ISO 19100 series of standards. This satisfies the goal of ISO/TC 211, to create a framework to enable syntactic interoperability and to support semantic interoperability, while supporting multiple interchange formats and multiple service implementations. UML is selected as the conceptual schema language for producing specifications that can support the creation of such a framework.

7.5 The approach to conceptual modelling

This subclause expands upon 7.2 and defines additional concepts needed to understand the ISO 19100 series of geographic information standards, using ISO/IEC 14481 as a partial basis. Figure 4 provides a graphical illustration of the role of conceptual modelling in representing geographic information. The figure shows the use of conceptual modelling to define information, which can be processed by a computer.

Figure 4 describes the relationship between modelling the real world and the resulting conceptual schema. A *universe of discourse* is a selected piece of the real world that a human being wishes to describe in a model. The *universe of discourse* may include not only features such as watercourses, lakes, islands, property boundaries, property owners and exploitation areas, but also their attributes, their functions and the relationships that exist among such features. A universe of discourse is described in a *conceptual model*.

The *conceptual schema* is a rigorous description of a conceptual model for some universe of discourse. As stated in 7.2, a *conceptual schema language* is used to describe a *conceptual schema*. A *conceptual schema language* is a formal language parsable by a computer or a human being that contains all linguistic constructs necessary to formulate a *conceptual schema* and to manipulate its content. A conceptual schema that defines how a universe of discourse shall be described as data is called an application schema.

A *conceptual schema language* is based upon a *conceptual formalism*. The *conceptual formalism* provides the rules, constraints, inheritance mechanisms, events, functions, processes and other elements that make up a conceptual schema language. These elements are used to create *conceptual schemas* that describe a given information system or information technology standard. A *conceptual formalism* provides a basis for the formal definition of all knowledge considered relevant to an information technology application. More than one *conceptual schema language*, either lexical or graphical, can adhere to and be mapped to the same *conceptual formalism*.

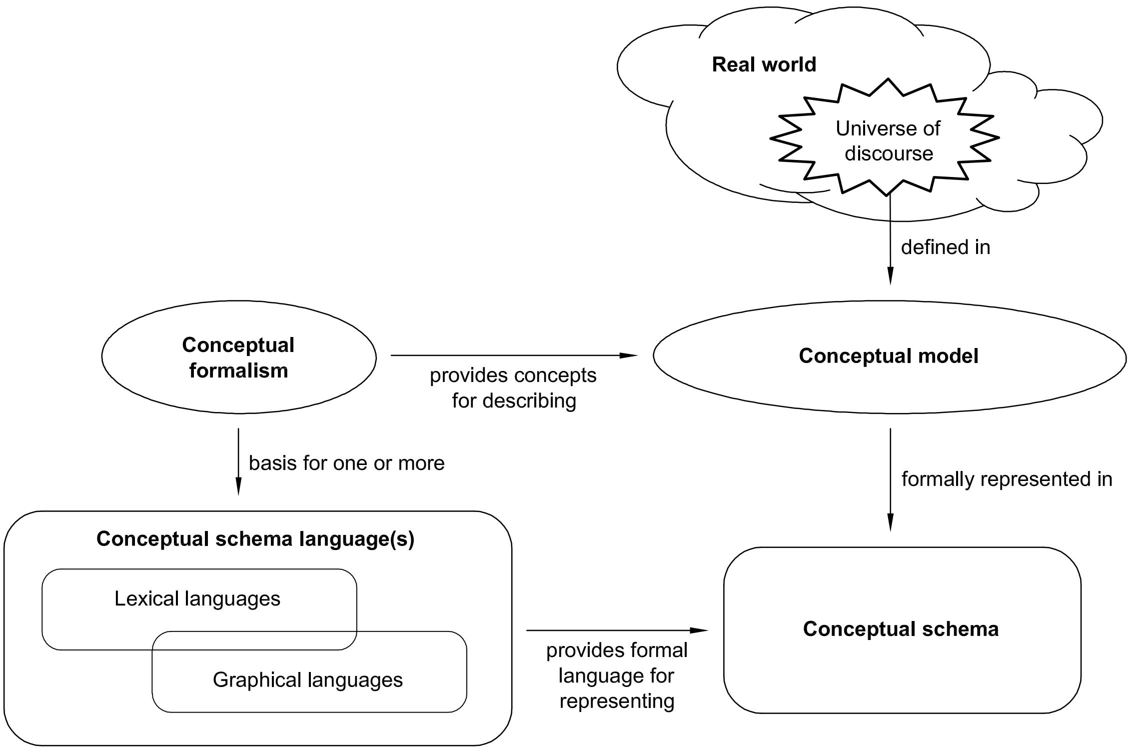


Figure 4 — From reality to conceptual schema

For the ISO series of standards, the applicable *conceptual formalism* is the object-oriented modelling as described by OMG in version 1.0 of UML. Clause 8 of this International Standard, the *Domain reference model*, follows the rules and principles of the object modelling formalism to provide a high-level representation of the domain of geographic information. The Unified Model Language is used to describe the *Domain reference model*. The object-oriented modelling formalism also serves as a basis for the other conceptual schema languages in 7.4.

Conceptual schemas developed for the ISO 19100 series of standards are represented using a *conceptual schema language*. These *conceptual schemas* are integrated into application schemas that define the structure of geographic data processed by computer systems. Encoding of geographic information in support of implementation is addressed in ISO 19118.

7.6 Principles of conceptual modelling

The principles listed in ISO/IEC 14481 govern the use of conceptual modelling and the development of conceptual schemas in the ISO 19100 series of standards. These principles are listed below.

— The **100 % principle** states that all (100 %) of relevant structural and behavioural rules about the universe of discourse shall be described in a conceptual schema. Thus, the conceptual schema defines the universe of discourse.

— The **Conceptualisation principle** states, according to ISO/TR 9007, that a conceptual schema should contain only those structural and behavioural aspects, that are relevant to the universe of discourse. All aspects of physical external or internal data representation should be excluded. This requires the production of a conceptual schema, which is independent with respect to physical implementation technologies and platforms.

— The **Helsinki principle** states that any meaningful exchange of verbal or written statements should be based upon an agreed set of semantic and syntactic rules. All statements in a conceptual schema shall be formulated and interpreted using such an agreed set of rules. The conceptual schema languages identified in 7.4 should provide the basic set of semantic and syntactic rules for representation of geographic information in conceptual schemas developed as part of the ISO 19100 series of standards. ISO/TS 19103 and ISO 19109 describe how conceptual schema languages are applied to create application schemas for geographic applications.

— The principle of **Use of a concrete conceptual schema language syntax** states that a formally defined conceptual schema language syntax shall be used to represent information in a conceptual schema. 7.4 identifies the conceptual schema languages that are used for the ISO 19100 series of standards.

— The **self-description principle** states that normative constructs defined in an international standard — and in this case the ISO 19100 series and profiles of the ISO 19100 series shall be capable of self-description.

These principles underlie the use of the conceptual schema languages identified in 7.4 for representing geographic information and geographic information services in the ISO 19100 series of standards.

7.7 Model integration

Model integration ensures the meaningful exchange and sharing of geographic data by computing systems. In addition it enables the integration and consolidation of geographic data from different sources. Within the context of the ISO 19100 series of standards, this concept is applied to ensure that conceptual schemas developed to describe the structure of data for geographic information systems are consistent with the schemas that are components of the different standards in the ISO 19100 series of standards. Model integration also ensures that schemas describing the structure of data processed by *geographic information services* are consistent with those of the ISO 19100 series of standards.

Model integration enables the exchange of geographic data by computing systems. By describing an approach for developing and integrating conceptual schemas, model integration enables the interoperation of *geographic information services* and geographic information systems in distributed computing environments.

Prerequisites for achieving model integration include the use of common, or at least compatible, conceptual schema languages based on a common conceptual formalism and adherence to rigorous modelling techniques for developing conceptual schemas. ISO 19109 addresses model integration. Beyond this an architecture for model integration may be created and used to enable the consistency of conceptual schemas that describe applications of geographic information. Such an architecture will define the different roles, conceptual schemas may play with respect to one or another, the different relationship identified among conceptual schemas and the different mappings required between conceptual schemas.

8 The Domain reference model

8.1 Content of this clause

This clause describes the aspects of geographic information that are addressed in the ISO 19100 series of geographic information standards. A basic definition of the *Domain reference model* is provided in 8.2 together with its scope and objectives. 8.3 describes the intended uses of this model. In 8.4, the model is presented at a high level intended for those who need only a basic familiarity with the model's contents. 8.5 and 8.6 provide a more detailed description that is intended for persons who require an in-depth understanding of the ISO 19100 series of standards and its relationship to the domain of geographic information.

8.2 Definition of Domain reference model

The *Domain reference model*:

— provides a high-level description of those aspects of geographic information that are addressed in the ISO 19100 series of standards;

— identifies the major concepts used in the ISO 19100 series of standards for the representation, organization, storage, interchange and analysis of geographic information for computing purposes.

The *Domain reference model* provides a generalized view of the subject matter standardized in the ISO 19100 series of standards. The *Domain reference model* shows the place of the General feature model in the context of geographic information (see 8.6.7). To provide more in-depth understanding of the domain of geographic information and its relationship to the ISO 19100 series of standards, this model employs concepts obtained from the ISO Conceptual Schema Modelling Facility (CSMF) (described in more detail in Annex A and ISO/IEC 14481) and the ISO Information Resource Dictionary System (IRDS) framework in ISO/IEC 10027. These standards have been developed by ISO in order to provide a framework for the use of information technology by ISO standards and to ensure an implementation-neutral specification.

8.3 Uses of the Domain reference model

The *Domain reference model* is intended for developers of geographic information standards, for GIS product developers and for GIS users. This model has three uses:

— The model provides a high-level description of the scope of standardization of the ISO 19100 series of geographic information standards.

— The model depicts relationships that exist in the domain of geographic information. This helps to understand the relationships between the standards in the ISO 19100 series that address subject matter in different areas of that domain.

— The goal of the *Domain reference model* is to provide a complete representation of the domain of geographic information. Thus, developers of geographic information standards may use this clause to identify topics that require standardization but are not addressed by the ISO 19100 series of standards. This provides a basis for expanding existing standards in the ISO 19100 series or developing proposals for new standards.

The high-level model presented in 8.4 satisfies the first use of the *Domain reference model*. This is intended primarily for GIS software product developers and GIS users who need to know the scope of applicability of the ISO 19100 series of standards.

8.5 and 8.6 provide a more detailed description to satisfy the second and third purposes listed above. These subclauses are intended for developers of geographic information standards within the ISO 19100 series of geographic information standards as well as for those who wish to have an in-depth knowledge of this family of standards. Developers of the standards in the ISO 19100 series, developers of future extensions of the ISO 19100 series and developers of standards that will be consistent with the ISO 19100 series should consult these subclauses to determine if their specification is within the scope of the ISO 19100 series of standards.

UML notation is used to provide a graphical description of the *Domain reference model*. The UML symbols used are summarized in 5.2. In the Reference model, UML models are used to describe concepts and are not a basis for implementation. Actual cardinality constraints for use in conformance of implementations are defined in other standards in the ISO 19100 series of standards.

