

BS EN ISO 14825:2011



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Intelligent transport systems — Geographic Data Files (GDF) — GDF5.0 (ISO 14825:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 14825:2011. It supersedes BS EN ISO 14825:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/278, Road transport informatics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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GDF5.0 (ISO 14825:2011)

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Foreword

This document (EN ISO 14825:2011) has been prepared by Technical Committee ISO/TC 204 "Intelligent transport systems" in collaboration with Technical Committee CEN/TC 278 "Road transport and traffic telematics" the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2012, and conflicting national standards shall be withdrawn at the latest by January 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 14825:2004.

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Endorsement notice

The text of ISO 14825:2011 has been approved by CEN as a EN ISO 14825:2011 without any modification.

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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 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14825 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

This second edition cancels and replaces the first edition (ISO 14825:2004), which has been technically revised.

Introduction

By the late 1980s, producers and users of digital road map data became increasingly aware of the need for a common data interchange standard. Lack of such a standard was seen as an impediment to the commercial growth and success of industries using such data. Before the advent of the Intelligent Transport Systems (ITS) industry, development of spatial data interchange standards was done mostly on a regional basis and not designed for the specialised requirements of road-transport-related applications. The establishment of ISO/TC 204 in 1993 sought to remedy the lack of international standards for ITS. The technical committee is divided into 16 working groups. Working Group 3 (WG 3) was charged with the responsibility of developing standards to promote interchangeability of map data and interoperability of systems using map databases.

The work of WG 3 started in 1994 with a review of the available regional standards documents, including standards developed by the Japan Digital Road Map Association (JDRMA) and developments in the US that resulted in the Spatial Data Transfer Standard (SDTS). European standardization efforts resulted in a standard called GDF3.0 (Geographic Data Files), which eventually was adopted as the basis for internationalized developments, leading to the publication of GDF4.0 in 2004.

In the 1990s, the GDF standard was instrumental in enabling the European business-to-business (B2B) market for in-vehicle navigation in that it provided interoperability for exchanging digital map data between map manufacturers and navigation system integrators. The GDF specifications provided a base for both the capturing of geographic content and the exchanging of it. Its original design foresaw a powerful, application-independent model, while its initial rendition as a standard specifically addressed the requirements for the richness of navigable map databases. Since then, GDF has evolved in terms of boosted data modelling capabilities, broadened international applicability, expanded geographic domains, and diversified exchange formats. As a result, GDF covers a wide range of application domains and has been adapted to many geospatial technologies.

The current document presents the specification for GDF5.0, resulting from approximately 30 rounds of meetings held between 2001 and 2008 and involving experts from Australia, Canada, the Czech Republic, France, Germany, Japan, the Republic of Korea, the Netherlands, and the United States of America. Extensive activities towards harmonization with ISO/TC 211 standards were undertaken. Major GDF5.0 enhancements include UML model migration and refinements, harmonization with linear referencing and geospatial web standards, support for 3-D content and time coordinates, comprehensive character set and phonetic representations, and new XML- and SQL-based delivery formats.

The specification of this International Standard is divided into several parts.

After the introductory clauses, the overall conceptual data model is specified. In it, the basic building blocks of GDF and their interrelations are explained. It contains a specification of the different types of topology supported by this International Standard. It furthermore describes how database representations of real world objects, referred to as Features, are defined. It describes the characteristics of Features, called Attributes, and the topological and non-topological interrelations between Features. Finally, it describes the organization of the Features in GDF. Semantically, Features are organized in different Feature Themes. Logically and physically, Features are organized in Sections by area or in Layers by contents.

In the Feature Catalogue, the different Features supported by this International Standard are defined. A special case is the Features from the Services Feature Theme. Because the requirements for this Feature Theme are highly market-oriented, the Services Feature Theme does not contain any normative Features, but contains an annex comprising an informative list of service definitions to assist users of this International Standard (see Annex C).

In the Attribute Catalogue, the different characteristics of Features, called Attributes, are defined. A usage matrix outlines applicability of Attributes per Feature Theme and per Relationship.

In the Relationship Catalogue, the different non-topological (i.e. semantic) Relationships which Features can have are defined. Relationships can relate Features of different Feature Themes, or those from the same or different Section and/or Layer.

In the Feature representation rules, the possible geometrical ways in which the individual Features can be represented are specified for each topology type. This International Standard supports zero-, one- and two-dimensional primitives and up to four-dimensional coordinates.

The specification of Features, Attributes and Relationships by no means dictates mandatory inclusion. The actual contents of GDF, apart from a minimum set of metadata elements as specified in the delivery formats, is not specified by this International Standard since this is considered to be an issue between clients and vendors. This International Standard allows the introduction of user-defined Features, Attributes and Relationships.

In certain cases, different alternative ways of modelling and representation are offered. Representing Features in different geographical areas also may require the use of different basic representation mechanisms such as character sets, projection systems, etc. It is important that all these individual choices associated with GDF are specified. Furthermore, GDF should essentially be self-contained and be readable without any external specification. In order to make this possible, this International Standard specifies ways of describing GDF by means of metadata, captured by the Metadata Catalogue.

Apart from providing a standard for the definition of geographic road databases, this International Standard also specifies mechanisms for data exchange and delivery. In order to facilitate the definition and exchange of data, a logical view of the data organization is important. This logical view is presented in the Logical Data Structures. The data structures are specified using the data description language ESN.

Three physical realisations for data exchange and delivery are specified; the Media Record Specifications (ASCII flat file), the XML schema specifications, and the SQL encoding specifications. These specifications support the explicit registration of updated information, thereby allowing map databases to continue to reflect ground truth over time.

Features, Attributes and Relationships appear in the physical GDF as codes. These codes are specified in Annex A. Codes used in the metadata are given in Annex B, which is an informative part of this International Standard. In order to access the most up-to-date information, the user is referred to the original source organization. Annex C contains the specification of Features of the theme Services as an informative part of this International Standard. In Annex D, the syntax for specifying temporal aspects of geographic information is described. The specific rules for organizing GDF in different spatial subdivisions (Sections) is described in Annex E. As informative parts of this International Standard, guidelines for the formation of Level 2 Features from the Feature Theme Roads and Ferries are given in Annex F. A list of local Administrative Area names in different countries is provided in Annex G, as well as illustrative examples for the description of the (non-hierarchical) geopolitical structures and their components in a number of countries. Finally, the use of notation and phonetic Attributes for character strings are illustrated in the informative Annex H. Annex H provides a range of examples showing how the different notation- and phoneme-related Attribute properties can be used to qualify name strings, in both their written and their pronounced form.

Intelligent transport systems — Geographic Data Files (GDF) — GDF5.0

IMPORTANT — The colours represented in the electronic file of this document can be neither viewed on screen nor printed as true representations. For the purposes of colour matching, see ISO 3864-1 which provides colorimetric and photometric properties together with, as a guideline, references from colour order systems.

1 Scope

This International Standard specifies the conceptual and logical data model and physical encoding formats for geographic databases for Intelligent Transport Systems (ITS) applications and services. It includes a specification of potential contents of such databases (data dictionaries for Features, Attributes and Relationships), a specification of how these contents shall be represented, and of how relevant information about the database itself can be specified (metadata).

The focus of this International Standard is on ITS applications and services and it emphasizes road and road-related information. ITS applications and services, however, also require information in addition to road and road-related information.

EXAMPLE 1 ITS applications and services need information about addressing systems in order to specify locations and/or destinations. Consequently, information about the administrative and postal subdivisions of an area is essential.

EXAMPLE 2 Map display is an important component of ITS applications and services. For proper map display, the inclusion of contextual information such as land and water cover is essential.

EXAMPLE 3 Point-of-Interest (POI) or service information is a key feature of traveller information. It adds value to end-user ITS applications and services.

Typical ITS applications and services targeted by this International Standard are in-vehicle or portable navigation systems, traffic management centres, or services linked with road management systems, including the public transport systems.

The Conceptual Data Model has a broader focus than ITS applications and services. It is application independent, allowing for future harmonization of this International Standard with other geographic database standards.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 690, *Information and documentation — Guidelines for bibliographic references and citations to information resources*

ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*. Codes are available at <http://unstats.un.org/unsd/methods/m49/m49alpha.htm>

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General terms

3.1.1

cartographic primitive

atomic construction element in a cartographic representation, i.e. Node, Edge and Face

3.1.2

data file

collection of related data records having a homogeneous structure

NOTE See Reference [34].

3.1.3

data record

record containing Feature-related data

3.1.4

global record

record that logically precedes the data records and contains control parameters, data definition and documentation necessary to interpret companion data records

NOTE See Reference [25].

3.1.5

Medium Unit

object for data storage that can be considered as a physically undivided whole

EXAMPLE One floppy disk, one magnetic tape, a CD, or a DVD.

3.1.6

multi-media

any kind of data other than conventional data

EXAMPLE Graphic, audio or visual data.

3.1.7

Multi-media Object

piece of multi-media to be processed by an application

EXAMPLE A picture, a text, a movie, or a sound.

3.1.8

repeating Attribute Type

Attribute Type that may have multiple values associated to one and the same instance of a particular Feature Class

3.1.9

Spatial Domain

description of the limits of a geographical area to which a particular set of data belongs spatially

3.1.10

source material

origin of data in analogue or digital representation, stored on any kind of data medium

3.1.11

topology

field of mathematics that deals with characteristics of geometric structures that are preserved after continual variation

NOTE See Reference [43].

3.1.12

transcription

rendering of geographic names from a non-alphabetic script into an alphabetic one or vice versa

NOTE 1 See Reference [40].

NOTE 2 The term is also applied to initial recording in script of hitherto unwritten names.

3.2 Mathematical terms

3.2.1

Area Feature

two-dimensional Feature, defined by one or more Faces

3.2.2

Edge

directed sequence of non-intersecting Line Segments with Nodes at each end

NOTE See Reference [34].

3.2.3

enclave

small part of an area enclosed by another area, seen from the area to which that part belongs

3.2.4

exclave

small part of an area enclosed by another area, seen from the enclosing area

3.2.5

Face

two-dimensional element bounded by a closed sequence of Edges and by zero or more sets of non-intersecting closed sequences of Edges within the first sequence of Edges

NOTE The Face is the atomic two-dimensional element.

3.2.6

graph

set of points and a set of arrows, with each arrow joining one point to another, whereby the points are called Nodes of the graph, and the arrows are called the Edges of the graph

NOTE See Reference [34].

3.2.7

Intermediate Point

point, other than a Node, that defines the shape of an Edge

3.2.8

Line Feature

one-dimensional Feature defined as a sequence of one or more Edges

3.2.9

Node

zero-dimensional element that is a topological junction of two or more Edges, or an end point of an Edge

NOTE See Reference [34].

3.2.10

non-planar graph

graph which cannot be embedded in a plane

3.2.11

planar graph

graph which can be embedded in a plane, meaning that it can be drawn on the plane so that Edges intersect only at a Node mutually incident with them

3.2.12

point

zero-dimensional element that specifies geometric location specified by one coordinate pair or triplet

NOTE See Reference [34].

3.2.13

Line Segment

Segment

direct connection between two Intermediate Points, two Nodes or a Node and an Intermediate Point

3.2.14

valency

degree

number of Edges which are incident with a particular Node

3.3 Geodetical terms

3.3.1

control point

point having known coordinates in the real world and identifiable with a corresponding point in a map or an aerial photograph or satellite image

3.3.2

ellipsoidal height

distance between a point and the reference ellipsoid, measured along the ellipsoidal normal

3.3.3

geodetic datum

mathematical surface that approximates a portion of the earth's surface

3.3.4

geoid

model of the figure of the earth, that coincides with the mean sea level over the oceans and continues in continental areas as an imaginary sea level surface, defined by spirit level

NOTE At every place, geoid level/surface is perpendicular to the pull of gravity. The shape is irregular but can, for most purposes, be approximated by an oblate ellipsoid.

3.3.5

Geoid Undulation

difference between the orthometric height and the ellipsoidal height, measured along the ellipsoid normal

3.3.6
height
elevation

(vertical) distance between a point and the reference height level or the reference ellipsoid

NOTE On land maps, the reference level is commonly the mean sea level.

3.3.7
horizontal reference system
reference system for positions

3.3.8
magnetic declination
angle between Magnetic North and True North

NOTE See Reference [40].

3.3.9
map projection
transformation method used to represent the curved earth surface on a plane

3.3.10
offset
pair of values subtracted from all coordinate values in order to shorten these coordinate values

3.3.11
orthometric height
distance between a point and the geoid, measured along the perpendicular line

3.3.12
reference ellipsoid
oblate ellipsoid of revolution that is used to approximate the figure of the geoid

NOTE It is specified by two parameters: a semi-major axis a (equatorial radius of the earth) and a semi-minor axis b (polar radius). The flattening f is defined as: $f = (a - b)/a$.

3.3.13
reference height level
level to which all terrestrial heights are referred

NOTE It changes from country to country and it forms part of the national coordinate system for surveying and mapping.

3.3.14
reference system
coordinate system on which a national survey is based

NOTE See Reference [40].

3.3.15
vertical reference system
reference system for elevations

3.3.16
world geodetic system
WGS
set of standard reference ellipsoids that define latitude, longitude and height for every point on the earth

3.4 GDF terms

NOTE All Feature Classes mentioned below are defined in the Feature Catalogue.

3.4.1

Album

collection of related Datasets (logical sub-division) and, if applicable, Volumes (physical sub-division)

3.4.2

Attribute

characteristic of a Feature which is independent of other Features

NOTE See Reference [34].

3.4.3

Attribute Code

alphanumeric identifier for an Attribute Type

NOTE See Reference [57].

3.4.4

Attribute Name

name associated to an Attribute Type

NOTE See Reference [57].

3.4.5

Attribute Type

defined characteristic of a Feature, which is independent of the other Features

3.4.6

Attribute Value

specific quality or quantity assigned to an Attribute

NOTE See Reference [34].

3.4.7

Dataset

sub-division of Album, which in turn can be sub-divided into Sections

NOTE A large set of data covering a particular geographic area can be considered a Dataset.

3.4.8

District

area regarded as a geographical unit, which is defined by the delivery of a specific public or private sector service

3.4.9

Feature

database representation of a real world object

3.4.10

Feature Category

type of representation of a Feature, including Point, Line, Area and Complex Feature

3.4.11

Feature Class

categorization of a Feature

3.4.12

Feature Class Code

alphanumeric identifier for a Feature Class

NOTE See Reference [57].

3.4.13

Feature Name

name associated with a Feature Class

NOTE See Reference [34].

3.4.14

Feature Theme

specified group of related Features

3.4.15

field

set of characters representing one unit of data

3.4.16

Layer

certain subset of a Dataset based upon information contents

3.4.17

Manoeuvre

ordered sequence of a Road Element, a Junction and one or more Road Elements, and optionally associated with a Traffic Sign

3.4.18

Place

administrative area of the types: Order-i Area, Country, Supra-National Area, Administrative Place A-Z or Named Area Feature of the types: Built-up Area, Named Area, District

3.4.19

Property

combination of Attribute and Relationship values which pertain to a Feature and which together define a certain characteristic of the Feature

3.4.20

Relationship Code

alphanumerical identifier for a Relationship

3.4.21

Relationship name

name associated with a Relationship Type

NOTE See Reference [34].

3.4.22

Relationship Type

defined characteristic of a Feature which is dependent on other Features

3.4.23

Semantic Relationship

Relationship

characteristic of a Feature involving other Features

3.4.24

Section

spatial subset of a Dataset

NOTE The coverage area of a map sheet, confined by geographic coordinates, can be considered a Section.

3.4.25

Transportation Element

Road Element, Pathway, Railway Element, Path, Ferry Connection, Water Body, Water Boundary Element, Junction, Railway Element Junction or Water Boundary Junction

3.4.26

turn

ordered sequence of a Road Element, a Junction and a Road Element

NOTE A turn is a special case of a Manoeuvre, relating exactly two Road Elements.

3.4.27

Volume

smallest physical unit of a medium

NOTE A single Volume can contain one or more GDF Datasets depending on Dataset size.

EXAMPLE A magnetic tape, a floppy disk, etc.

4 Symbolization and notation elements

4.1 GDF symbolizations

Many of the basic concepts of GDF are best expressed diagrammatically in data models. The Unified Modeling Language (UML) [31] has been adopted as the conceptual modeling language for GDF.

4.2 UML notation

4.2.1 Introduction

This subclause provides a summary of the UML Class Diagram notation conventions used in this International Standard. It is consistent with the use of UML in the ISO 191xx series of geographic information standards of ISO/TC 211 (see [27], ISO 19107:2003, 5.1, Presentation and notation).

4.2.2 UML classes

4.2.2.1 General

A UML class is a description of a set of objects (instances) that share the same attributes, operations, relationships¹, and semantics. A class is represented in a UML Class Diagram as in Figure 1.

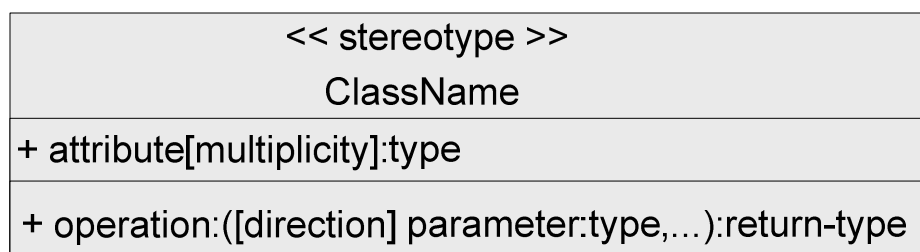


Figure 1 — Class with attributes and operations

The rectangular box representing a class has three parts: class, attributes, and operations. The full class content is usually only presented in one figure. If the class is repeated on another figure, attributes and operations are not shown and the box is a single rectangle containing only the class name and stereotype as in Figure 2:

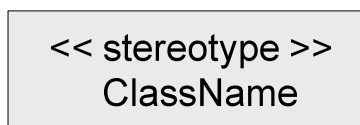


Figure 2 — Class with attributes and operations suppressed

4.2.2.2 Class name and stereotype

The mandatory top part of the class rectangle contains the name of the class in UpperCamelCase. If the class is abstract (it cannot have any instances), then the name is shown in *italics*.

¹ GDF has its own definition of relationship. Here, the UML definition is used. It includes both associations and generalizations between classes. Associations can be ordinary, aggregate, or composite.

Stereotype can take any of the following values:

Feature: (consistent with ISO 191xx) – classes that have identifiers can have geospatial location; primary features in mapping; corresponds to GDF Feature classes.

Enumeration: (consistent with ISO 191xx) – class provides a fixed list of alternative values.

CodeList: (consistent with ISO 191xx) – similar to an enumeration, in that one of a number of values is possible, but differs in intent, in that a code list may be expanded over time.

DataType: (consistent with ISO 191xx) – have no identity of their own; can be associated with other classes but are not enumerations or code lists.

Union: (consistent with ISO 191xx) – a type consisting of one and only one of several alternatives (listed as member attributes) representing a discriminating union of these alternatives.

Relationship: (special for GDF) – have identifiers; correspond to the Relationships between Features or Attributes.

Attribute: (special for GDF) – correspond to GDF Composite Attributes.

Association: (special for GDF) – used to identify an Association Class (consistent with ISO 191xx) which adds attributes to an association which exists between two classes.

4.2.2.3 UML class attributes

The middle part of the rectangular box representing a class optionally contains a set of attributes (properties) for the class. Each attribute is specified by the following:

“attribute” is the name of an attribute² of the class in lowerCamelCase. It is prefixed by a visibility indicator with a value of public (+), private (-) or protected (#), indicating the visibility of this attribute from outside the objects in this class. Most attributes in GDF have public visibility.

“[multiplicity]” indicates the number of values that this attribute can have for any instance of the class, assumed to be organized as a set unless otherwise specified. Multiplicity is specified as a range with a format of “begin-value..end-value”. Begin-value is any positive integer or zero. End-value is an integer greater than begin-value. If only a begin-value is specified, then exactly that number of values must exist for this attribute. For example, a multiplicity of ‘1’ specifies that the attribute must have a single value for each instance of the class. A multiplicity of ‘0..1’ specifies that the attribute is optional, but if it exists, it has a single value for that instance of the class. A multiplicity of ‘0..*’ specifies that the attribute is also optional, but if it exists, it can have one or more values for that instance of the class. A multiplicity of ‘1..*’ specifies that the attribute is mandatory, and it must have one or more values for each instance of the class. The absence of [multiplicity] is the same as a multiplicity equal to ‘1’, i.e., exactly one value must exist for this attribute for each instance of the class.

“type” is the type of the attribute in UpperCamelCase. It may be either a value type, such as Number, or the name of a class.

NOTE Specific to GDF, a type of “PositiveInteger” has been introduced for object IDs, including those for Feature, Relationship, Attribute, Node, Face, Edge, Album, Dataset, Layer, and Section. It is defined to be an Integer with attribute >0 = True.

² GDF Simple Attributes are shown in this manner. GDF composite attributes are modeled as a separate class.

4.2.2.4 Class operations

The lower part of the rectangular box representing a class contains an optional set of operations³ for the class. Each operation shall have a list of zero or more parameters. An operation is specified by the following:

“operation” is the name of an operation of the class. It is prefixed by a visibility indicator with a value of public (+), private (-) or protected (#), indicating the visibility of this operation from outside the objects in this class.

“[direction]” is the optional indicator of direction flow for a parameter being either “in” (the value is set before invocation and affects the operation), “out” (the value is set during the operation and its value is accessible by the invoker upon completion of the operation), or “inout” (the value is set before the invocation, affects the operations, and is reset by the operation to a value accessible by the invoker upon completion of the operation). The default direction of any parameter is “in”.

“parameter” specifies the name of the parameter.

“type” is the type of the parameter. It may be either a value type, such as integer, or the name of a class.

“return-type” is the type of the return value or object for the operation. It may be either a value type, such as integer, or the name of a class.

4.2.3 UML class relationships

4.2.3.1 Generalization/specialization relationship

Classes can be “subclassed” into more specific classes. Figure 3 specifies a subclass relationship in a Class Diagram. Classes Type1A and Type1B are subclasses of Type1. As such, they inherit all of the methods, operations, relationships, and semantics of Type1 and instances of classes Type1A and Type1B can be substituted for a Type1 instance wherever a Type1 instance is specified. They typically extend Type1 with additional attributes and/or additional or overriding operations. Only these additional attributes and/or operations will appear in the subclass boxes.

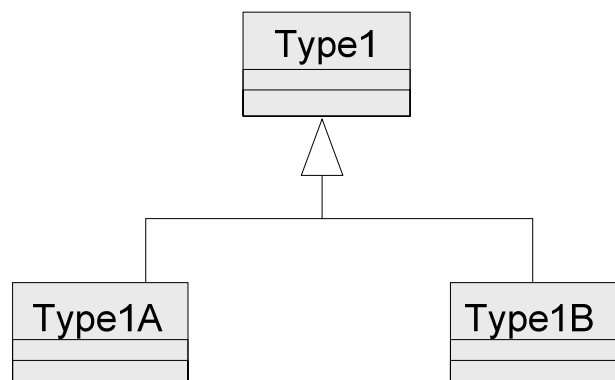


Figure 3 — Subclass hierarchy

³ Operations are not specified in this version of GDF.

4.2.3.2 Other class relationships: associations

4.2.3.2.1 General

In addition to the subclass relationship, Classes may be associated with other classes.

4.2.3.2.2 Regular associations

Associations are represented in a UML Class Diagram using the syntax shown in Figure 4.

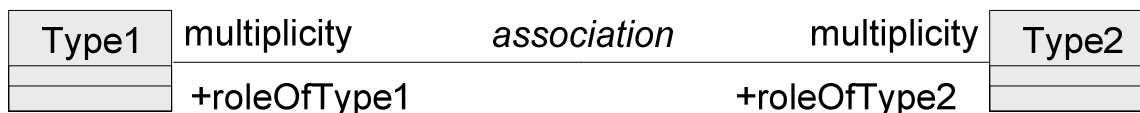


Figure 4 — Class associations

The association link between the two classes may be adorned with the following information:

“association” is the name of the association between the two classes. Association names are rarely included; their use is suggested in order to differentiate multiple associations between the same two classes.

“role” is the name of the role, in lowerCamelCase, which the class nearest the adornment plays in the association. It is prefixed by a visibility indicator with a value of public (+), private (-) or protected (#), indicating the visibility of this role from outside the objects in this class. Most roles in GDF have public visibility. The role can be interpreted as follows: roleOfType2 can be read as a property of Type1 whose value is the instance of Type2. Consequently, if Type1 is involved in multiple associations, the roleOfType2 role names must be different.

“multiplicity” indicates the number of instances of the class nearest the adornment that can participate in each instance of the association. Multiplicity is specified as a range with a format of “begin-value..end value”. Begin-value is any positive integer or zero. End-value is an integer greater than begin-value. If only a begin-value is specified, then exactly that number of instances of the class must exist for this association. For example, a multiplicity of ‘1’ at the Type1 side of the association specifies that every instance of Type2 must have this association with one and only one instance of Type1. A multiplicity of ‘0..1’ specifies that every instance of Type2 must have this association with zero or one instances of Type1. A multiplicity of ‘0..*’ specifies that every instance of Type2 must have this association with zero or more instances of Type1. A multiplicity of ‘1..*’ specifies that every instance of Type2 must have this association with one or more instances of Type1.

An arrowhead on one side of the association line indicates that navigation is only required in the direction of the arrowhead. For example, an arrowhead on the Type2 side in Figure 4 would indicate that, given an instance of Type1, it is possible to obtain all of the associated instances of Type2. No arrowhead means, e.g., “backward pointers”, are required to get all Type1 instances associated with each Type2 instance. If a role is shown on the Type1 side of the association and an implementation chooses to include navigation in the optional direction, then that implementation shall use the role name shown. If no arrowheads appear, then the association is assumed to be navigable in both directions.

4.2.3.2.3 Aggregation/composition associations

If each instance of Type2 is made up of instances of Type2A or Type2B, an aggregation or composition association is represented in the Class Diagram as in Figure 5 by adding a diamond to the “container” side of the association line. An open diamond specifies an aggregation; an instance of Type1 is comprised of

instances of Type2A but the instances of Type2A can exist in their own right. A shaded diamond indicates the stronger, composition association: instances of Type2B are dependent on the existence of an instance of Type2. Type2B instances cannot be created unless they are associated with a Type2 instance. If the Type2 instance is deleted, the associated instances of Type2B are also deleted.

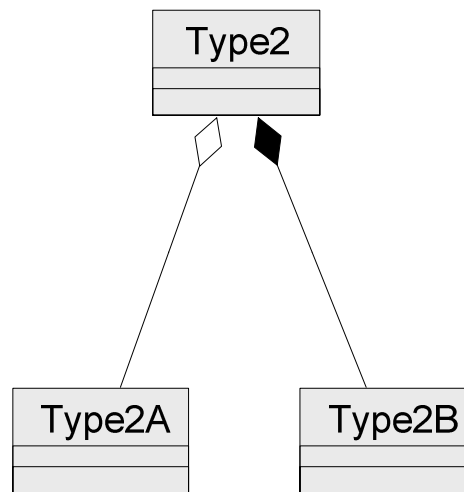


Figure 5 — Aggregation/composition associations

4.2.3.2.4 Association class

In order to specify attributes about the association between two classes, an Association Class is used. The attributes of this class are the attributes of the association. Association Classes are represented in a UML Class Diagram using the syntax shown in Figure 6.

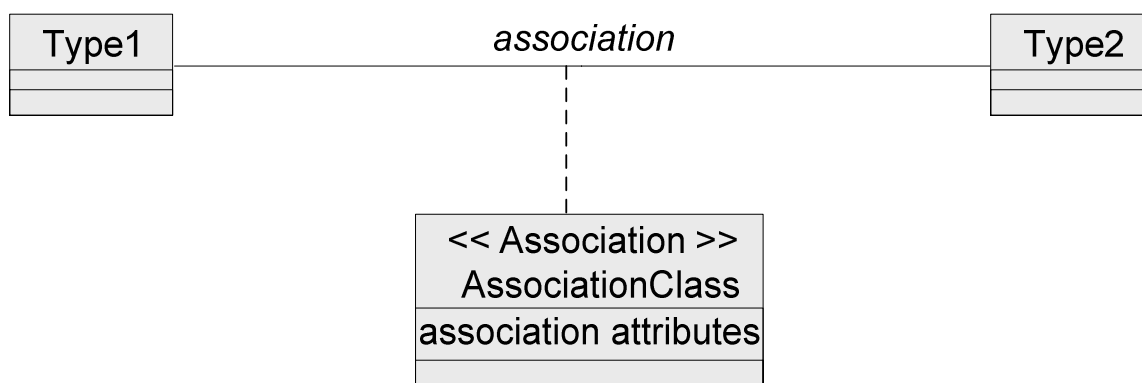


Figure 6 — Association Class

4.2.3.2.5 Qualified association

A special case of association attribute is a qualifier. The qualifier qualifies the association. An instance of the source class in the association plus a qualifier value maps to a specific instance of the target class in the association. An example of how a qualified association is represented in a UML Class Diagram is shown in Figure 7.