8.4 Overview of the Domain reference model

Figure 5 shows a high-level view of the domain of geographic information.

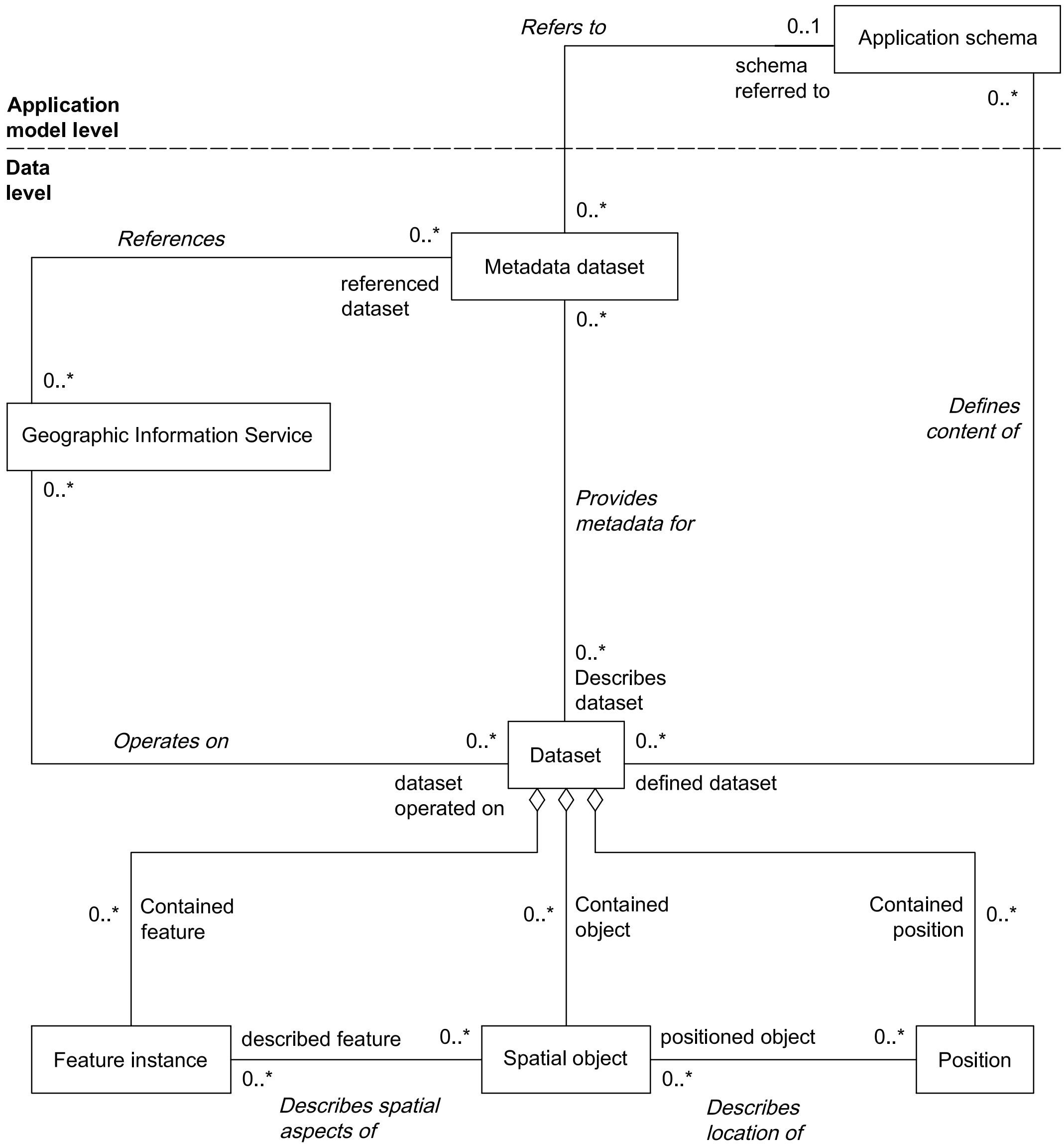


Figure 5 — High-level view of the Domain reference model

The contents of this diagram may be described as follows.

— The *dataset* which contains:

1) *Features*, including feature attributes, feature relationships and feature operations (defined mathematical operations for computing information about features).

2) *Spatial objects* that may describe the spatial aspects of *features*, or are complex data structures that associate values of attributes to individual positions within a defined space. There are two general approaches to model the spatial aspects of geographic information:

— To perceive the space as occupied by features, which are described by using vector data.

— To imagine the variation of values of interest over the space as some distribution function.

3) Descriptions of the *position* of *spatial objects* in space and time, using units of measure provided by reference systems.

NOTE The existence of direct position is dependent upon the existence of the *spatial object* whose position it describes. Indirect position and temporal position are associated with features (see 8.6.4).

- The *application schema* provides a description of the semantic structure of the *dataset*. The *application schema* also identifies the spatial object types and reference systems required to provide a complete description of geographic information in the *dataset*. Data quality elements and data quality overview elements are also included in the application schema (see 8.6.5 for details).

- The *metadata dataset* allows users to search for, evaluate, compare and order geographic data. It describes the administration, organization, contents and quality of geographic information in *datasets*. It may contain or reference the application schema for the geographic dataset. It may contain or reference the feature catalogue that contains the definitions of concepts used in the application schema. The structure of the *metadata dataset* is standardized in a metadata schema that is defined in ISO 19115. The metadata schema is described further in 8.6.6.

- *Geographic information services*, implemented as software programs operate on geographic information contained in *datasets*. These services reference information in the *metadata datasets* in order to correctly perform retrieval operations as well as manipulation operations such as transformation and interpolation.

Services access data in a networked environment in which *datasets* are stored in distributed database management systems. Within *datasets*, *features* may be associated with a set of values that is derived from a distribution function in order to provide information about areas.

For the ISO 19100 series of standards, non-geographic features are also valid. Such features may be included in the *application schema* and not have spatial characteristics.

8.5 Use of abstraction levels in the Domain reference model

Abstraction is a process by which the relevant characteristics of features or concepts are selected, defined and clearly represented. Abstraction provides a method both for gaining greater insight into a field of study and for defining computer information systems. The use of higher levels of abstraction helps to better understand the domain of geographic information and relationships of various aspects of this domain to the different standards in the ISO 19100 series.

The *Domain reference model* utilizes three levels of abstraction that are described below. These levels are based on the Conceptual Schema Modelling Facility (CSMF) Schema Architecture described in ISO/IEC 14481 (see Annex A for additional information.[2])

- The *data level* contains information describing specific features, or *instances*, found in reality. This includes *features*, the description of spatial aspects of features and position.

- The *application model level* contains both *application schemas* and the *conceptual schemas* standardized in the ISO 19100 series of standards. These schemas define the types of *instances* that exist at the *data level*. The metadata schema is also at this level.

  1) *Application schemas* describe geographic information datasets. They consist of type definitions for collections of similar *instances* found at the data level. Examples of abstract type definitions include feature types, types of spatial objects and data quality elements. Reference systems are also specified as part of the *application schema*. These type definitions may be obtained from standardized conceptual schemas (described below).

  2) The *application model level* also contains conceptual models developed using the General Feature Model that serve as a basis for defining *application models.* The application level includes schemas standardized in the ISO 19100 series of standards, such as the spatial schema, temporal schema, metadata schema, or the quality schema as well as schemas from other standards. Profiles and product specifications also are within the *application model level*. *Application schemas* are required to conform to conceptual schemas standardized in the ISO 19100 series of standards.

2) The reader may wish to consult Annex A to obtain a more complete description of the ISO CMSF Schema Architecture levels of abstraction before proceeding.

— The *meta-model level* [meta-model level/Language level] identifies the language used to define a schema at the *application model level*. This includes the *conceptual schema languages* used to describe schemas at the *application model level* and the *General feature model*.

In the high-level view of the domain of geographic information shown in Figure 5, all entities are at the *data level*, with the exception of the application schema. The *application schema*, which may be referenced by the *metadata dataset*, is at *application model level*.

8.6 Detailed description of the Domain reference model

8.6.1 Introduction

The information in Figure 5 showing the high-level view of the *Domain reference model* is expanded in six subclauses within this clause. The subclauses also describe the connections of the entities to standards in the ISO 19100 series of standards and point out interrelationships between different standards.

— 8.6.2 describes the *application schema*.

— 8.6.3, 8.6.4 and 8.6.5 provide a generalized view of the standardized schemas from which parts of the *application schema* are drawn. 8.6.3 provides additional information about *spatial objects* and their relationship to *position*. This is followed by 8.6.4 which provides more information on *position* and its relationship to *reference systems* and by 8.6.5, which focuses on quality and its relationship to the *dataset*.

— 8.6.6 focuses on metadata and its relationship to the *dataset*. 8.6.7 describes the relationship of the *General feature model* to *feature catalogues* and other parts of the *Domain reference model*.

8.6.2 Application schema

8.6.2.1 Introduction

For each geographic dataset an *application schema* exists. (It may be explicitly given in a conceptual schema language, or implicitly given by the internal structure of a software program.)

The *application schema* is a conceptual schema at the *application model level* and contains the complete and exact definition of the contents and structure of the geographic dataset. It contains selected parts of standardized schemas. The *application schema* may be purely internal for a certain implementation (either a system or a database), or may be common for two or more implementations.

An *application schema* that conforms to the ISO 19100 series of standards shall be defined in a formal conceptual schema language. This will allow automated processing of geographic datasets, e.g. encoding, data access, data transfer, querying and updating.

8.6.2.2 Details of the application schema

An application schema has the following parts:

— The *application schema* contains a complete and precise description of the semantic content of the geographic dataset following the concepts and structure defined in the General feature model. This schema contains concepts that can be mapped to feature types, feature attribute types, feature relationship types and feature operation types and which may originate in a *feature catalogue*. The *General feature model* is described at a high level in 8.6.7.

— The *application schema* contains a specification of the reference system(s) used to represent position or — the reference system(s) to which position is referenced. (Position is described by a reference system, discussed in 8.6.3 and shown in Figure 6.)

— The *application schema* contains the spatial object types used to represent the spatial aspects of *features* (spatial object types are obtained from the spatial schema which is described in 8.6.3 and shown in Figure 7).

Figure 6 illustrates the application schema and its possible content graphically.