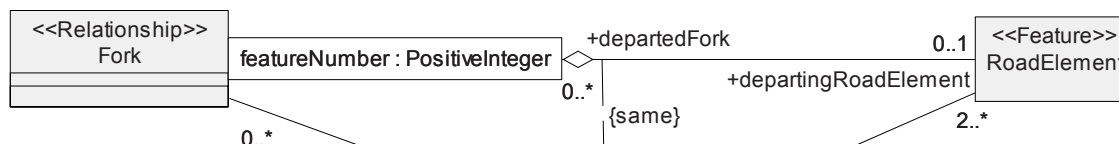


Figure 7 — Qualified association example

Fork is the source class of the departing association; RoadElement is the target class. For a specific instance of a Fork, the departing Road Element instances are distinguished by the positive integer, featureNumber qualifier. The aggregation association is adorned with a rectangular box on the source end containing the association attribute(s) which help qualify the association.

The cardinality on the source side is 0..* since any Road Element instance may be associated with any number of fork instances by playing the role of departing Road Element in the qualified association. The cardinality on the target side is 0..1 because for each combination of a fork instance and a positive integer, there is either none or one Road Element playing the role of departing Road Element.

In the figure, the second (unqualified) association specifies that in total, there are 2..* departing Road Element instances for each fork instance. Since this unqualified association is in reality the same association as the qualified one, the “same” constraint links the two. The (same) applicable role names are not repeated for the second association.

4.2.4 Constraints

When additional restrictions are mandated on the syntax or semantics, a Class Diagram can be further adorned with constraints. These are supplied as text inside of {curly braces}. There is no prescribed syntax for the constraint text. An example from GDF is {ordered}, which specifies that the set of supplied values must be in a specific order. Another example is the exclusivity constraint in the Fork Relationship:

{notEqual(approachingRoadElement,departingRoadElements)},

which states that the approaching Road Element and all of the departing Road Elements must be different Road Elements.

Constraints which adorn an association at either end are typically part of the UML model. Constraints which appear in an annotation text box are typically only part of the figure in which they appear.

5 Overall conceptual data model

5.1 Conceptual data models in GDF

The general data model of GDF is presented in Figure 8 and Figure 9, Figure 11 through Figure 15, and Figure 17 through Figure 25. See Figure 1 through Figure 7 for the UML notation used. Detailed sub-schemas are presented in the respective clauses. The data model diagrams convey a range of dedicated terms describing concepts of the GDF model; according to UML practise, these terms are spelled using "CamelCase" notation. Textual descriptions complementing the graphical descriptions use initial capitals for each constituent word of a given GDF term.

The general data model—serving as meta-model for the respective semantic models of the individual Feature classes (see Feature Catalogue), of the individual Attribute types (see Attribute Catalogue), and of the individual Relationship Types (see Relationship Catalogue)—are presented and explained in detail in the remainder of this clause. Each Feature class, Attribute type, and Relationship Type can be considered an instance of the generic UML classes for Feature class, Attribute type, and Relationship Type, respectively, in the meta-model. This two-level notion is implemented using UML class sub-typing.

While ID's are usually not part of a conceptual model, it has been decided to explicitly include them here due to their conceptual relevance. This refers to the fact that they provide a means of unique identification of elements regardless of a particular physical realization of the GDF conceptual model. This, despite the fact that certain physical realizations may not require the use of physical ID's. Consequently transition between different physical realizations will not result in loss of information.

5.2 The general data model of GDF

5.2.1 The Feature model

In the centre of the model in Figure 8 resides the "Feature" which is a database representation of a real world geographic object. Examples of real world geographic objects are roads or buildings. Note that in this diagram "Feature" has the meaning of Feature instance, i.e. an individual occurrence of a geographic object, such as the Eiffel Tower in Paris.

Figure 8 shows that each Feature must belong to exactly one Feature Class and exactly one Feature Theme. The diagram also shows that Feature Classes and Feature Themes are uniquely referenced by a name and a code.

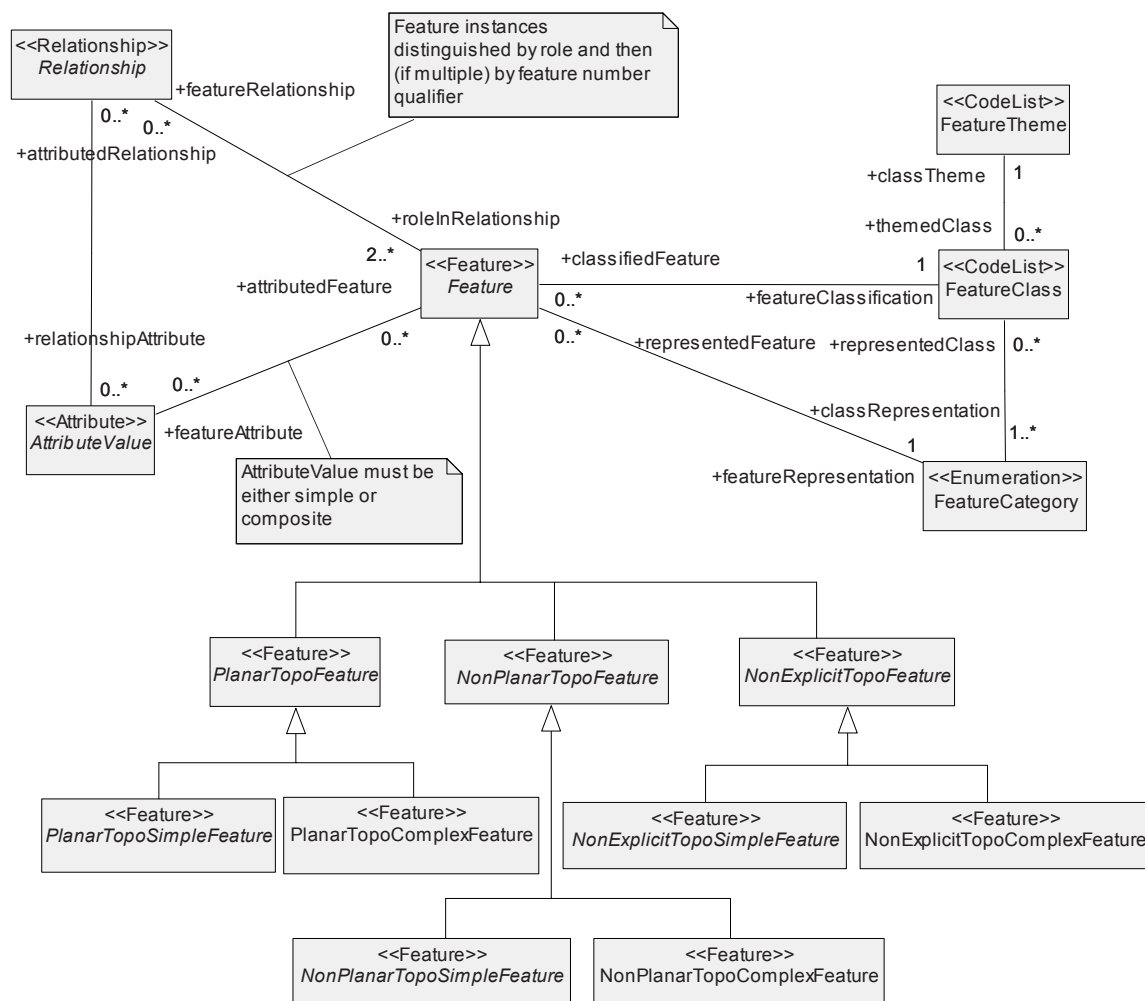


Figure 8 — The overall Conceptual Data Model

Each Feature belongs to exactly one Feature Class. This constraint is indicated in diagram 2a by the depiction of Feature Class with a multiplicity of 1 in the association between classes Feature and Feature Class. Thus neither classless Features (Features belonging to no Feature Class) nor hybrid Features (Features belonging to multiple Feature Classes) are allowed in a GDF.

A Feature may have zero or more Attributes. Attributes serve to represent characteristics of a Feature that are independent of other Features.

A Relationship is used to associate two or more Features together. However a Feature is not required to participate in a Relationship. A Relationship may have zero or more Attributes.

Each Feature is of exactly one Feature Category. A Feature Category is uniquely referenced by a Name and a Code. GDF defines four Feature Categories – Point, Line, Area and Complex. Collectively, Point, Line, and Area Features are referred to as Simple Features. Complex Features are aggregations of other Features, either Simple, Complex or in combination.

5.2.2 Graph topology

The first subdivision of Features relates to the topology of the underlying graph with which the Features are defined. The GDF supports three different types of graph topologies: Planar topology, Non-planar topology and Non-explicit topology:

- Non-explicit topology: No topological relations between objects are explicitly defined. That is, topological relations are only defined via coordinate values.
- Non-planar topology: Topological relations are explicitly defined; objects may fully or partially coincide, or intersect or overlap each other.
- Planar topology: Topological relations are explicitly defined; objects must not fully or partially coincide, and must not intersect or overlap each other. Intersecting objects or overlapping objects are broken-up into object fragments, whereby common parts (such as a street co-inciding with a boundary) are present only once.

In exceptional cases the standard also supports the explicit definition of topology on the Feature level⁴.

Non-explicit topology gives the possibility to define and process data, for which topological relations are less relevant (e.g. map display data) in a very efficient way. Non-planar topology gives the possibility to perform network operations efficiently. Planar topology gives also the possibility to efficiently integrate area information in network operations.

In the GDF model, the rendering method chosen for planar topology is the full integration method, and for non-planar topology the connectivity method. Both methods are further described below.

Obviously since planar topology is a special case of non-planar topology it is quite possible to have utilized the "connectivity" approach to render the planar topology case. However, it is even conceivable (although less likely) to make use of the full integration method to render non-planar topology. It is important not to confuse the rendering choice with the topology choice.

In planar topology, the zero- and one-dimensional basic building blocks, Nodes and Edges, form a graph. In special cases where in reality two Point Features are located above each other, a single Node is being defined (possibly connected by a vertical Edge (of "length" zero) representing a Line Feature, e.g. an elevator between different building levels). Furthermore, in the GDF model of topological planarity, a fully topologically integrated representation is provided for Area Features. Area Features are defined by referencing the two-dimensional building blocks, Faces, which make up that Area Feature (Figure 9).

⁴ The standard allows the following additional explicit definitions of topology:

- The start and end Point Feature of a Line Feature
- The start and end Complex Feature of a Complex Feature.
- Through the use of Relationships (See below: The Relationship Model).

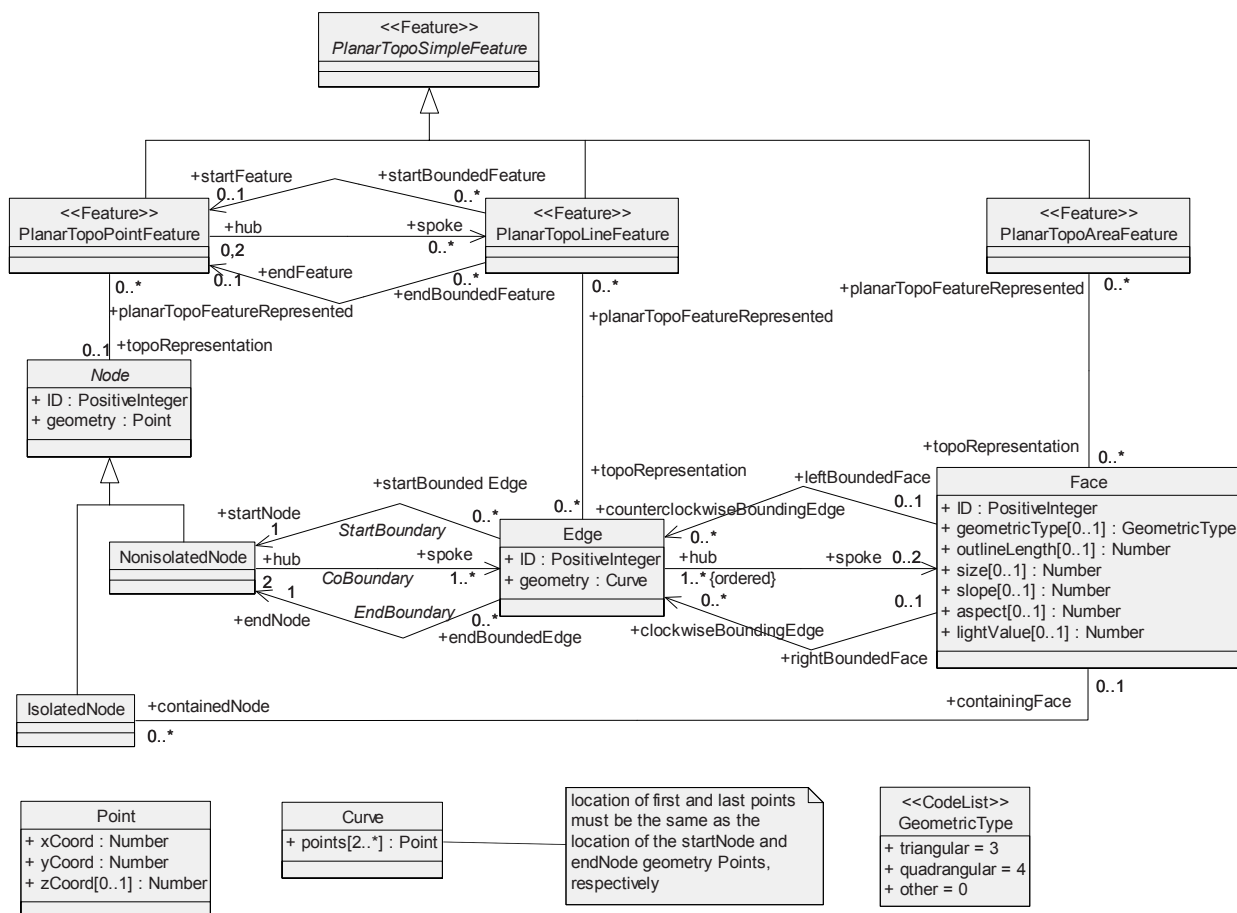


Figure 9 — The conceptual data model of Planar Topological Simple Features

Here, an Area Feature must have at least one Face and a Face at least one Edge. This constraint is depicted in Figure 9 by the hub and spoke association between Face and Edge. The relation between a Face and its composing Edges is determined by the location of the Face relative to the Edge (left or right) relative to the direction of an Edge or, when approached from the Face, by the orientation of the Edge (clockwise or counter clockwise) when seen from the inside or the outside of the Face. This means that an Edge which bounds two Faces will have a clockwise orientation in the definition of one Face and a counter-clockwise orientation in the definition of the other Face (See Figure 10).