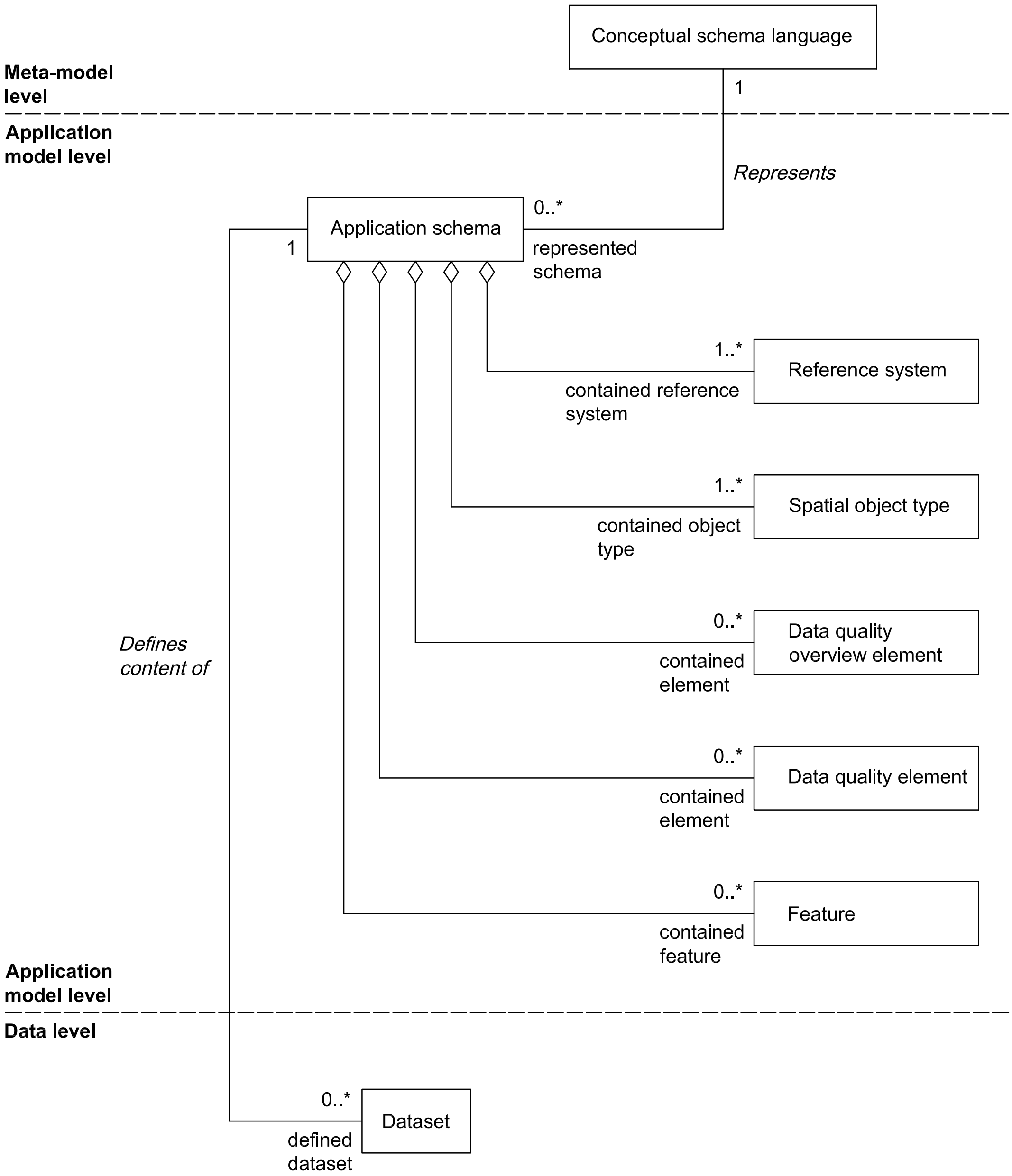


Figure 6 — Details of the application schema

The *application schema* also contains *data quality elements* and *data quality overview elements*, described in 8.6.5, that contains quality information for individual features, feature attributes and feature relationships.

The *application schema* contains and integrates parts of the other standardized schemas that are necessary to describe the structure and content of a particular *dataset*, including *spatial schema*, *quality schema* and the *reference system schemas* (described below). The integration into the application schema of the standardized ISO 19100 series of standards schemas is defined in a rigorous manner in order to facilitate automated processing of geographic *datasets*. The rules on how to create an application schema for a geographic information dataset using the ISO 19100 series of standards schemas are found in ISO 19109.

8.6.2.3 Application schema, data interchange and encoding rules

Data interchange is the procedure for encoding, delivery, transfer, receipt and interpretation of (geographic) *dataset*. Successful data interchange depends on the knowledge of the content and structure of the *dataset*, the encoding rules applied and the kind of transfer protocol used. The *application schema* defines the possible content and structure of the dataset.

The encoding rules define the conversion rules for coding the *dataset* into a system independent data structure. The system independent data structure can be transferred using a transfer service that utilizes on-line or off-line or combination of off-line transfer protocols and communication media, e.g., ftp, Internet, mail, or CD ROM. Data interchange is realized using generic information technology. ISO 19118 defines the encoding rules to be used to ensure a consistent conversion to a system independent format.

8.6.3 Spatial objects and position

Spatial objects and *position* can be related to more abstract concepts that may require standardization to ensure interoperability among computing systems. These concepts directly relate to ISO 19107, ISO 19108, ISO 19111 and ISO 19112.

In Figure 7 individual *spatial objects* are defined by *spatial object types* that in turn can be defined using constructs of the *spatial schema*.

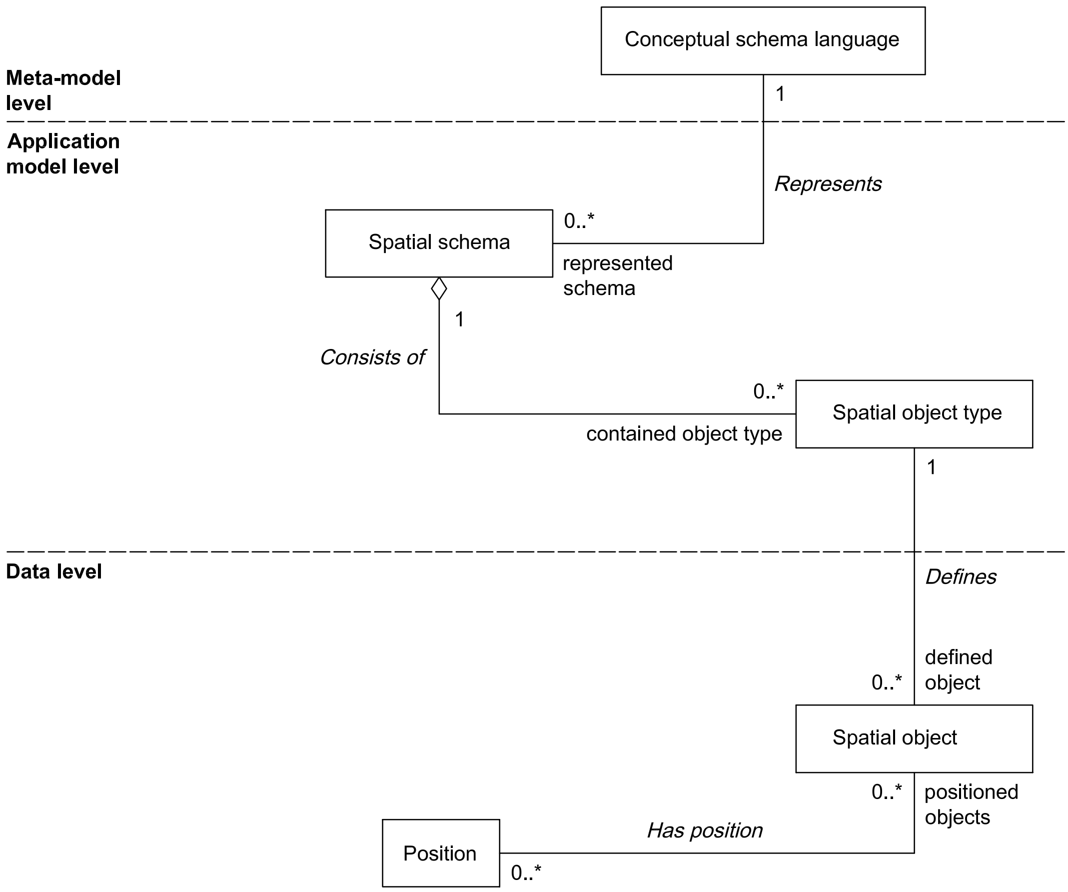


Figure 7 — Detail on spatial objects [3)]

3) Further detail on position is provided in 8.6.4 and Figure 8. This includes direct, indirect and temporal position and the relationship of these types of position to spatial objects and features.

Spatial objects and *position* are at the data level in Figure 7. *Spatial object types* and the *spatial schema* are at the *application model level*. In the ISO 19100 series of standards, the *spatial schema* encompasses different kinds of spatial organizations. To develop an application schema, the *spatial schema* may be specialized, providing constructs for defining a limited set of *spatial object types*. The relationship of *spatial object types* to the *application schema* was described in 8.6.2. The *spatial schema* is placed at the *application model level* and is represented by *conceptual schema languages* at the *meta-model level*.

8.6.4 Reference systems

In Figure 8 *position* is described in terms of, or referenced to, one or more spatial and temporal *reference systems* which define the method for describing position in space and time respectively. Figure 8 shows this relationship and enumerates some subtypes of reference systems. *Reference systems* are subtyped into *spatial reference systems* and *temporal reference systems*.

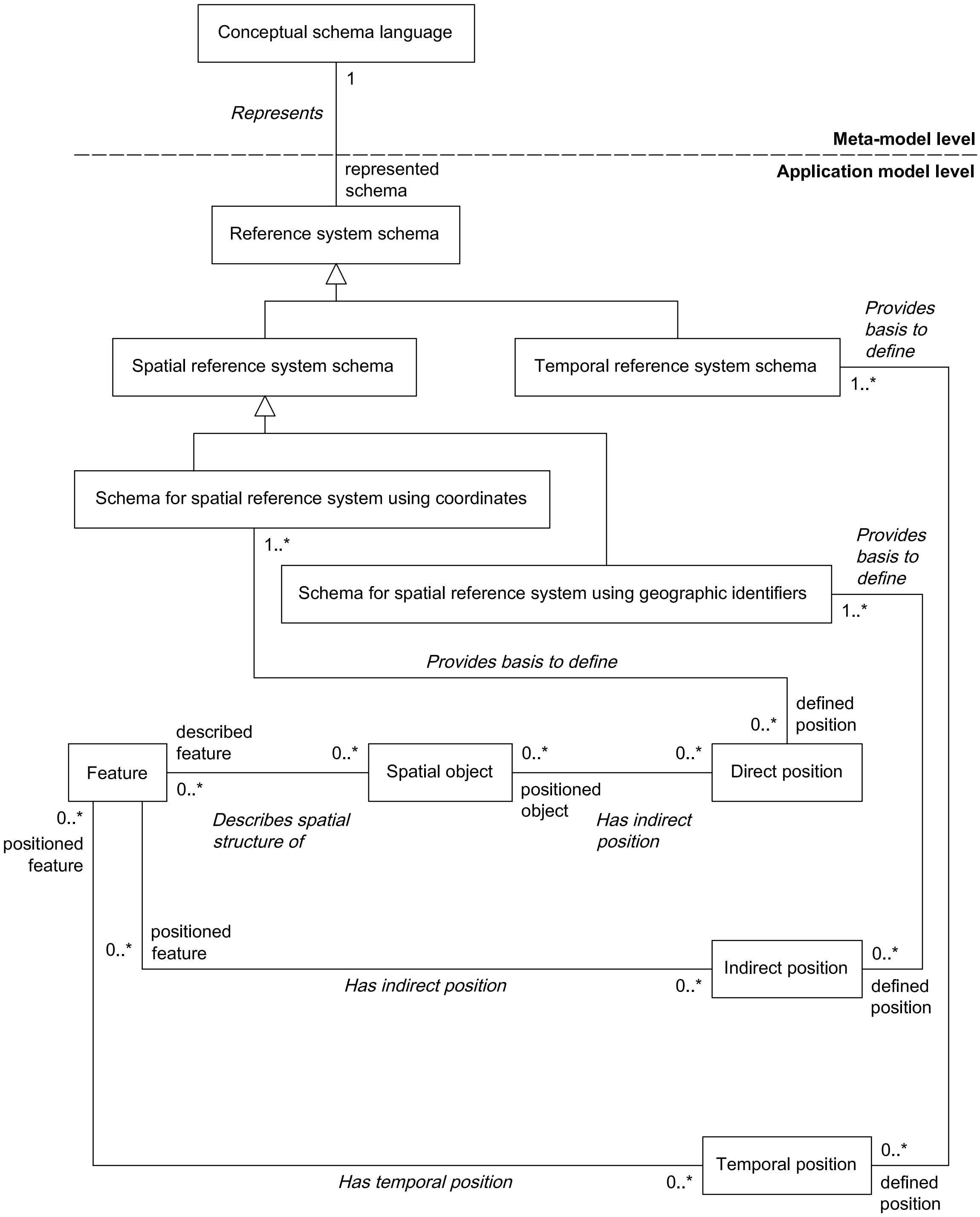


Figure 8 — Detail on position

Spatial reference systems are subtyped into spatial reference systems using coordinates and spatial reference systems using geographic identifiers. All types of reference systems are considered schemas at the application model level. Reference systems are represented using conceptual schema languages at the meta-model level. At the *data level*, a dataset may contain spatial objects whose position is described by more than one type of reference system. In addition, more than one spatial object may have the same position. Position and temporal position of features may also be described in terms of spatial reference systems for geographic identifiers and temporal reference systems respectively.

8.6.5 Quality

Figure 9 provides a graphical description of the essential relationship of quality to geographic data. Quality is described in detail in ISO 19113.

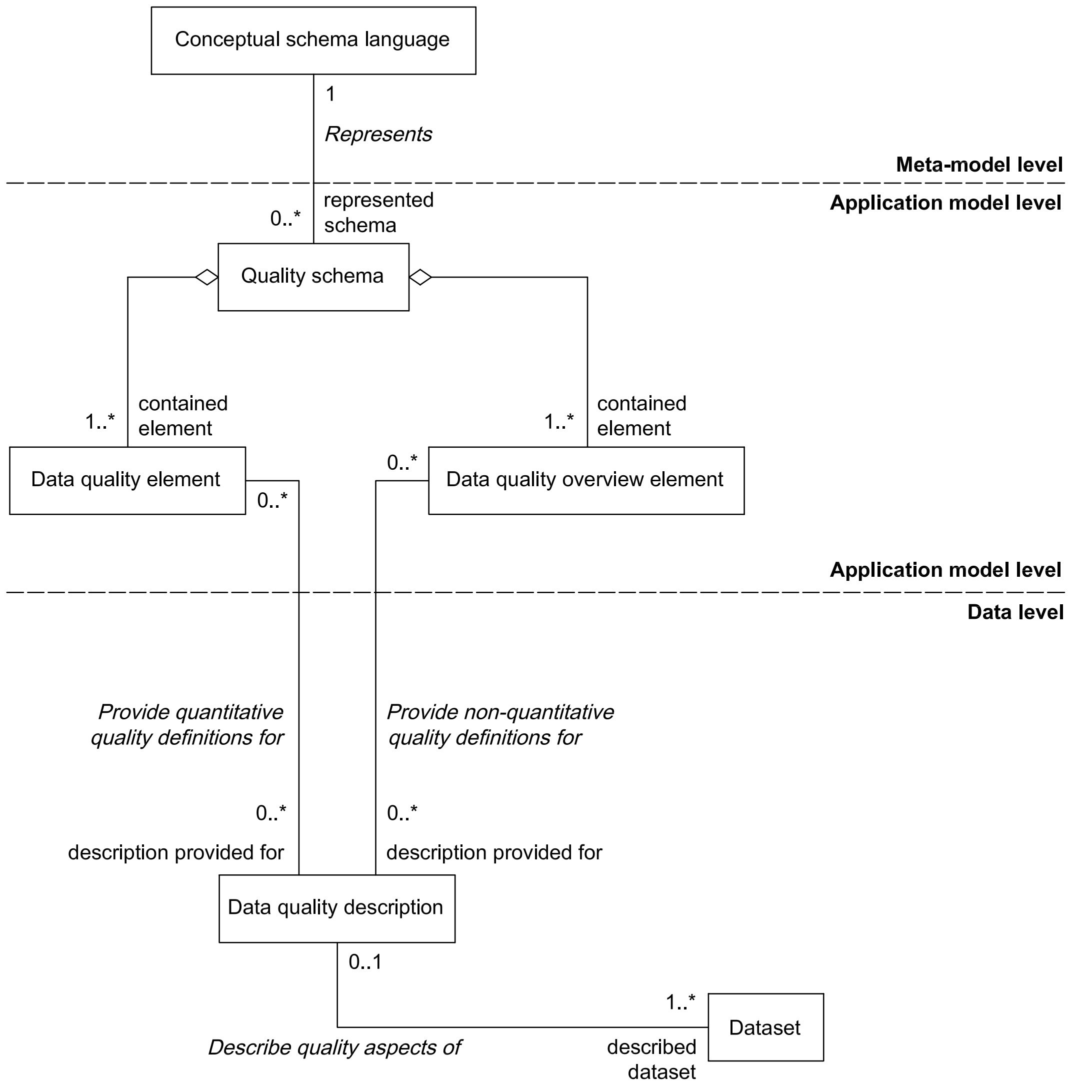


Figure 9 — Data quality and geographic information

Data quality elements and *data quality overview elements* are defined in the *quality schema*, a standardized schema at the *application model level*. The quality information for applicable *data quality elements* (that describe quantitative quality information) and *data quality overview elements* (that describe non-quantitative quality information) is reported in the *data quality description*, placed at the data level. The *data quality description* reports quality information for:

— geographic *datasets* and

— individual *features*, *feature attributes*, or *feature relationships*.

Examples of *data quality elements* are completeness and positional accuracy. Examples of data quality overview elements are purpose and lineage.

Quality information may or may not be provided for geographic data; hence the relationship is denoted as being optional. The placement of *data quality elements* and *data quality overview elements* with respect to the *application schema* was described in 8.6.2.

8.6.6 Metadata

This subclause provides further information on *metadata* including the standardized *metadata schema* and its relationship to *metadata datasets* and geographic *datasets*. The role of the *application schema* is restated to make clear its relationship to *metadata*. This is shown in Figure 10. For detailed information on metadata, please refer to ISO 19115.

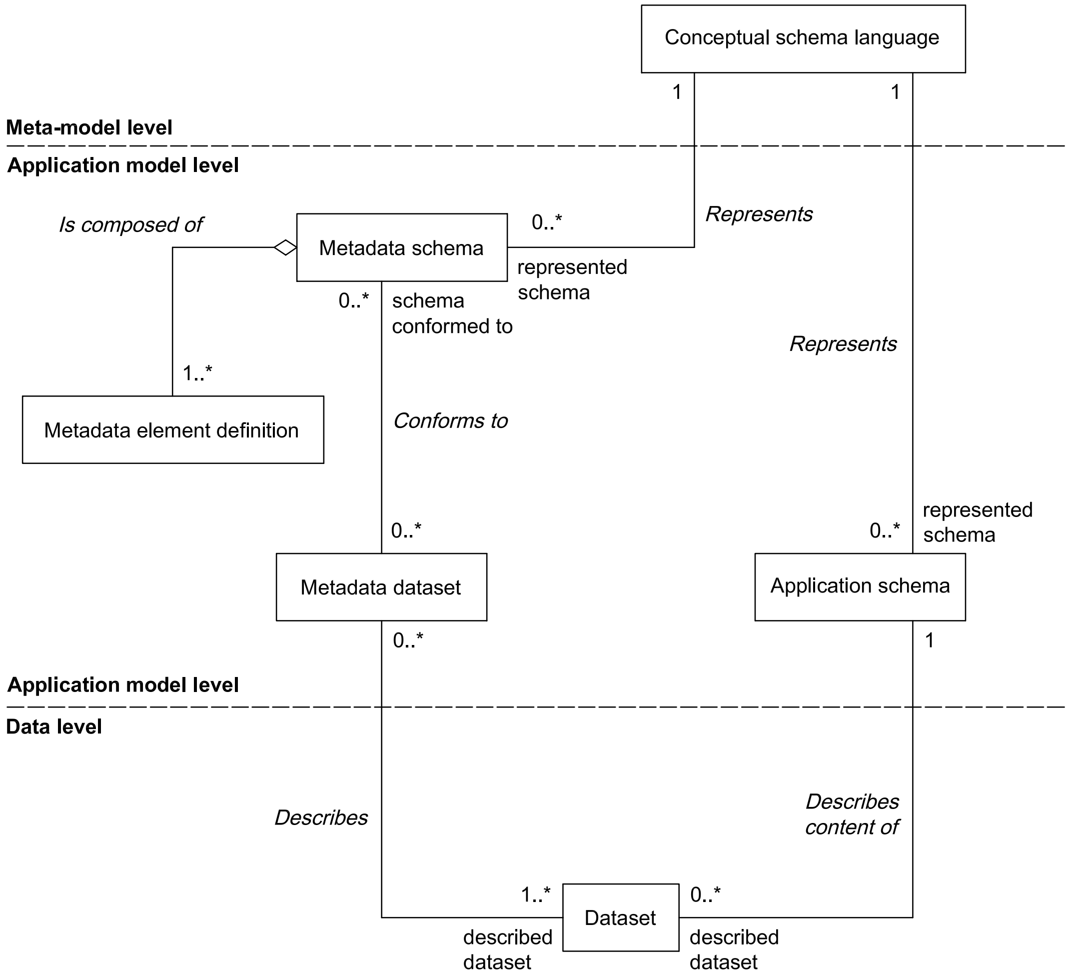


Figure 10 — Detail of metadata relationships

In Figure 10, a *conceptual schema language* at the *meta-model level* represents a *metadata schema*, a standardized schema at the *application model level*. The *metadata schema* is a standardized schema described in ISO 19115. This schema provides the *metadata element definitions* (or types of metadata elements) for the metadata in a *metadata dataset*.

A *metadata dataset*, in turn, describes the administration, organization and content of a *dataset* at the *data level*. The *metadata dataset* provides necessary information in order to support access to, and transfer of, the *dataset*. The *application schema* may be referred to by, or included in, the *metadata dataset*. In Figure 10, the *metadata dataset* is shown as conforming to the standardized *metadata schema*.