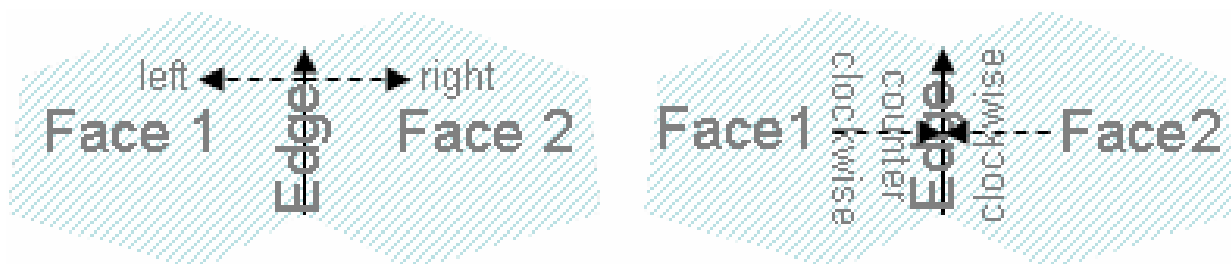


Figure 10 — Relation between Faces and bounding Edges

In non planar topology the Nodes and Edges together form a non-planar graph. That is, where in reality two Line Features cross at different levels (e.g. two roads crossing via a bridge), the Edges which represent these Line Features cross without forming a Node on the point of crossing. Also, in special cases where in reality

two Point Features are located above each other, two Nodes are being defined (possibly connected by a vertical Edge representing a Line Feature, e.g. an elevator between different building levels). In the GDF model of topological non-planarity, Faces do not exist, i.e. only topological connectivity is represented. Two dimensional Features are defined by referencing the Edges making up this boundary (Figure 11).

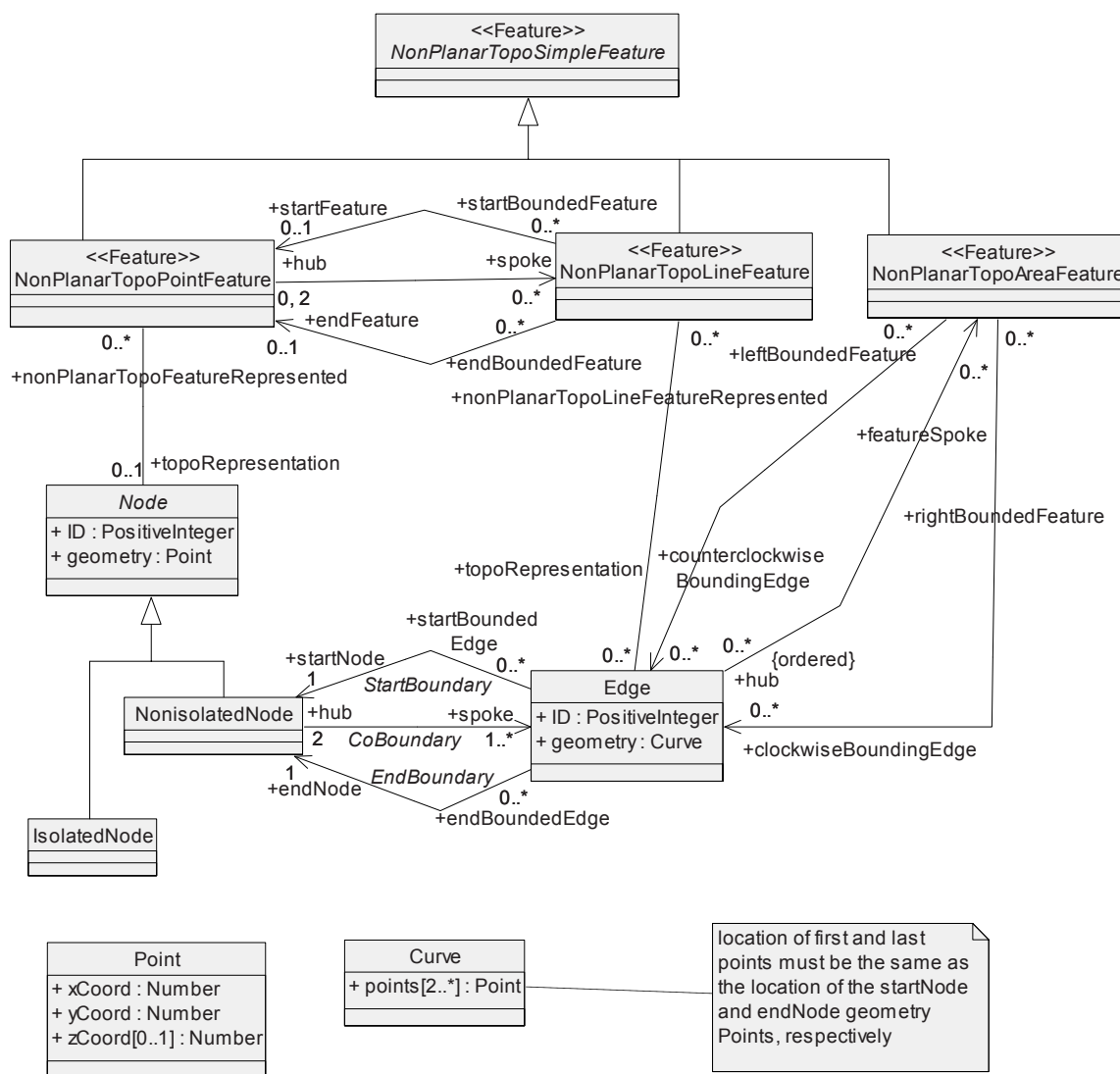


Figure 11 — The conceptual data model of Non-planar Topological Simple Features

As is stated above, in planar topology, the basic graph represents objects in a single plane. Reality however is not planar. Roads for instance can cross each other at different grades. This non-planarity shall be introduced on the Feature level⁵

In non-explicit topology the basic building blocks of zero-, one- and two- dimensional Features are Dots (zero dimensional), Polylines (one dimensional) and Polygons (two dimensional). Dots, Polylines and Polygons are defined without explicit topological relations.

⁵ In addition to this, the standard allows the definition of the height level of *Edges* (See 10.2.4.5).

In the remainder of this chapter, the planar topology and the non-planar topology will be both referred to as “topology” and the corresponding Features as topological Features, while the non-explicit topological way will be referred to as the non-explicit topology or NET way and its corresponding Features as “non-explicit topological or NET Features”.

In topology, Features are defined by the basic building blocks Nodes, Edges and Faces. Figure 9 and Figure 11 show that a topological Point Feature is always represented by exactly one Node, a topological Line Feature by one or more Edges and a topological Area Feature either by one or more Faces or by one or more Edges forming one or more closed boundaries. The lowest part of each Figure illustrates how the basic building blocks Node, Edge and Face (Face in planar topology only) are mutually related in each of the supported topologies. Within the conceptual model Nodes can be broken down into two types. Isolated Nodes are Nodes which do not coincide with other geometry. Otherwise a Node is considered a non-isolated Node which means it is connected to one or more Edges.

In non-explicit topology, Features are defined by the basic building blocks Dots, Polylines and Polygons. Figure 12 shows that a NET Point Feature is always represented by exactly one Dot, a NET Line Feature by exactly one Polyline and a NET Area Feature by exactly one Polygon. As can be seen, no relations are defined between these basic building blocks, thus signifying their non-explicit topological nature. An important distinction here is that in contrast with topology there is no reuse within the building blocks—neither a Polyline reuses (references) Dots, nor a Polygon reuses Polyline. Thus shared geometry never occurs and overlapping Features need to have their building blocks replicated. In non-explicit topology reuse can occur in the definition of Complex Features.

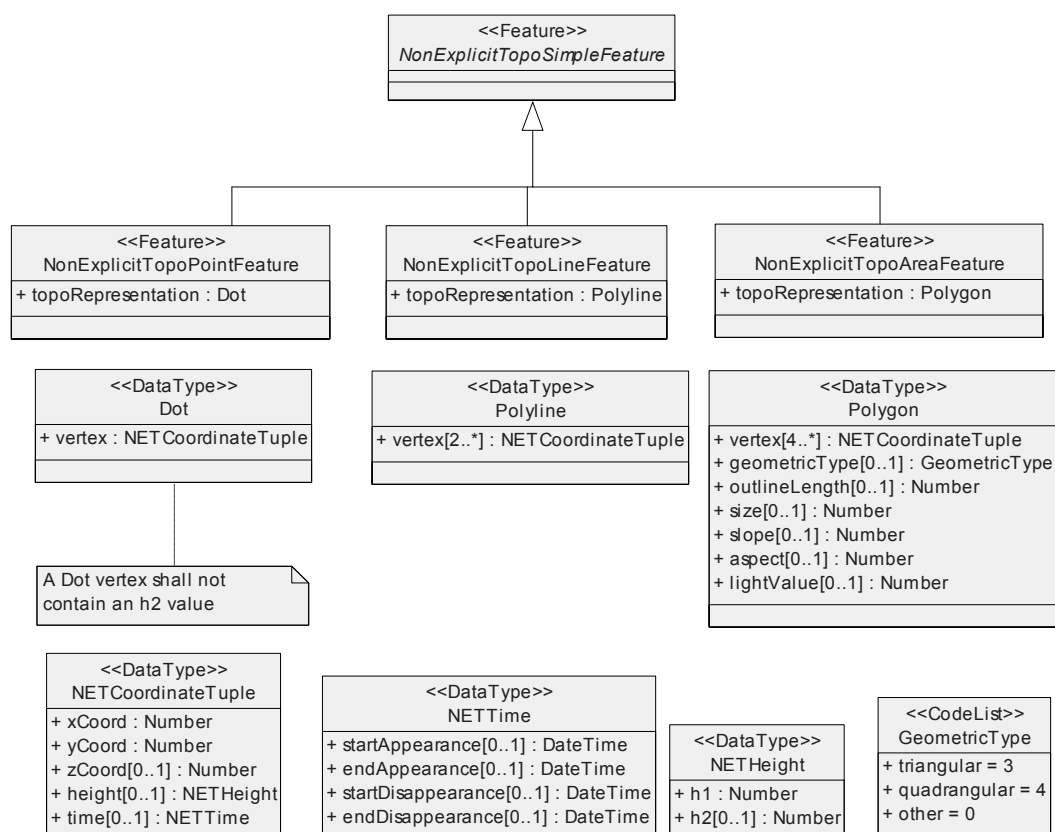


Figure 12 — The conceptual data model of NET Simple Features

It is not allowed to mix the use of topologies, i.e. a GDF Layer can only contain data from one type of topology (See Figure 21 and Figure 22).

One should note that the multiplicity of classes representing the basic geometric building blocks (Nodes, Edges and Faces) in the associations with the classes representing Features with the different Feature Categories (Point, Line and Area) in planar and non-planar topology have zero as begin value.. This indicates that geometry-less Features are allowed. I.e. the standard allows the definition of Features for which the geometry is not defined.

“multiplicity” indicates the number of instances of the class nearest the adornment that can participate in each instance of the association. Multiplicity is specified as a range with a format of “begin-value..end-value”. Begin-value is any positive integer. End-value is an integer greater than begin-value. If only a begin-value is specified, then exactly that number of instances of the class must exist for this association. For example, a multiplicity of ‘1’ at the Type1 side of the association specifies that every instance of Type2 must have this association with one and only one instance of Type1. A multiplicity of ‘0..1’ specifies that every instance of Type2 must have this association with zero or one instances of Type1. A multiplicity of ‘0..*’ specifies that every instance of Type2 must have this association with zero or more instances of Type1. A multiplicity of ‘1..*’ specifies that every instance of Type2 must have this association with one or more instances of Type1.

5.2.3 Levels in GDF

The different objects together making up a GDF are conceptually divided over three different levels, Level-0, Level-1 and Level-2. The topological primitive building blocks, Node, Edge, and Face, reside on Level-0. The Simple Features, as referred to in the previous paragraph and in the data models there together make up Level-1. Simple Features can form aggregated Features which are called Complex Features. Complex Features comprise Level-2. Figure 13, Figure 14 and Figure 15 give the data model of Complex Features for the three different types of topologies. As can be seen in these figures, Complex Features can only consist of Features defined with the same topology.