Also included in the metadata dataset is the quantitative and non-quantitative quality information for geographic information datasets (as opposed to individual feature described in 8.6.5). Other parts of the metadata dataset, not described here, provide identifying information for the dataset itself and are also at the data level (see ISO 19115).

8.6.7 General feature model

The *General feature model* (GFM) is a meta-model for developing conceptual models of feature types and their properties. It defines the concept of feature type, feature attribute, feature association and feature operation. It also serves as a meta-model for feature catalogues by providing the structure for representing the semantics of geographic information in these terms.

As there is no GFM-language and the conceptual schema must be expressed in a CSL, the concepts of the GFM must be mapped into the concepts of the used conceptual schema language. The structure and concepts of the GFM must be kept in mind when making the conceptual model. The result can be documented in terms of GFM in a feature catalogue.

The *application schema* contains instances of types defined in the *General feature model*. It is used by experts in business requirements for the geographic information domain to develop *application schemas* for specific *applications*. For example, the *General feature model* defines the concept of feature type while an *application schema* defines specific feature types such as Road or Lake.

Figure 11 shows the relationship between the *General feature model*, the *application schema* and the *feature catalogue*.

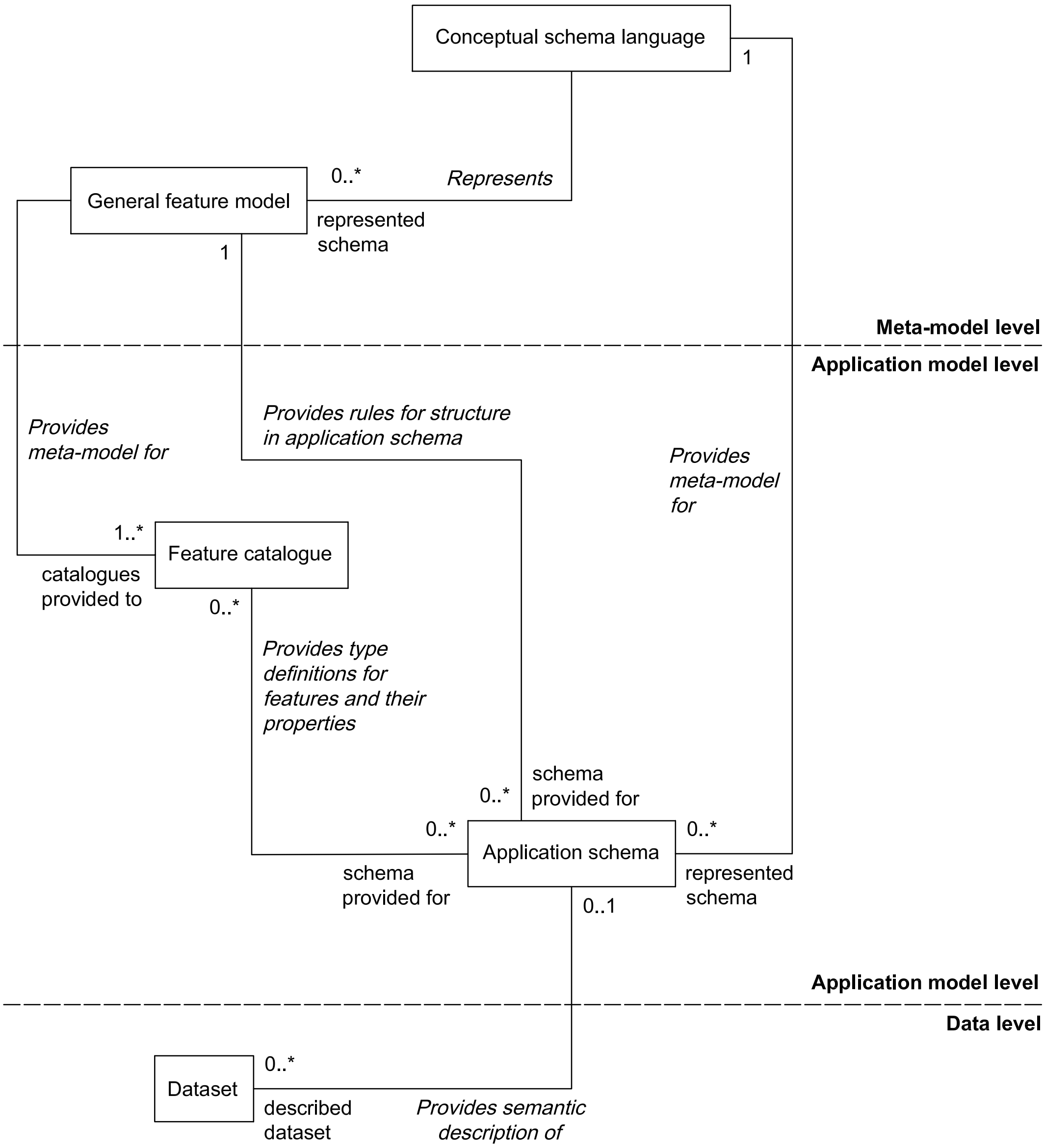


Figure 11 — Detail of relationships to the General feature model

The relationship between the *application schema* and *dataset* described in 8.6.2 is repeated in this diagram. Similarly, the relationship of *conceptual schema language* to the *application schema* is also shown again for illustrative purposes. It should also be noted that *feature catalogues* may be included in the metadata set (not depicted in Figure 11).

See ISO 19109 for further detail on the *General feature model*.

9 The Architectural reference model

9.1 Content of this clause

The *Architectural reference model* defines a structure for *geographic information services* and a method for identifying standardization requirements for those services. The basic definition of the *Architectural reference model* is provided in 9.2, together with its scope and objectives. 9.3 provides a description of the intended uses of this model. 9.4 provides a high-level description intended for those who need only a basic familiarity with the model. 9.5 provides a detailed description of the structure of *geographic information services*. 9.6 explains the method of identifying standardization requirements. 9.5 and 9.6 are intended for persons who require an in-depth understanding of the *Architectural reference model*.

The basis for the *Architectural reference model* is the ISO Open Systems Environment (OSE) Reference Model, described in ISO/IEC TR 14252. While prior knowledge of the OSE Reference Model is useful, the careful reader who has a basic familiarity with the concept of reference models can understand the content of this clause.

9.2 Definition of the Architectural reference model

The *Architectural reference model* defines a structure for *geographic information services* and a method for identifying standardization requirements for those services. This model provides an understanding of what types of services are defined in the different standards in the ISO 19100 series of standards and distinguishes these services from other information technology services. The *Architectural reference model* shows how to determine which aspects of geographic information will need to be standardized to support the operation of those services. Thus, the model provides guidance to the program of standardization undertaken in the ISO 19100 series of standards. Other standards bodies that are standardizing geographic information may also consult the *Architectural reference model* for guidance.

9.3 Uses of the Architectural reference model

The *Architectural reference model* is intended for developers of geographic information standards, for GIS developers and for GIS users. This model:

— Defines classes of information technology services, providing a framework for identifying individual *geographic information services*.

— Provides a method for determining requirements for standardizing geographic information that will enable *geographic information services* to function.

The *Architectural reference* model ensures that the ISO 19100 series of geographic information standards addresses all relevant standardization requirements for geographic information. 9.4 provides an overview of the entire model. 9.5 describes the types of geographic information services and their relationship to the different standards in the ISO 19100 series. GIS software developers and GIS users who need to gain an understanding of geographic information services in the ISO 19100 series of standards should read 9.5. Standards developers who need to ensure consistency with the ISO series of standards should refer to this subclause to identify which services are supported by their specification. These services should fall within the service classes described in this subclause.

9.6 should be read by developers and users of geographic information standards who wish to understand how the identification of geographic information services can be used to determine standardization requirements for geographic information. Developers of the ISO series of standards and developers of standards that are intended to be consistent with the ISO 19100 series of standards should consult this subclause to determine what standardization requirements are addressed by their specification. These requirements should support geographic information services that fall within the services classes outlined in 9.5.

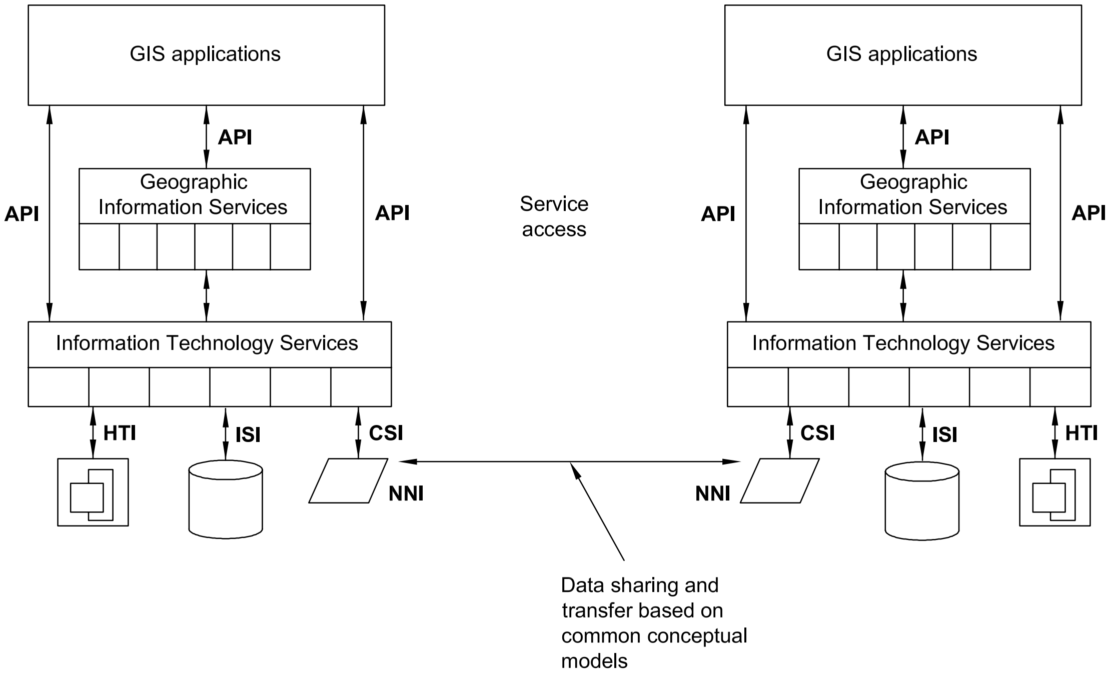
9.4 Overview of the Architectural reference model

9.4.1 Introduction

The *Architectural reference model* is a specialization of the Open Systems Environment (OSE) Reference Model for geographic information services in distributed computing environments. The *Architectural reference model* is shown in Figure 12.

9.4.2 Services and service interfaces

Figure 12 depicts the basic OSE worldview in which GIS applications utilize capabilities provided by services.



Key

API Application Programming Interface
HTI Human Technology Interface
ISI Information Services Interface
CSI Communications Services Interface
NNI Network to Network Interface

Figure 12 — The Architectural reference model

The diagram shows application systems and services residing at different computing sites linked by a network. *Services* are capabilities provided for manipulating, transforming, managing, or presenting information. *Service interfaces* are boundaries across which services are invoked and across which data is passed between a service and an application, external storage device, communications network, or a human being. The diagram shows four interfaces:

— The **Application Programming Interface** (API) is the interface between services and application systems. This is the interface used by application systems to invoke *geographic information services*. *Standardization of the API for geographic information services is central to the ISO 19100 series of geographic information standards.*

— The **Communications Services Interface** (CSI) is the interface across which applications and services access data transport services to communicate across a network. Different computing networks may be connected through a special interface known as the network-to-network interface (NNI).

— The **Human Technology Interface** (HTI) allows the human end user to access the computing system. This interface includes graphic user interfaces and keyboards.

— The **Information Services Interface** (ISI) is a boundary across which database services are provided, allowing persistent storage of data.

Standardization of these interfaces for *geographic information services* is addressed by the ISO 19100 series of standards.

9.4.3 Identifying services and service interfaces for geographic information

The extension of the structure of the OSE Reference Model for geographic information has two key aspects:

— The separation of *geographic information services* from more generic information technology services defines capabilities that are specific to the manipulation, transformation, storage and exchange of geographic information. Figure 13 shows the separation of *geographic information services*. In 9.5, the *Architectural reference model* describes six classes of geographic information services. The standards in the ISO 19100 series define specific services within these classes.

— Service interfaces provide access to geographic information services and enable exchange of data between services and service users, information storage devices and networks. The *Architectural reference model* identifies general types of interfaces that are used by geographic information services. 9.6 provides a method for identifying standardization requirements for those interfaces. The purpose of this method is to guide the standardization of geographic information in order to enable the interoperability of GIS in distributed computing environments.

The definition of service interfaces enables a variety of applications with different levels of functionality to access and use geographic information. While specialized services will remain an area for proprietary products, the interfaces to those services will be standardized. Geographic information system and software developers will use these standardized interfaces to define and implement geographic information services.

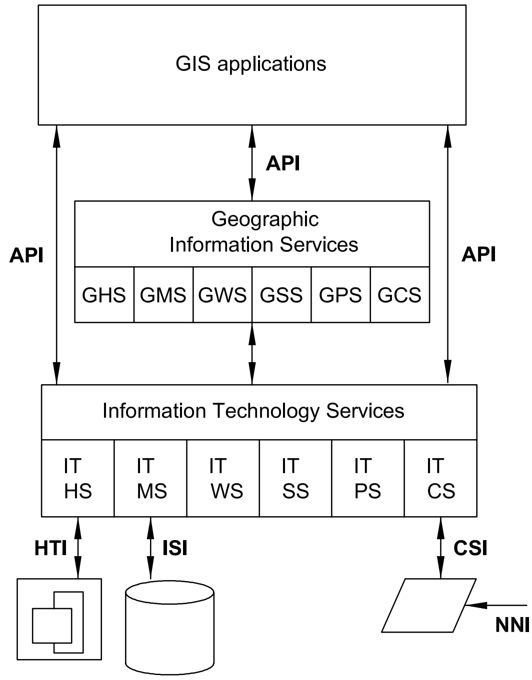
9.5 Types of geographic information services

9.5.1 Introduction

This subclause lists six classes of information technology services that are important for geographic information. Further detail is provided on the extension of each of these classes for geographic information.

9.5.2 Types of information technology services relevant to geographic information

The ISO 19100 series of geographic information standards identifies six classes of generic information technology services of particular importance for geographic information. Each of these classes provide a basis for definition of services that are specific to geographic information. These classes and their extensions for geographic information are depicted in Figure 13 and defined below.



The approach is to define Geographic Information Services in each of the six groups, where general Information Technology services do not meet the requirements.

Key

G	Geographic
IT	Information Technology
HS	Human Interaction Services
MS	Model Management Services
WS	Workflow/Task Services
SS	System Management Services
PS	Processing Services
CS	Communication Services

Figure 13 — The six classes of services

— **Model/Information Management Services** are services for management of the development, manipulation and storage of metadata, conceptual schemas and datasets.

— **Human Interaction Services** are services for management of user interfaces, graphics, multimedia and for presentation of compound documents.

— **Workflow/Task Services** are services for support of specific tasks or work-related activities conducted by humans. These services support use of resources and development of products involving a sequence of activities or steps that may be conducted by different persons.

— **Processing Services** are services that perform large-scale computations involving substantial amounts of data. Examples include services for providing the time of day, spelling checkers and services that perform coordinate transformations (e.g., that accept a set of coordinates expressed using one reference system and converting them to a set of coordinates in a different reference system). A processing service does not include capabilities for providing persistent storage of data or transfer of data over networks.

— **Communication Services** are services for encoding and transfer of data across communications networks.

— **System Management Services** are services for the management of system components, applications and networks. These services also include management of user accounts and user access privileges.

Not every information technology service needs to be changed or specialized to be useful for processing geographic information. The different standards in the ISO 19100 series indicate whether a service is a generic information technology service or whether it is specialized for geographic information.

9.5.3 Extension of service types for geographic information

This subclause describes how the six service classes identified above may be extended to define classes of geographic information services. Standards in the ISO 19100 series that address these specializations are identified.

— **Geographic Information Model/Information Management Services**. The specialization of this class of services focuses on management and administration of geographic information, including conceptual schemas and data. Specific services within this class are identified in ISO 19119. These services are based on the content of those standards in the ISO 19100 series that standardize the structure of geographic information and the procedures for its administration, including: ISO 19107, ISO 19108, ISO 19109, ISO 19110, ISO 19111, ISO 19112, ISO 19113, ISO 19114 and ISO 19115. Examples of such services are a query and update service for access and manipulation of geographic information and a catalogue service for management of feature catalogues.

— **Geographic Information Human Interaction Services**. This class of services focuses on providing capabilities for managing the interface between humans and Geographic Information Systems. This class includes graphic representation of features, described in ISO 19117.

— **Geographic Information Workflow/Task Management Services**. The specialization of this class of services focuses on workflow for tasks associated with geographic information — involving processing of orders for buying and selling of geographic information and services. These services are described in more detail in ISO 19119.

— **Geographic Information Communication Services**. The specialization of this class of services focuses on the transfer of geographic information across a computer network. Requirements for Transfer and Encoding services are found in ISO 19118.

— **Geographic Information Processing Services**. The specialization of this class of services focuses on processing of geographic information. ISO 19116 is an example of a processing service. Other examples include services for coordinate transformation, metric translation and format conversion.

— **Geographic Information System Management**. The specialization of this class of services focuses on user management and performance management. These services are described in more detail in ISO 19119.

9.5.4 Service types in the ISO 19100 series compared to other service models

ISO 19119 provides a comparison of service classes identified in the preceding subclauses to ISO OSE Reference Model described in ISO/IEC TR 14252, the ECMA/NIST model, the CEN ENV 12009, the OpenGIS Service Model and the Object Management Group (OMG).

9.6 Service interfaces and standardization requirements

9.6.1 Introduction

This subclause describes a method for identifying standardization requirements for geographic information services. This method uses the geographic information service classes and service interfaces identified in 9.5. Developers of the ISO 19100 series of standards should use this method to identify standardization requirements for use in determining if these standards are complete and if new projects should be started. Developers of external standards that should be consistent with the ISO 19100 series of standards may use this method for purposes of comparison.

The process of requirements identification results in taxonomy of standardization requirements. The taxonomy is a tool for use by standards developers to guide the evolution of geographic information standards.

9.6.2 Identifying standardization requirements for geographic information services

The procedure for identifying standardization requirements is to first examine what service interfaces a particular geographic information service (or class of services) needs. The next step is to identify specific requirements for each service interface and to determine what must be standardized to enable the geographic information service (or class of services) to interoperate at that interface. The identification of combinations of geographic information services and service interfaces define standardization requirements for geographic information. Figure 14 depicts the static relationships that form the basis for this approach.

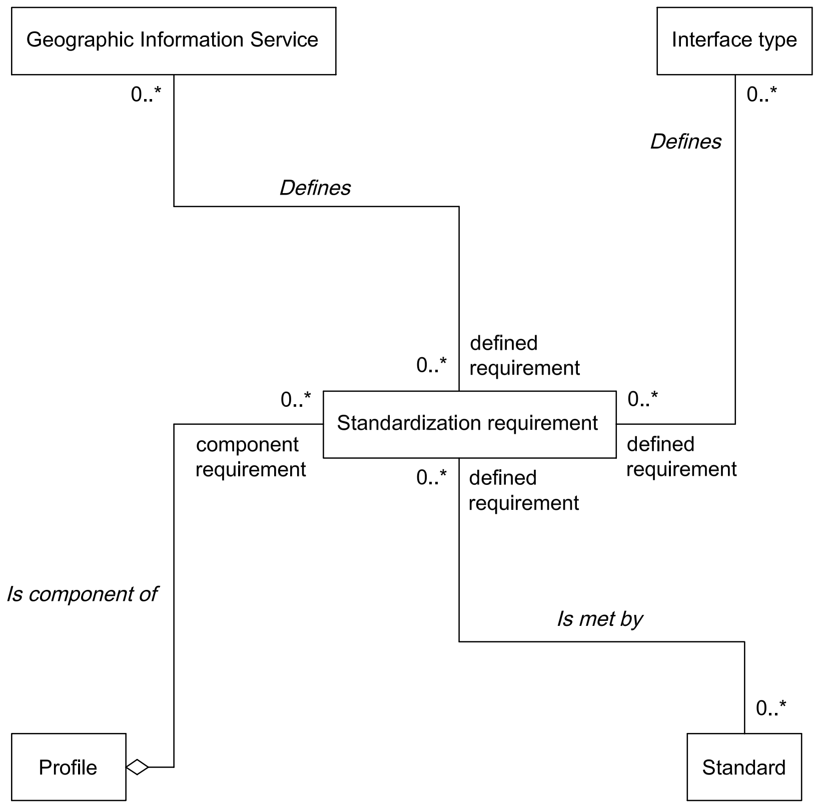


Figure 14 — Identification of standardization requirements

For any combination of service classes and service interfaces, standardization requirements may consist of specifying:

— the function provided by the service,

— how a geographic information service is invoked and the protocol messages for communicating with a service,

— the metadata description of the information that is sent or received by the service,

— the semantic content of the information that is sent by or received from the service, including description of quality information and

— the encoding, or transfer format, for the data that is sent or received by the service.

The *Domain reference model* provides initial guidance for considering the content of the information sent or received by *geographic information services*.

9.6.3 Fulfilling standardization requirements and the role of profiles

Candidate standards that meet individual standardization requirements may be:

— the different standards in the ISO 19100 series of geographic information standards,

— standards for geographic information external to the ISO 19100 series,

— general information technology standards, or

— profiles of the ISO 19100 series of standards, which can include ISO 19100 series base standards and external geographic information standards.

Open Systems Environment (OSE) profiles organize standardization requirements into collections for specific kinds of applications or purposes. The basic concepts of OSE profiles are described in ISO/IEC TR 10000-3. ISO 19106 specializes these concepts for geographic information and defines the process for developing Geographic Open System Environment (GOSE) profiles, each of which describes a number of specific standardization requirements together with the standards that meet these needs. The relationship between standardization requirements, standards that meet these needs and profiles is depicted in Figure 15. Clause 10 of this International Standard provides further information on profiles and functional standards.