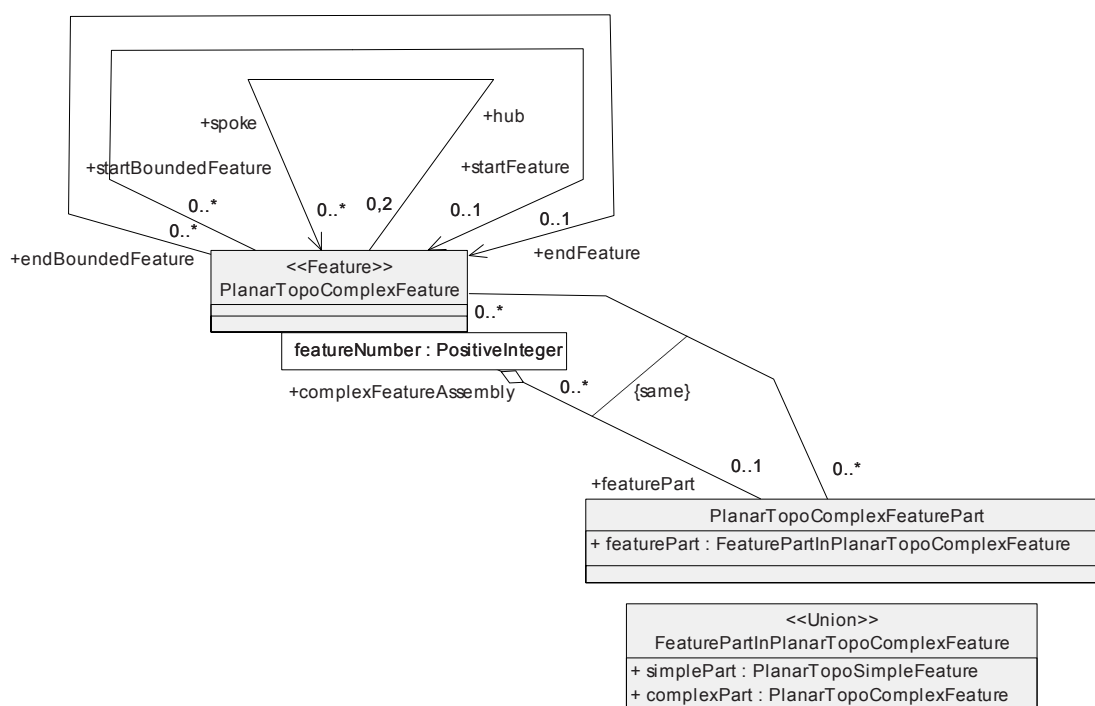


Figure 13 — The conceptual data model of Planar Topology Complex Features

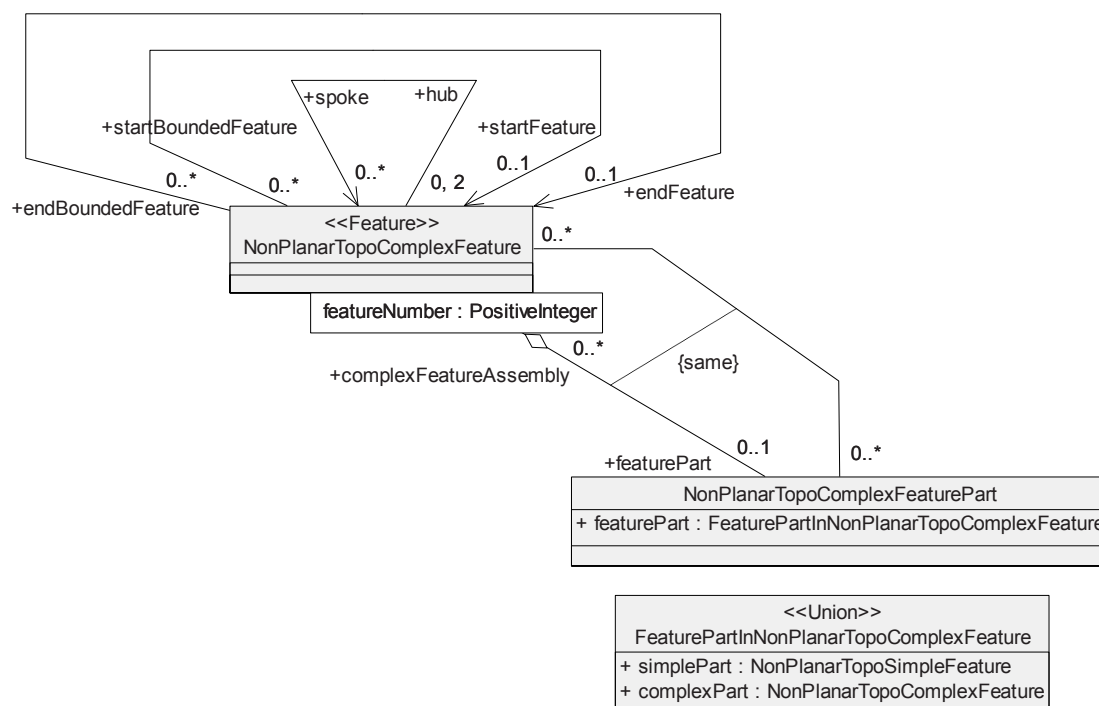


Figure 14 — The conceptual data model of Non-planar Topology Complex Features

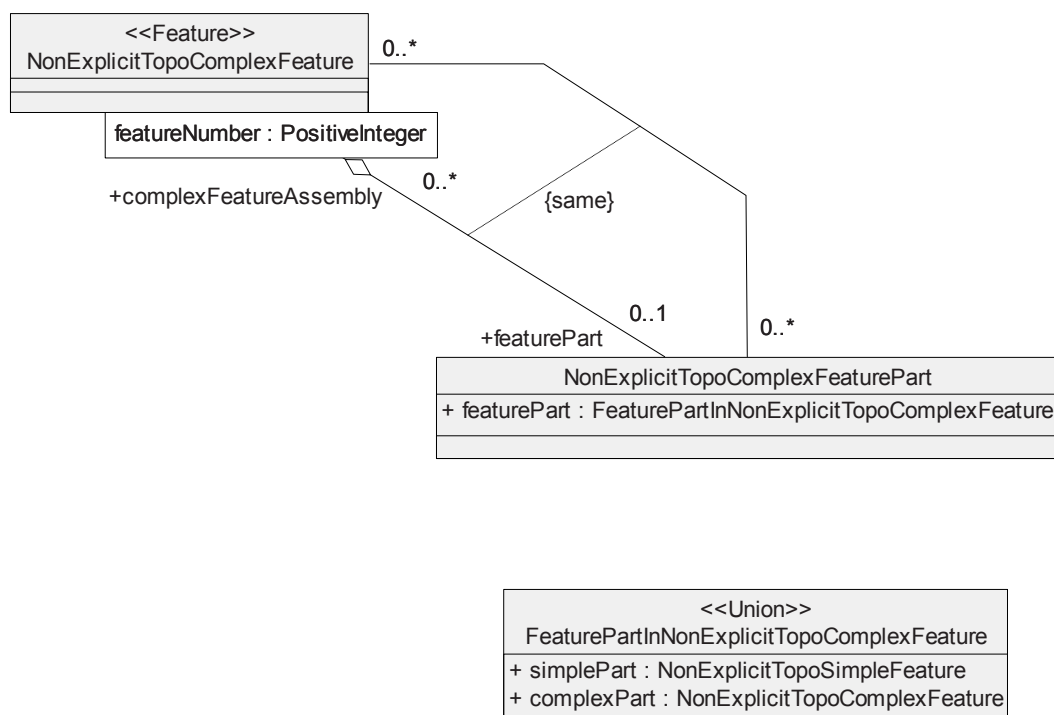


Figure 15 — The conceptual data model of Non-Explicit Topology Complex Features.

5.2.4 Height modelling and time modelling

So far, the different types of topology have been described in terms of their ability to define two dimensional objects. The standard however supports various levels of 3 dimensional modelling and also includes the possibility to model objects in a space-time continuum.

All different types of topology assume a two-dimensional plane to which the different Features are referred to. The standard also supports the definition of elevation above this plane in the sense that all geometries defined (by Nodes, Edges, Faces, Dots, Polylines or Polygons) can be given an elevation value representing terrain height.

In addition to this, non-explicit topology supports the 3-dimensional representation of Features. Next to their horizontal and elevation geometrical definition, Features are represented 3 dimensionally by a specification for each horizontal position of their minimum height and their maximum height above the terrain. In most cases the minimum height will be zero representing a Feature which extends from the ground a certain height vertically. This refers for instance to the case in which a normal building, located on the terrain with a certain height is represented. In certain cases however a Feature will extend from a certain height above the ground a certain height vertically. This refers for instance to arch shaped buildings which have a certain part starting a certain height above the ground and extending further upward (See Figure 16).

In non-planar and planar topology 3-dimensional aspects can be modelled via an Attribute solution. If a given Non-Explicit Topology Feature is subject to both 3-dimensional representation models (namely 3-dimensional characteristics on Feature level as well as 3-dimensional characteristics of Attributes of the Feature in question), the 3-dimensional characteristics on Feature level shall be given priority over the 3-dimensional characteristics on Attribute level.

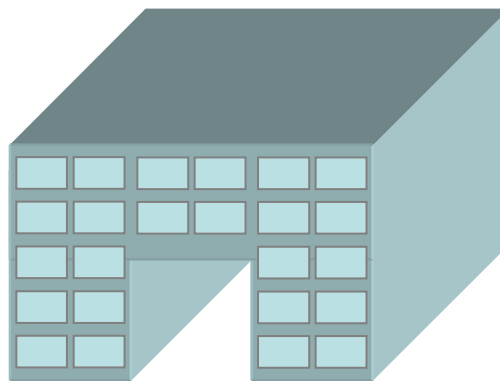


Figure 16 — Example of an arch shaped building

The standard also supports terrain modelling in which a 3-dimensional representation of the terrain may be defined. Four different methods are offered for this which include support for Triangular Irregular Networks (TIN's), contour lines and point grids. For the TIN support Faces and Polygons have been extended with enhanced geometric properties such as triangle size and slope. Contour Lines and Point Grids are modelled as Features and Attributes.

The standard also supports the representation of temporal characteristics of Features. This is supported for Non-Explicit Topology Features. This is done by extending each horizontal position of a Feature with four temporal definitions. These definitions stand for the moment of start of appearance (construction start), the moment of end appearance (opening), the moment of start of disappearance (closure) and the end of disappearance (demolition end). In this way the existence of a Feature over time can be represented. In non-planar and planar topology temporal aspects can be modelled via an Attribute solution. Here the Time Domain Model of GDF (See also 5.7) is applied whereby the start time and the duration of a certain construction status may be defined.

If a given Non-Explicit Topology Feature is subject to both time models (namely temporal characteristics on Feature level as well as temporal characteristics of Attributes of the Feature in question), the temporal characteristics on Feature level shall be given priority over the temporal characteristics on Attribute level.

5.3 The Attribute model

Characteristics of Features which are independent of other Features are modelled as Attributes. Attributes are of a certain Attribute Type identified by a name and code. The value of an Attribute instance is called an Attribute Value. Attribute data types include among others a code, text, an ID or number. This International Standard defines Attributes relevant for ITS applications and specifies which Attributes may be used in combination with which Features. For Complex Features, Attributes may be defined for a Complex Feature as a whole (assembly) or for a particular Feature part on an instance by instance basis.

In certain cases Attribute Values are defined within the GDF itself. In other cases only the domain of the Attribute Value is specified. This is the case when the Attribute Value is a measure (e.g. Average Speed) or is defined by a string of characters (e.g. Official Street Name Text). Another case relates to user-defined Attributes. User-defined Attributes are defined by the user within the context of a particular GDF. Certain Attributes that have been defined in the GDF do not have their Attribute Values defined. For example, the Attribute Value of Multimedia File Attachment is the reference to external files rendered in binary, XML, or other physical encodings.

The Attribute Catalogue defines a set of Attribute Types and corresponding reference names and codes. It also defines the Feature Class and/or the Relationship Type to which a particular Attribute Type may be attached. Figure 17 and Figure 18 give the conceptual data model for this. The diagram shows that an Attribute may be an aggregation of other Attributes. Such an Attribute is called a Composite Attribute, as opposed to a normal (non-aggregated) or Simple Attribute. A Composite Attribute consists of a number of Sub-Attributes. Semantically, a Composite Attribute specifies an aggregated value, which is composed of a number of values, specified by the value of the respective Sub-Attribute. Their appearance in a Composite Attribute specifies the fact that they represent partial information and that the complete information can be found in the other Sub-Attributes of the Composite Attribute.

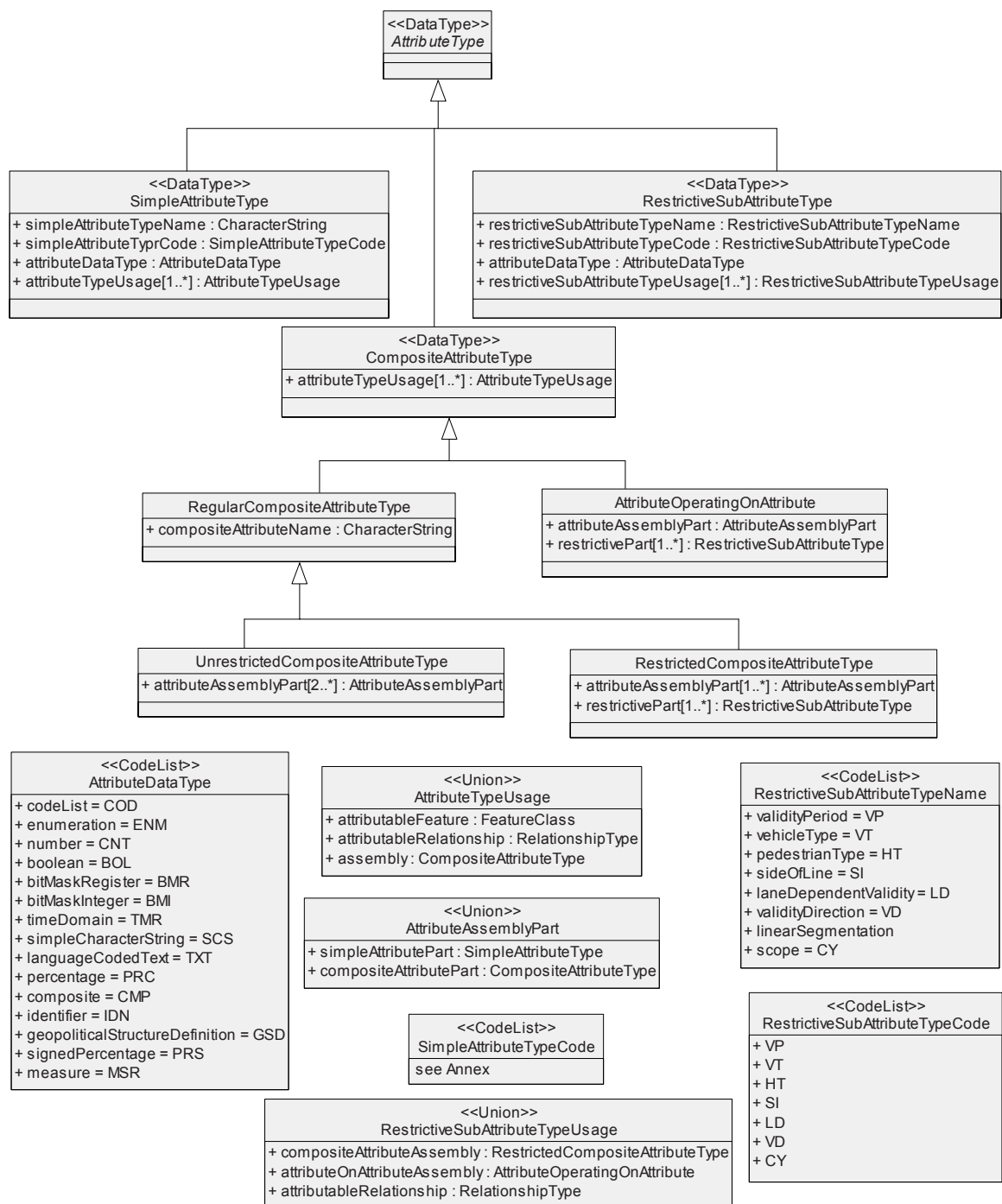


Figure 17 — The conceptual data model for Attribute Types

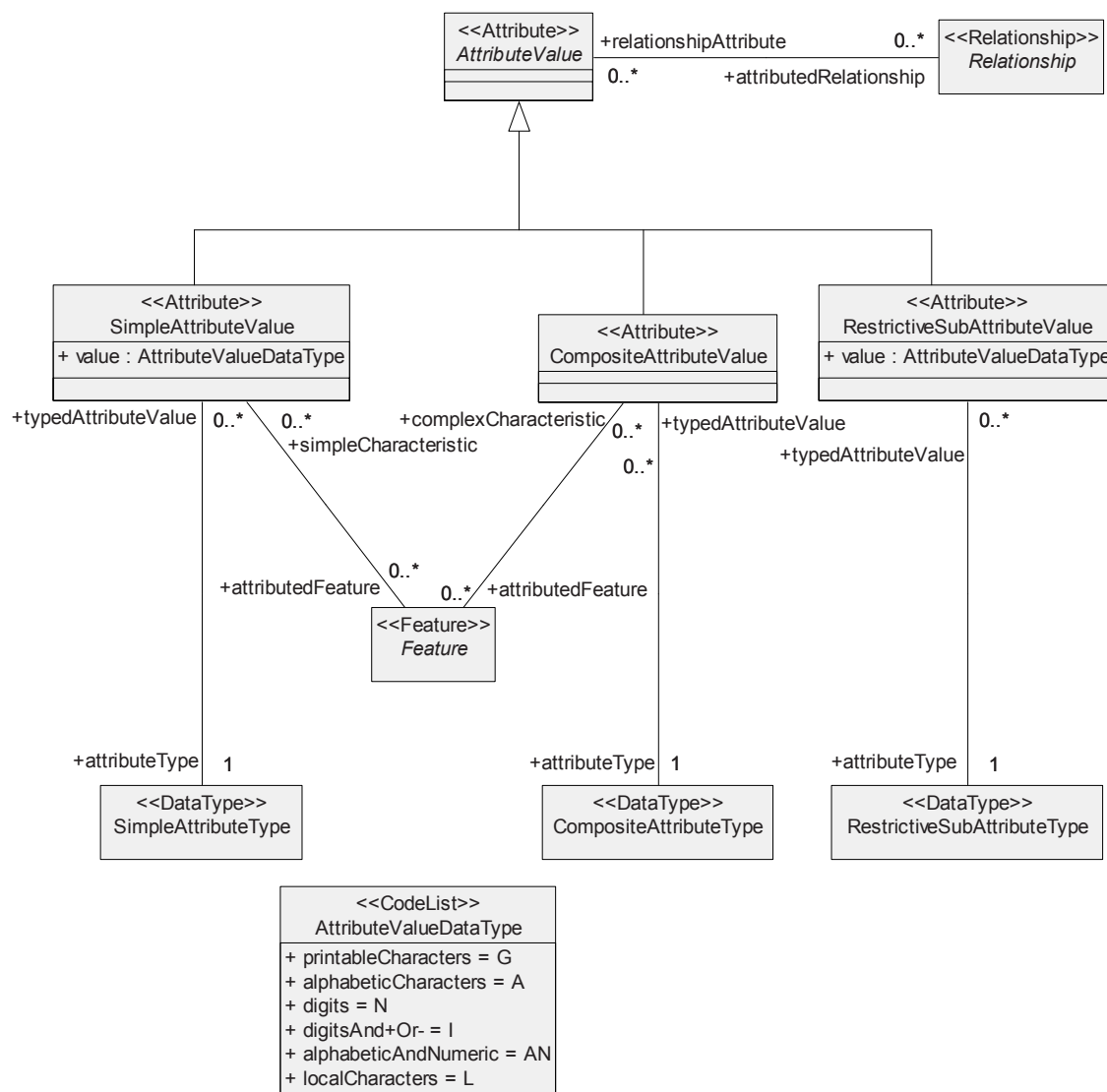


Figure 18 — The conceptual data model for Attribute Values

In most cases, like values of normal Attributes, Sub-Attributes values are independent. Cases where Sub-Attribute Values are not independent are cases where an Attribute (Simple or Composite) are combined with a so-called Restrictive Sub-Attribute operating in said Attribute. In these cases, the validity of the Attribute is restricted to the value specified in the Restrictive Sub-Attribute. Restrictive Sub-Attributes values may never be attached to a Feature individually. They shall always appear in combination with the Attribute they restrict. Restrictive Sub-Attribute Values may be attached individually to Relationship. In these cases they restrict validity of the Relationship.

Each Sub-Attribute of a Composite Attribute is either a Simple Attribute, a Composite Attribute, or a Restrictive Sub-Attribute. Any Sub-Attribute being a Composite Attribute recursively builds a hierarchical tree of Sub-Attribute sets at different hierarchical scope level. In case a Restrictive Sub-Attribute operates on a (Simple or Composite) Attribute, it implies representing a different scope level then said Attribute.

5.4 The Relationship model

A Semantic Relationship specifies a meaningful relation between two or more Features, which are not necessarily of different classes. Furthermore, the Features in a Semantic Relationship can be in the same or in different Sections or Layers.

Semantic Relationships with a common structure (e.g. linking Feature A to Feature B, where the instances of A are always of the same class and where the instances of B are always of the same class) and with a common meaning, are grouped into a Relationship Type. A particular Relationship Type is uniquely referred to by a Name and Code (see Figure 19).

Relationships are in many cases binary, i.e. involving two Features. However there are instances when three or more Features are involved in a Relationship. For example, the Relationship Prohibited Manoeuvre requires a Road Element, a Junction and at least one other Road Element, each playing a pre-defined and recognizable role.

A Relationship may be further qualified by means of Attributes. Similar to Attributes attachable to Complex Features assemblies and attachable to their parts, Attributes of a Relationship may be attached to a Relationship as a whole or to a particular Feature partner (per role). The set of attached Attributes may or may not be an ordered set. Whether the Attributes of a particular Relationship need to be an ordered sequence is explicitly specified.

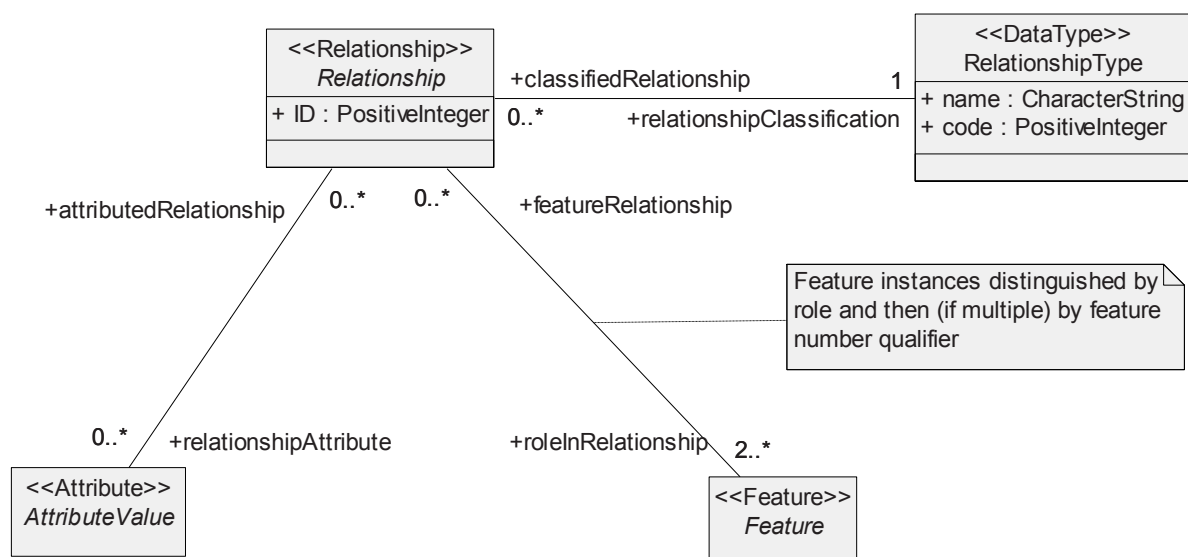


Figure 19 — The conceptual data model for Relationships

5.5 Linear referencing

GDF supports an ISO 19148-compatible mechanism of linearly referencing positions along Line Features. This allows to map different sets of corresponding Line Features to each other (such as Road Elements on one hand and Anchor Sections embodying a Linear Datum on the other hand) by means of linear assignments, to position Point Features along Line Features by means of point assignments, and to designate the validity of Attribute properties to a confined linear extent along a Line Feature in terms of linear segmentation.

5.6 The Feature representation scheme

The Feature Model, the Attribute Model and the Relationship Model can be considered as being valid for a wide range of applications. The Feature Representation Scheme is application specific in the sense that it specifies the representation needs of applications that share the same representation needs. The Feature Representation Scheme contained in the current standard specifies the needs of ITS applications. From these needs it follows for instance that a Road Element shall always be represented by a Line Feature. Another Feature Representation Scheme (not contained) may specify that a Road Element shall be represented by an Area Feature.

The most important role of the Feature Representation Scheme is to specify to which Feature Category or categories a particular Feature Class must or may belong. Seven different categories are distinguished: Topological Point, Line and Area Features, Complex Features and non-explicit Topological Point, Line and Area Features.

In Figure 20, two different possibilities are conceivable for a particular Feature Class:

- a) all instances must be of one and the same category.
- b) some instances may be of one category, other instances of another one.

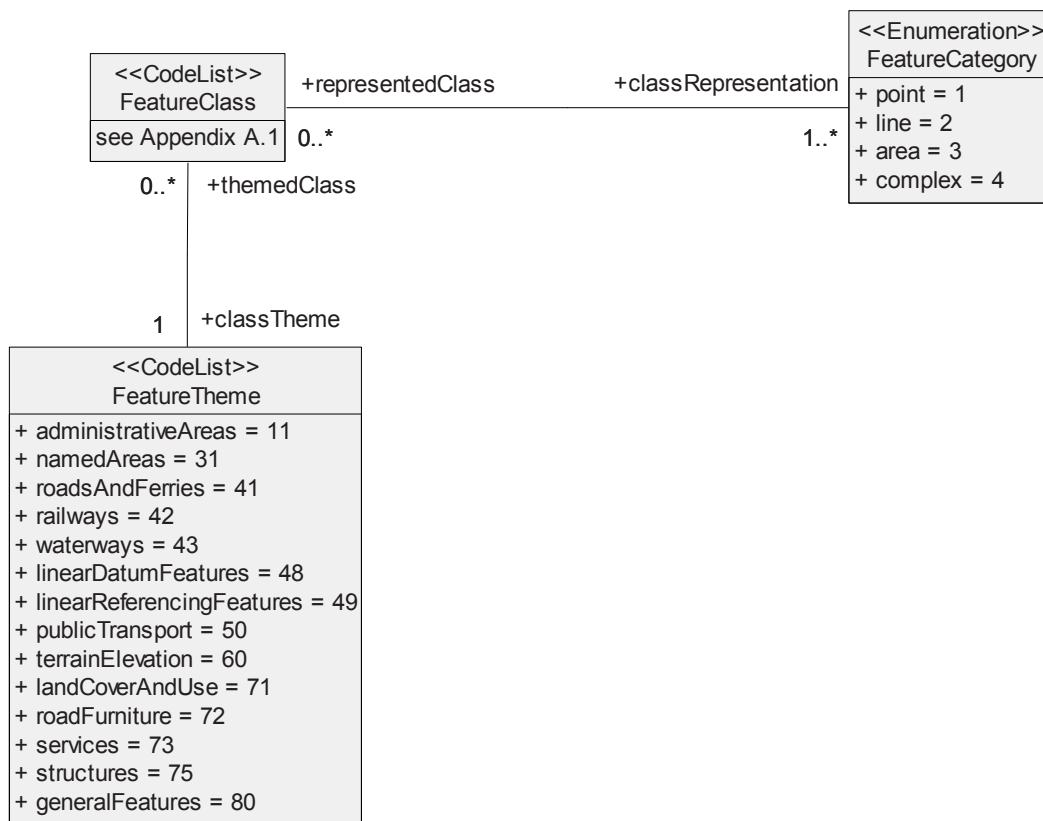


Figure 20 — The conceptual data model for Feature Representation

5.7 Time modelling

GDF supports the definition of temporal aspects. These can relate to Features, Attributes or Relationships. Temporal aspects of Features already have been conceptually described in section 5.2.4. In this paragraph reference was made to the GDF Time Domain Model. The GDF Time Domain Model also is used to define temporal aspects of Attributes and Relationships. The model uses starting time, ending time and duration as

basic elements to describe a specific period. Time expressions can either be modelled as a starting time and an ending time, or as a starting time and a duration. In special cases Time expressions may consist of a starting time alone or a duration alone. In addition to sharply defined time components (e.g. January 1, 2009 at 0h:00) the standard also supports the definition of more fuzzy time components (e.g. after sunrise). The time domain model is applied in certain “time-relevant” Attributes. Through this mechanism the time during which a certain Attribute or Relationship is valid may be modelled.

5.8 Data management: organisation of Feature data into Layers and Sections

The contents of a digital road map can be thought of as being structured spatially and according to the Feature content. This International Standard identifies the need to define a GDF as a set of different independent chunks of data. For this, the following conceptual model is provided.

Figure 21 through Figure 25 depict the overall structure under which Features are organised within a GDF. Figure 21 shows that one complete GDF is contained in an Album. An Album must be composed of one or more Datasets, whereby each Dataset contains a certain aerial subset of the total area covered by the GDF. Each Dataset must be composed of one or more Layers (see 10.1.3 for more on Albums and Datasets). Generally, the area covered by a Dataset and a Layer coincides. A Layer represents a division according to the Feature contents. It contains Feature data of one or more Feature Themes, of a uniform topology. Thus a Layer may contain exclusively Features represented under planar topology, non-planar topology, or non-explicit topology, but not a mixture (see Figure 22). This also means, that Planar Topo Section comprises Nodes, Edges and Faces as its primitives, whereas Non Planar Topo Section comprises only Nodes and Edges (See Figure 23).

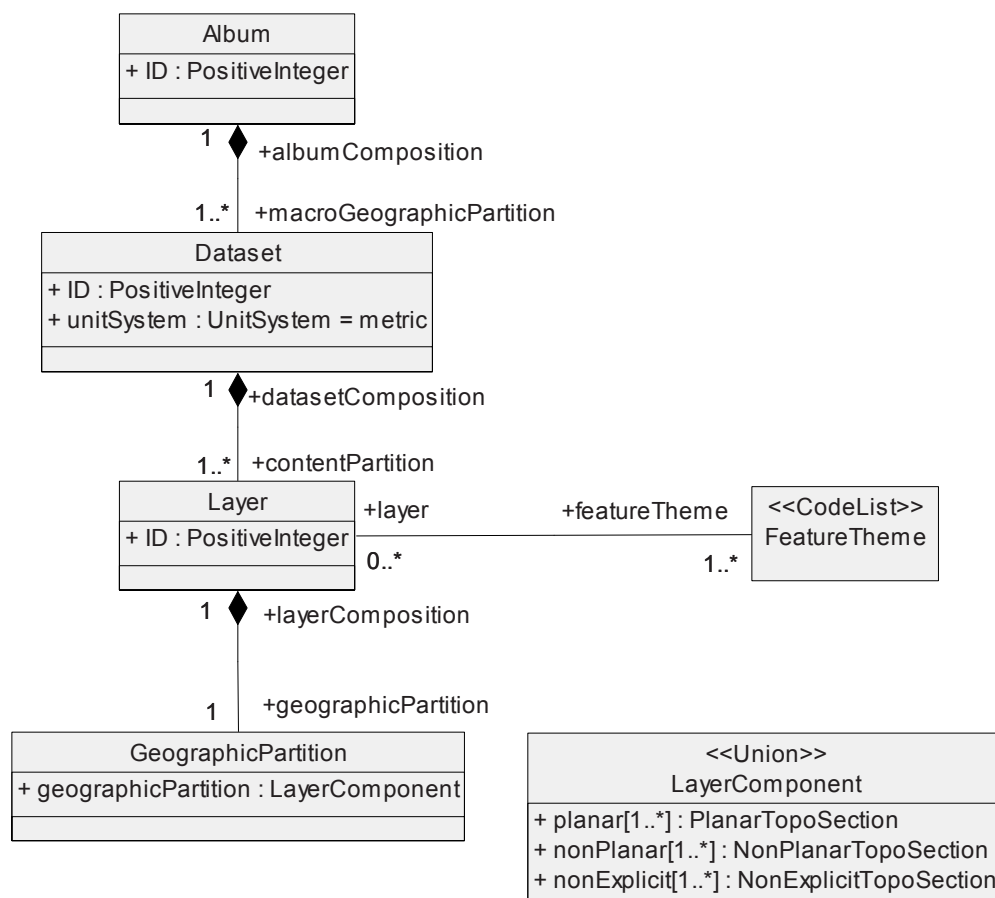


Figure 21 — The organization of data in Albums, Datasets, Layers and Sections

A Layer must be composed of one or more Sections, each of which represents a different geographic area. Figure 22 shows that the topology-based Sections of Figure 21 are composed of Features of their corresponding topologies. Thus a Planar Topo Section must be composed of one or more Planar Topo Features and so on. Sections can take the form of rectangular meshes or more natural areas like Administrative Areas. All Layers in a Dataset may have Sections with the same spatial extend or Sections with a Layer specific spatial subdivision may be defined.