9.6.4 Elaboration of standardization requirements

The basic approach described in the previous subclause is elaborated below in an example. Figure 15 shows two geographic information service classes (or subclasses) identified in clause 9 of this International Standard and identifies standardization requirements at the Application Programming Interface. The standardization requirements are shown as subtypes of a generic standardization requirement. Each requirement may be related to different standard(s) of the ISO 19100 series.

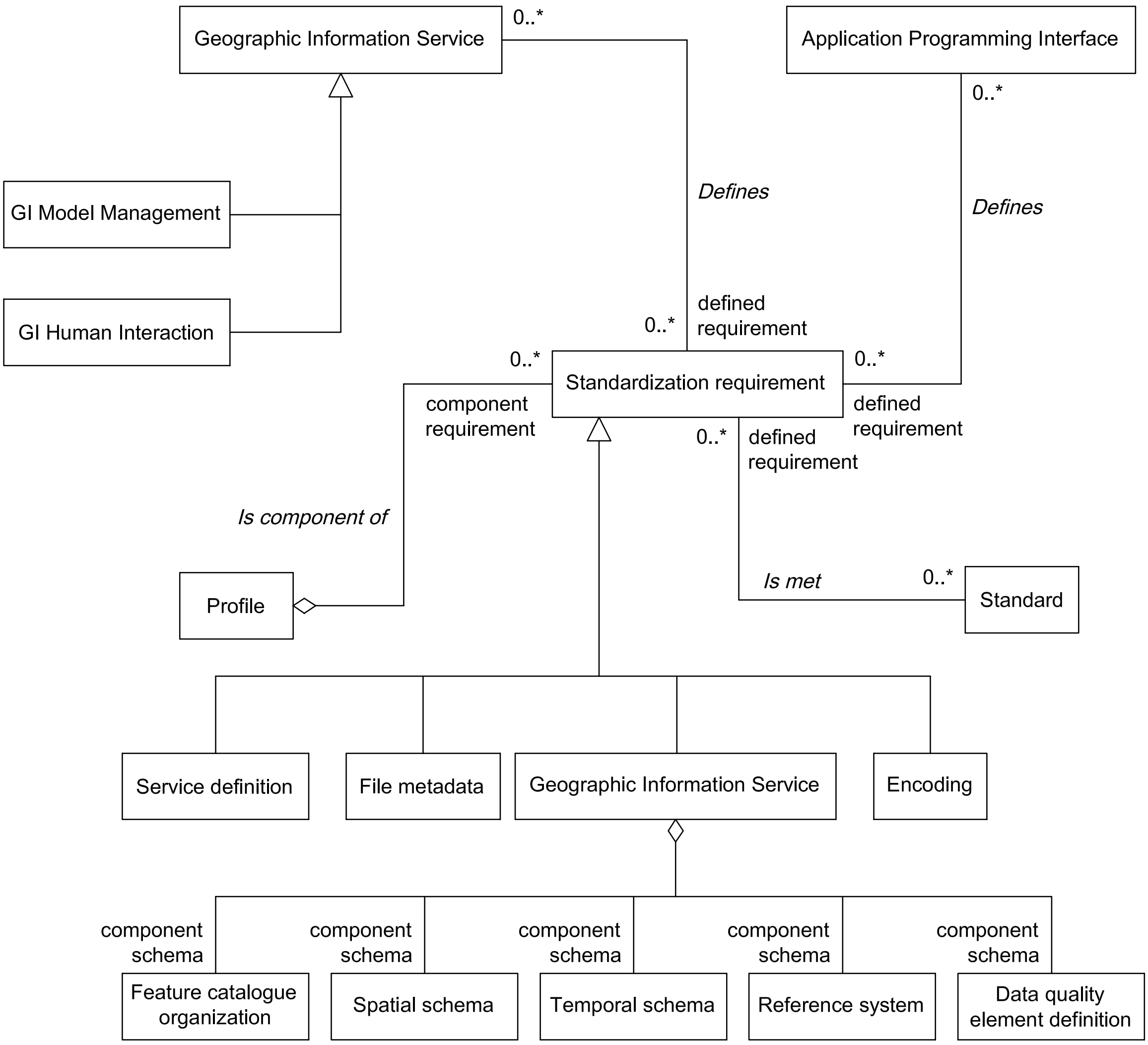


Figure 15 — More detailed view of services and standardization requirements

This approach is usable to develop a complete taxonomy of standardization requirements for geographic information.

9.6.5 Using this procedure to identify requirements for geographic information standards

This procedure is intended to help ensure that the ISO 19100 series of standards addresses all relevant standardization requirements for geographic information. Specifically, the procedure should be used to:

— identify specific standardization requirements that will enable the interoperation of geographic information services at service interfaces,

— relate standardization requirements to the different standards in the ISO 19100 series to ensure that the work programs of existing projects are complete,

— determine which standards external to the ISO 19100 series of standards fulfil the requirements identified for the ISO 19100 series,

— identify additional work that may need to be undertaken as part of the ISO 19100 series of standards.

10 Profiles and functional standards

10.1 Content of this clause

The comprehensiveness and large number of options available in various base standards make it difficult to combine them for practical applications. The concept of *profile* is a useful tool for actually establishing such combinations, thereby providing a mechanism to use the standards in the ISO 19100 series in real applications. A profile integrates a set of base standards and/or modules (predefined subsets) of base standards to meet a specific implementation requirement. The concept and development of profiles of the ISO 19100 series of standards follows the guidelines set forth in ISO/IEC TR 10000-1.

10.2 Profiles and base standards

A profile is a set of one or more base standards and, where applicable, the identification of chosen clauses, classes, subsets, options and parameters of those base standards, that is necessary to accomplish a particular function. A base standard is any standard in the ISO 19100 series or any other Information Technology standard that can be used as a source for components from which a profile may be constructed.

Base standards define fundamentals and generalized procedures. They provide an infrastructure that can be used by a variety of applications, each of which constitutes a specific selection from the options offered.

10.3 Modularity concept

A module is a predefined set of elements in a base standard that may be used to construct a profile. These predefined sets of elements are defined in the ISO 19100 series of base standards, to restrict the number of possible combinations of the components and instantiations of the rules of the ISO 19100 series of standards. Usually modules form the lowest level of granularity from which elements for a profile may be selected. The modular structure of the ISO 19100 base standards makes the creation of profiles more efficient and transparent, and promotes interoperability.

10.4 Use of profiles

Profiles defining conforming subsets or combinations of the ISO 19100 series of base standards and/or subsets thereof, are used to perform specific functions. Profiles identify the use of particular options available in the base standards and provide a basis for development of uniform, internationally recognized conformance tests.

10.5 Product specifications

A product specification is a description of the universe of discourse and the specification for mapping the universe of discourse to a dataset.

A product specification is similar to a profile; in as much as it consists of a selection of optional items from the series of ISO 19100 standards. However, a product specification differs from a profile in that a product specification is a complete description of all of the elements required to define a particular geographic data product. A product specification may include information such as: data content and classification; standards and profiles; spatial referencing; data structures; sources and data capture; update; data presentation; data quality and integrity; applicability and metadata.

10.6 Relationship of profiles to base standards

ISO 19106 is a procedure standard. ISO 19106 provides the principles for profiles of the standards in the ISO 19100 series, possibly in combination with one or more other IT base standards, guidelines for their creation, a classification scheme and a mechanism and procedures for their registration. ISO 19106 also provides the concept of modularity, which has been applied to the ISO 19100 base standards to enable the efficient use of components thereof to build a profile.

10.7 Functional standards

Some existing international geographic information standards that are currently in widespread use have been identified as so-called functional standards. These standards have been analysed in terms of the ISO geographic information projects in order to identify the capabilities and functions that are required in the standards in the ISO 19100 series and to ensure that the base standards are compatible with the existing functional standards. In the future, in co-operation with the agencies responsible for each of the functional standards, these standards may be redefined in terms of the ISO 19100 base standards, as profiles thereof, to promote harmonization of these standards among themselves and with the ISO 19100 series of base standards.

10.8 Registration of profiles

ISO 19106 describes mechanisms and procedures for international, national and private registration of profiles. A profile that is registered through an ISO registration procedure becomes an International Standardized Profile (ISP). National standards that are expressed as profiles of ISO base standards may be registered at a national level. Registration at the private or industrial level will permit companies to develop products under their own authority that are compliant with ISO base standards, ISPs, or national profiles.

Annex A
(informative)

The Conceptual Schema Modelling Facility

A.1 Introduction

This annex provides a detailed description of external reference models and architectures which either provide a basis for or extend the concepts described in this International Standard. The reference models and architectures in this section are not strictly followed by ISO 19101.

The *Conceptual Schema Modelling Facility (CSMF)* (see ISO/IEC 14481) describes a Schema Architecture that defines different levels of abstraction for information in a conceptual schema. This section first describes the CSMF Schema Architecture and then places the different kinds of conceptual schema being developed by the ISO 19100 series of standards into that architecture. This section provides supplemental information for clause 8 of this International Standard, *Domain reference model*.

A.2 The ISO Conceptual Schema Modelling Facility Schema architecture

The ISO CSMF schema architecture is depicted in the Figure A.1. The schema architecture described herein is comprised of four distinct kinds of schemas. These are the defining schema, normative schema, meta-model or modelling schema and application schemas. These schemas are situated in the three partitions or levels of abstraction called *Application model level*, *Meta-model level* and the *Meta-meta model level*. These terms are defined below:

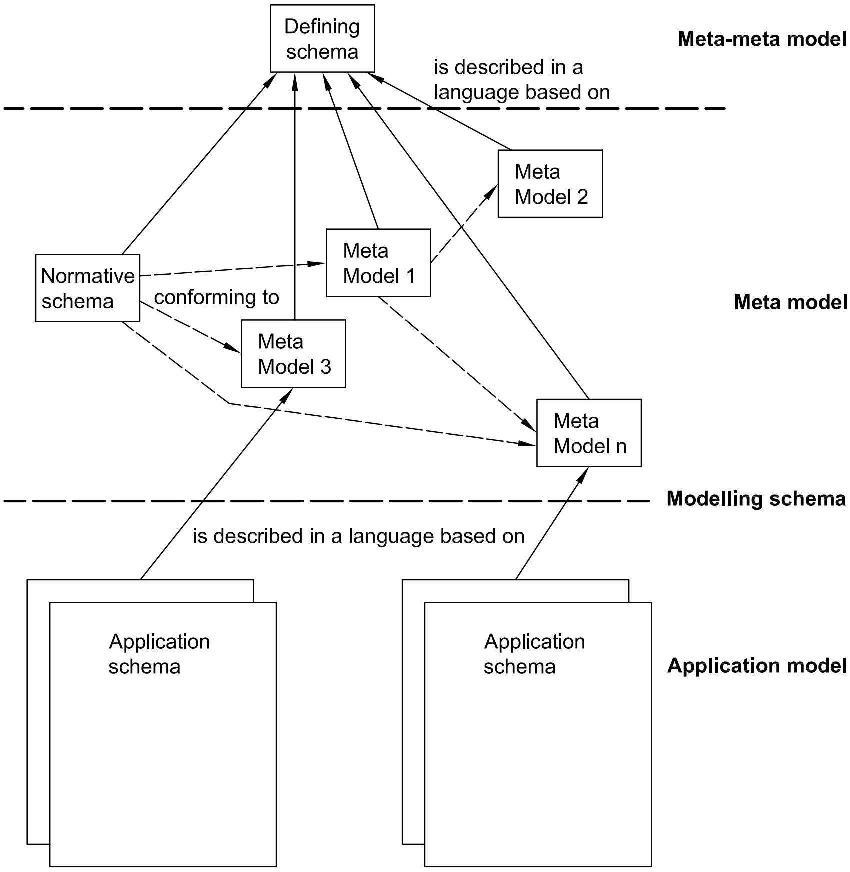


Figure A.1 — ISO CSMF schema architecture

— *Meta-meta Model Level*. In the schema architecture, this is the innermost layer. The meta-meta model level contains the *defining schema*, which specifies the concepts, terminology, operations and assumptions needed to specify the basic constructs in the meta-model level. It is usually expressed in natural language and is not itself subject to standardization.

— *Meta-Model Level*. The meta-model contains the definitions of the concepts; terminology, operations and assumptions needed to construct application schemas. The meta-model descriptions contain the syntax and semantics of various modelling or representation languages — including conceptual schema languages, schemes or paradigms used for modelling. The normative schema constructs, which are part of the meta-model partition, are described in a language based on the fundamental concepts in the defining schema. The meta-models (modelling schemas), which are also part of the meta-model partition, conform (in varying degrees) to the constructs defined in the normative schema. The normative schema can also be called the "root" meta-model.

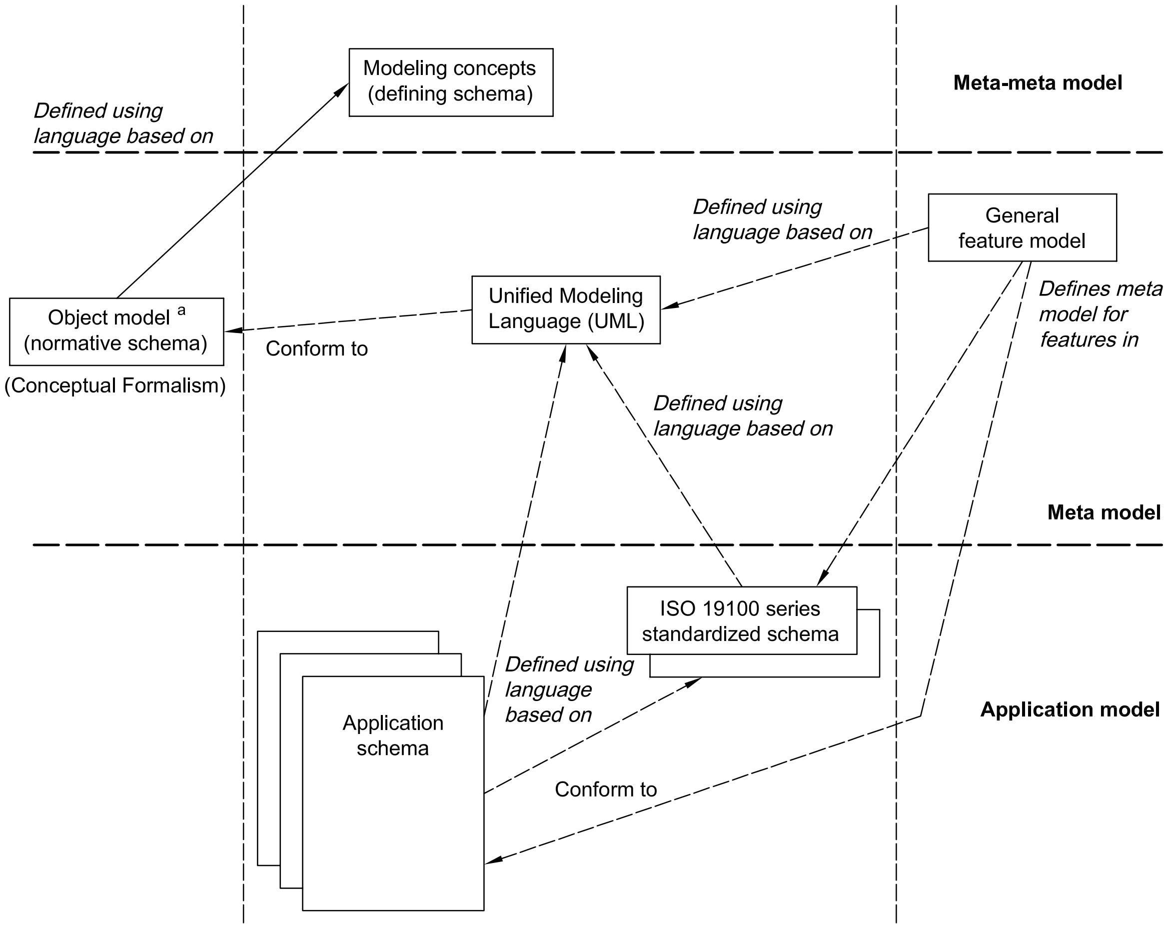
— *Application Model Level*. Application schemas define the types of features and processes that are instantiated to produce datasets of geographic information. The application schema is expressed using the syntax and semantics of one or more conceptual schema languages represented at the meta-model level.

In addition, a fourth partition or level of abstraction exists *"below"* the application model level: *the data level*. The data level contains that actual data that is defined by the application schema at the application model level. The relationship of the application model level to the data level is that of types to *instances*.

The guiding principle in use of this architecture (and all architectures that describe relationships between different levels of abstraction) is that the information at any abstraction level is defined in terms of the types provided by a language at the next highest abstraction level. This principle is set forth in Information Resource Dictionary System (IRDS) framework in ISO/IEC 10027.

A.3 ISO CSMF schema architecture and the ISO 19100 series of geographic information standards

Figure A.2 maps the conceptual schema languages and conceptual schemas relevant to the ISO 19100 series of standards onto the CSMF architecture using the approach described in Annex B.



a Model of abstract data typing.

Figure A.2 — CSMF schema architecture in the ISO 19100 series of standards

In this mapping, the meta-meta model level contains concepts necessary for defining conceptual formalisms and conceptual models used by the ISO 19100 series of standards at the meta-model level. There are no standards in the ISO 19100 series placed at the meta-meta model level.

For the ISO 19100 series of standards, the object model is a conceptual formalism that plays the role of a normative schema at the meta-model level. For the ISO 19100 series, UML is the conceptual schema language whose meta-models conform to the normative object model conceptual formalism (See clause 7 of this International Standard for further detail). This is depicted in Figure A.2. This meta-model, and the conceptual schema language it supports, is used to define conceptual schemas at the CSMF application model level. Similarly, the *meta-model level* identifies the more basic types, models and languages used to describe geographic information. An example of such a meta-model is the *General feature model*. This meta-model of geographic information is also used to define conceptual schemas at the application model level.

The conceptual schemas standardized in the ISO series of standards are at the application model level. Application schemas, both those produced for individual geographic information systems and those associated with profiles and product specifications, conform to the ISO 19100 series of standards standardized schemas at the application model level.

Annex B
(informative)

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

This annex describes more precisely the focus of the ISO 19100 series of standards in terms of the ISO Open Distributed Processing (ODP) standard, described in ISO/IEC 10746-1. The ISO ODP Reference Model identifies five viewpoints, or perspectives, on information technology:

- enterprise viewpoint,
- information viewpoint,
- computational viewpoint,
- engineering viewpoint,
- technology viewpoint.

Figure B.1 shows the relationships between the five ODP viewpoints graphically. *The information and computational viewpoints are the primary focus of the ISO 19100 series of geographic standards*.

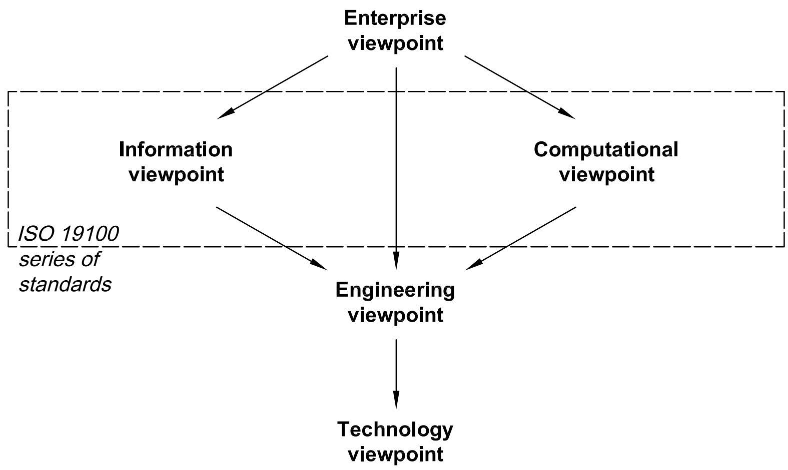


Figure B.1 — Viewpoints in the ISO RM ODP Model

- **The enterprise viewpoint** is concerned with the purpose, scope and policies of an organization in relation to geographic information systems. Examples of organizations are businesses, government agencies and educational institutions. The enterprise viewpoint describes the relationship of the information system to its environment in the organization, the role of the information system in the organization and the policies for using the information system. This viewpoint is used to generate requirements and varies among different organizations and it therefore is not within the purview of the ISO 19100 series of standards.

- **The information viewpoint** is concerned with the semantics of information and information processing. A specification developed from this viewpoint provides a model of the information in a GIS and defines the processing that is performed by such a system. The information provides a consistent common view on information that can be referenced in a GIS. The information viewpoint is the most important viewpoint for the ISO 19100 series of standards. The standards in the ISO 19100 series of standards and their profiles provide standardized descriptions of geographic information for use in developing a GIS that can interoperate in distributed computing environments.

- **The computational viewpoint** is concerned with the patterns of interaction between services that are part of a larger system. A specification of a service is a model of the service as seen by a client or by a set of other services with which this service interacts. The computational viewpoint is the second most important viewpoint for the ISO 19100 series of standards. The standards in the ISO 19100 series and their profiles provide standardized descriptions of geographic information services for use in developing a GIS that can interoperate in distributed computing environments.

- **The engineering viewpoint** is concerned with the design of implementations within distributed, networked, computing systems that support the specifications defined from the perspective of the information and computational viewpoints. In the ISO 19100 series of standards, it is necessary to separate system implementation considerations from the specification of geographic information and services. Therefore little emphasis is placed on this viewpoint in the ISO 19100 series of standards.

- **The technology viewpoint** is concerned with the provision of an underlying infrastructure within which services operate. A technology specification defines how a system is structured in terms of hardware and software components. In the future, it may be necessary to extend the ISO 19100 series of standards and profiles of the ISO 19100 series to show how to map services onto underlying implementation technologies in order to develop GIS.

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