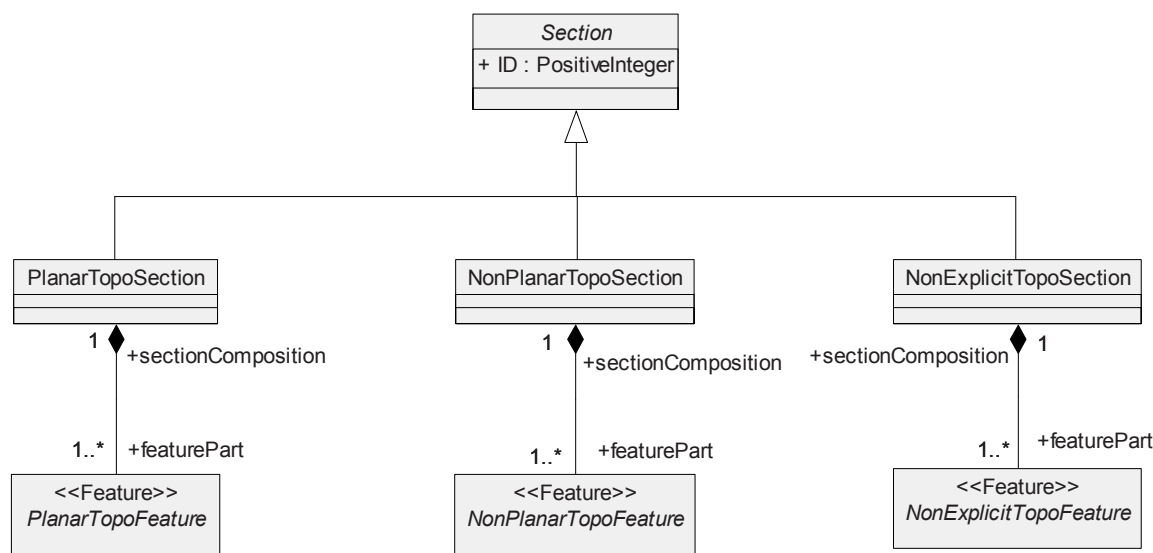


Figure 22 — Composition of Sections

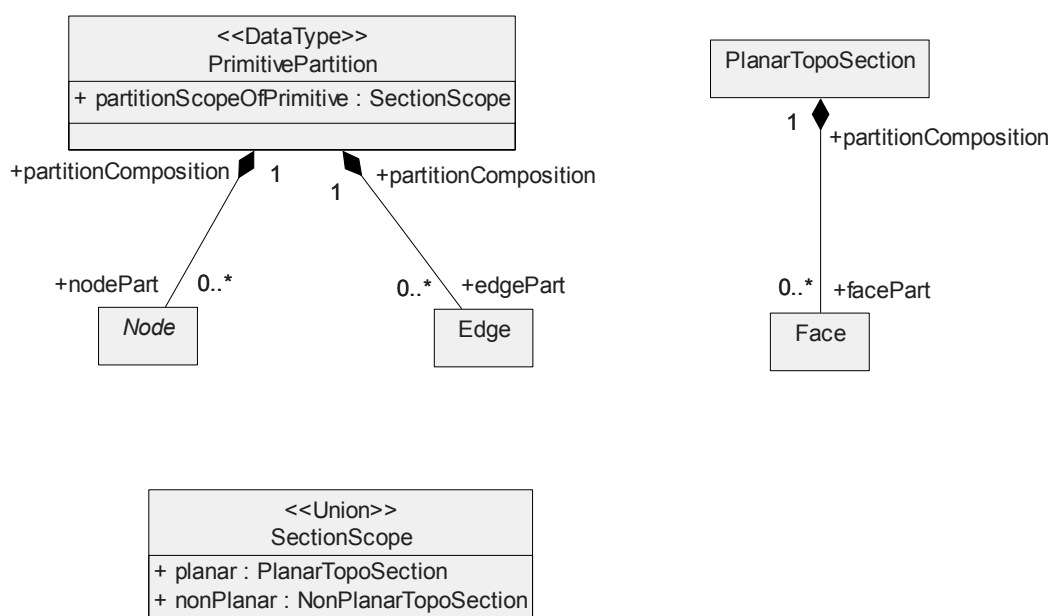


Figure 23 — Section Primitives

Each instance of an Attribute or a Relationship, respectively, can exist locally (partition scope is the Section), semi-globally (partition scope is the Layer), or globally (partition scope is the Dataset). This is depicted in Figure 24.

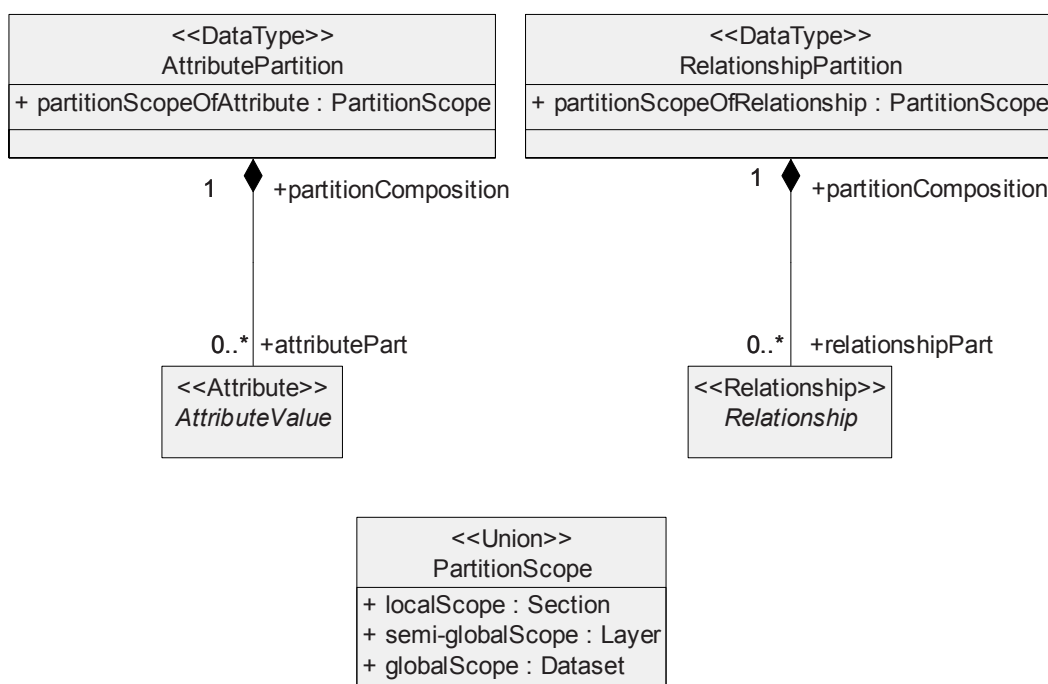


Figure 24 — Attribute and Relationship Partinoning Scope

At Section borders and Dataset borders (i.e. where a Section borders coincides with the Dataset border), Feature continuity is given by conversion information in terms of “translation” of Feature IDs (see Figure 25). The local instance of a Feature is logically connected to a foreign instance of the Feature that resides in an adjacent Section or Dataset. Annex A provides further details about this principle of GDF segmentation.

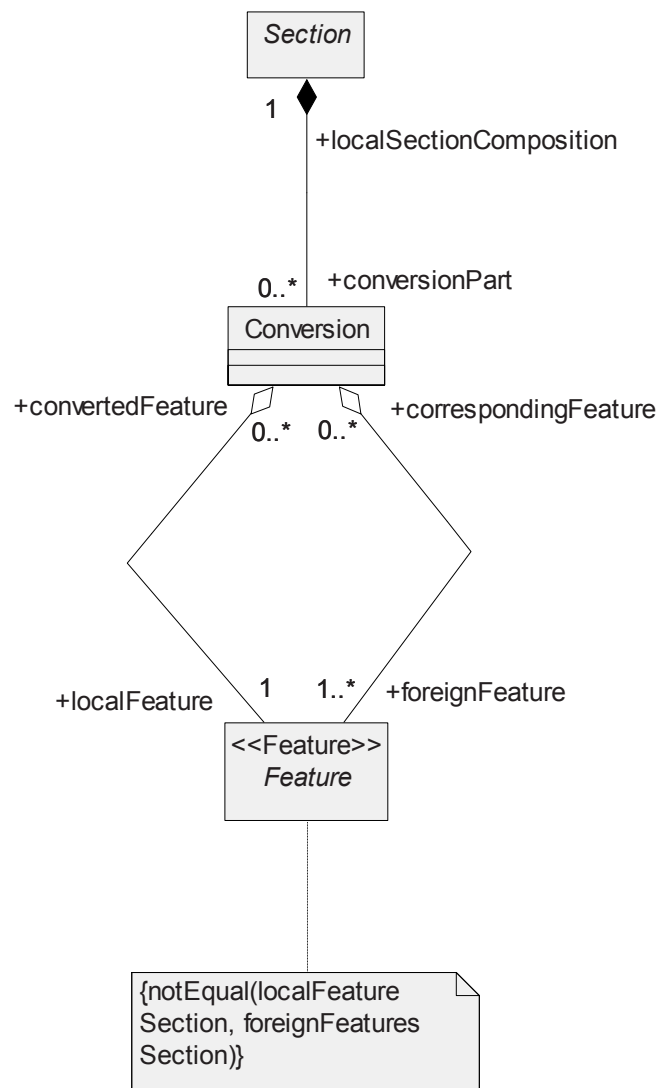


Figure 25 — Feature Conversion

6 Feature Catalogue

6.1 Generic specifications

6.1.1 Features and Feature Themes

In GDF real world objects or activities at a certain location are represented by “Features”. Examples of real world objects are roads and buildings. Examples of activities at a certain location are the services. Features such as “Roads” and “Ferries” may be grouped together into “Feature Themes” (for instance “Roads and Ferries”).

All Features and Feature Themes in the GDF are referenced throughout the manual by a Feature name or Feature Theme Name. Most of these names are derived from terms commonly used in daily life (for instance road, building). In order to distinguish a GDF Feature Name from these commonly used terms, the names of the Features and Feature Themes are written with an uppercase character at the beginning of each word (for instance “Road Element” versus “road element”).

6.1.2 Feature Class Codes

For data exchange the Features and Feature Themes are not referenced by their names but by a numeric code. A four-digit code is used for Features and a two-digit code for Feature Themes. A strict 1:1 relationship exists between Feature names and Feature Class Codes and between Feature Theme Names and Feature Theme Codes. A full list of codes is given in A.1.

6.1.3 Simple and Complex Features

GDF makes a distinction between Simple Features and Complex Features. A Simple Feature is a Feature not composed of other Features.

A Complex Feature is composed of Simple Features and/or other Complex Features. For example, an Intersection is a Complex Feature, made up of a set of Features such as Road Elements and Junctions. An example of a Complex Feature made up of other Complex Features is a Country made up of Order-1 (complex) Administrative Areas.

In case complex aggregations are subject to constraints (identifiable parts, ordered parts), this is explicitly specified.

6.1.4 Feature hierarchy

This International Standard supports the need to define a Feature hierarchy. In a Feature hierarchy definition, a certain Feature Class can be defined as a sub-type of a more generically defined super type. In this way, an instance of a sub-type can be considered on its own generalisation level as an instance of that sub-type while at a higher generalisation level as an instance of its super type. As an example, one can consider a Hotel which has as a super type Lodging Facilities which in turn can have as a super type Tourist Facility.

6.1.5 Data model for the Feature Catalogue

Figure 26 shows that part of the data model that is relevant for the Feature Catalogue. It shows that Features are organised into different Feature Themes.

6.1.6 User-defined Features

This International Standard supports the ability for a user to define Features that are not already defined. For these, special Feature Class Codes have been reserved. (See A.1.)

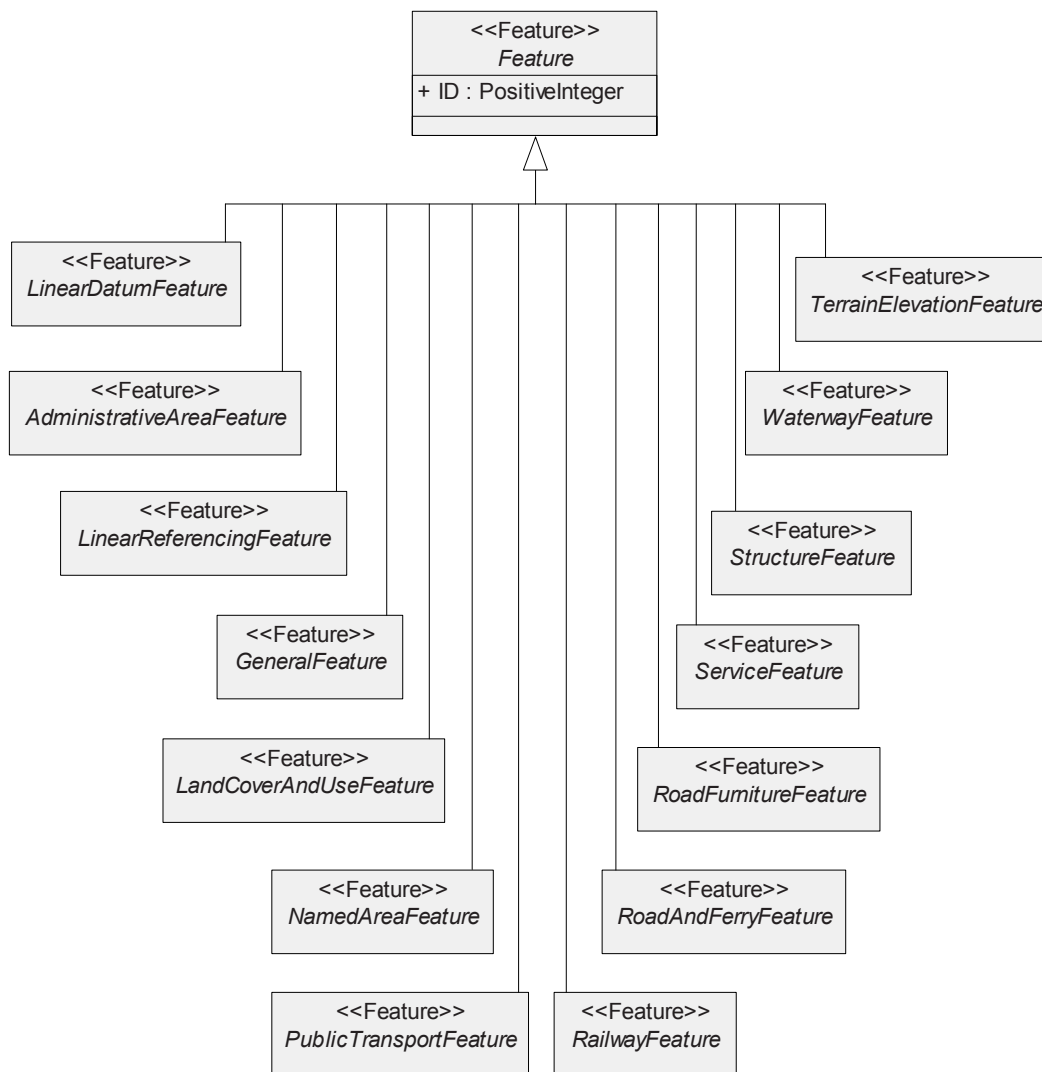


Figure 26 — The Conceptual Data Model of the Feature Catalogue

Features from the different Feature Themes are discussed in the following sub-clauses.

6.2 Roads and Ferries

6.2.1 General overview

The road network is seen here primarily from the viewpoint of transportation and traffic. Ferry connections are therefore placed together with road network elements in one theme.

The road network can be represented at two different levels, Level 1 and Level 2. Level 1 describes the Simple Features such as Road Element, Junction, Ferry Connection, Enclosed Traffic Area, Address area Boundary Element and Address Area, whereas Level 2 describes the Complex Features such as Road, Intersection, Ferry and Aggregated Way.

The Data Model for Roads and Ferries is given in Figure 27, Figure 28 and Figure 29 which describes Relationships between Features within and between Level 1 and Level 2.

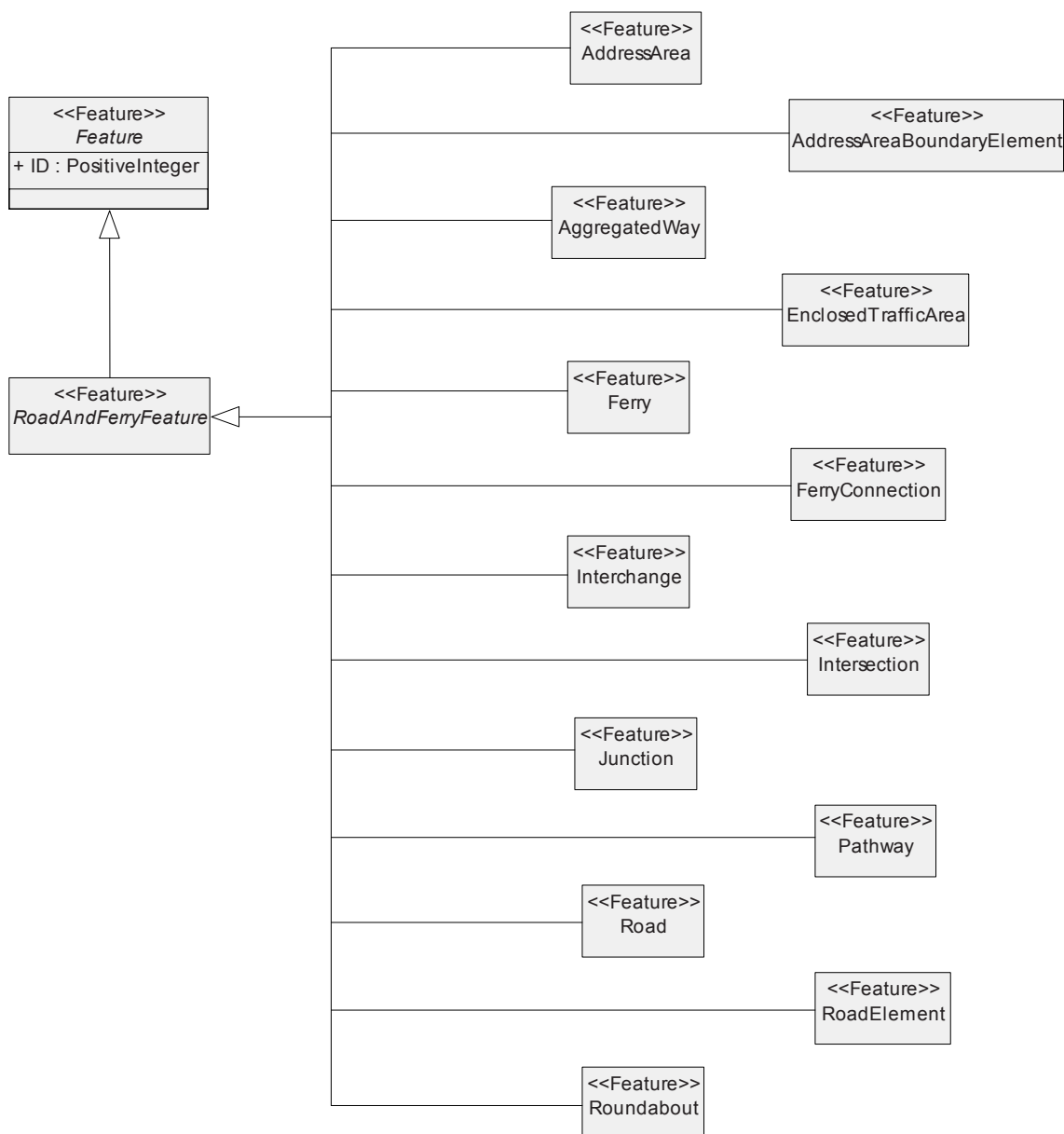


Figure 27 — The Conceptual Data Model for Roads and Ferries

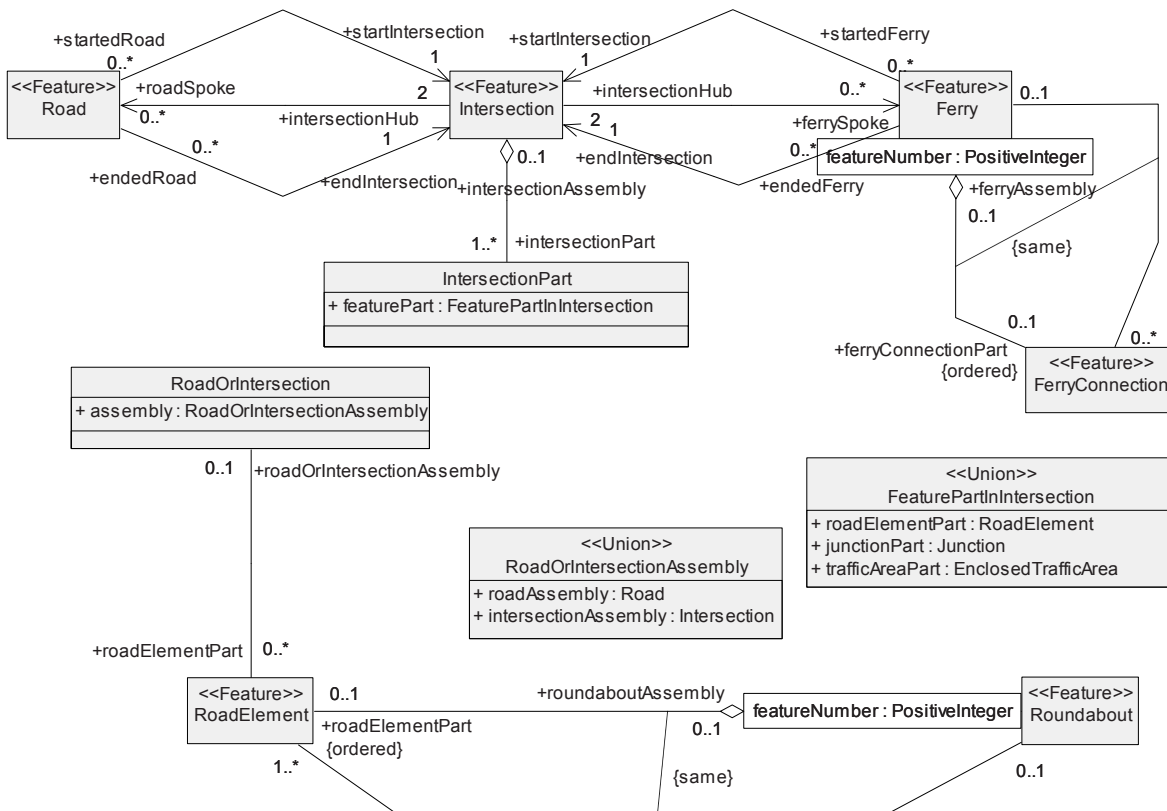


Figure 28 — The Conceptual Data Model for Roads and Ferries (continued)

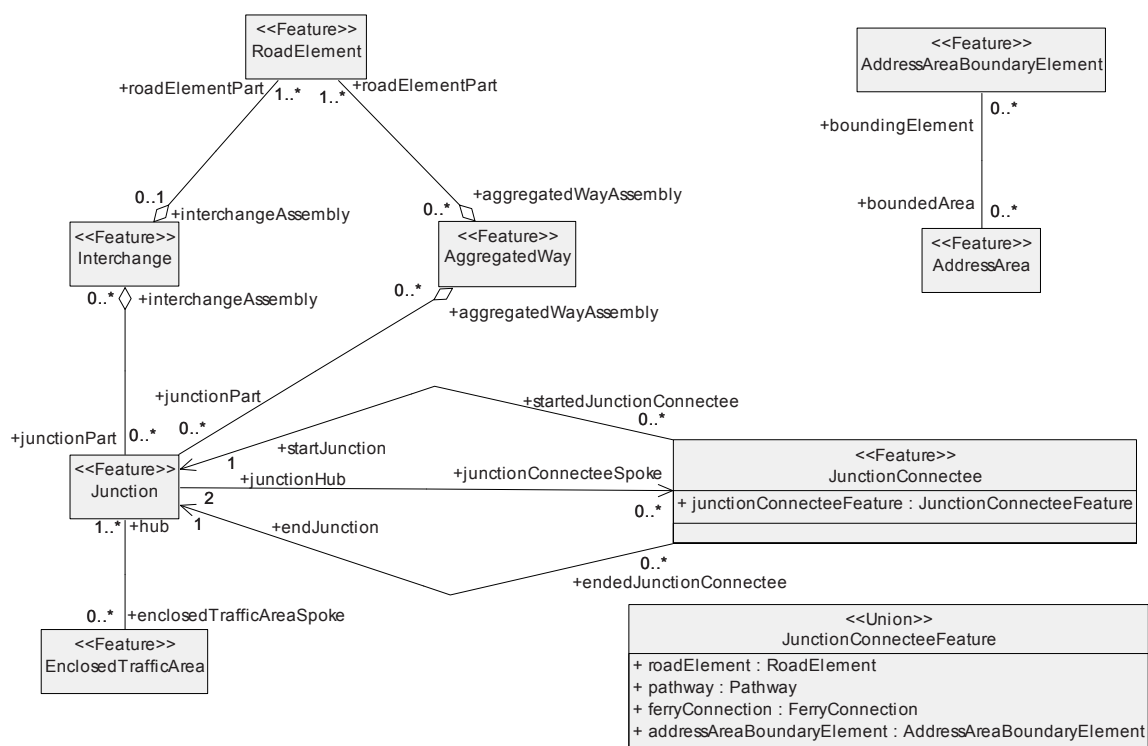


Figure 29 — The Conceptual Data Model for Roads and Ferries (continued)

6.2.2 Address Area

6.2.2.1 Definition

An area containing addresses which cannot be related to one or more Road Element.

6.2.2.2 Description

In certain situations addresses are defined in such a way that the information cannot be related to one or more Road Element. Two different situations can be identified:

- The addresses are located in a square, which has a name that is different from the name of the Road Element(s) representing the road network on that square.
- The addresses are defined according to building blocks. In these cases a building block has a name which differs from the name of an adjacent building block and of the Road Element which possibly divides the two building blocks.

An Address Area should always have a connection with the road network.

6.2.3 Address Area Boundary Element

6.2.3.1 Definition

A representation of the boundary of an Address Area.

6.2.3.2 Description

An Address Area Boundary Element describes the outer confinement of an Address Area. An Address Area Boundary Element is start and end bounded by a Junction that is defined where the Address Area intersects with the road network.

6.2.4 Aggregated Way

6.2.4.1 Definition

A set of associated Road Elements and, optionally, Junctions which share a common function or characteristic.

6.2.4.2 Description

An Aggregated Way is a Feature which has been defined by a user, for example a road authority, for the purpose of identifying and relating Features in their user-specified model to level 1 Features in the GDF.

A Road Element or Junction can belong to more than one Aggregated Way. Aggregated Ways do not have an implied topology; that is, they are not necessarily connected to other Aggregated Ways, and do not necessarily form a complete network.

6.2.5 Enclosed Traffic Area

6.2.5.1 Definition

Any confined area within which unstructured traffic movements are allowed.

6.2.5.2 Description

EXAMPLE Industrial Site, Car Park, Harbour area, Camp Site, Military Area or Unstructured Traffic Square.

6.2.6 Ferry

6.2.6.1 Definition

A set of Ferry Connections that describe a passage of a particular ferry line.

6.2.6.2 Description

A Ferry plays the same role in the ferry network as a Road in a road network.

6.2.6.3 Aggregation constraints

A Ferry is composed of an ordered sequence of concatenated Ferry Connections.

6.2.7 Ferry Connection

6.2.7.1 Definition

A vehicle transport path between two fixed locations on the road network which uses a prescribed mode of transport.

EXAMPLE boat ferry connection or rail ferry connection.

6.2.7.2 Description

Ferry Connection is the smallest independent unit of the transportation network operated by a ferry that is represented at Level 1.

Many situations look like the situation depicted in Figure 30. This is interpreted as one single Ferry Connection. But situations exist where one ferry service joins more than two locations as shown in Figure 31. This situation has to be interpreted as three different Ferry Connections: AB, BC and CA.

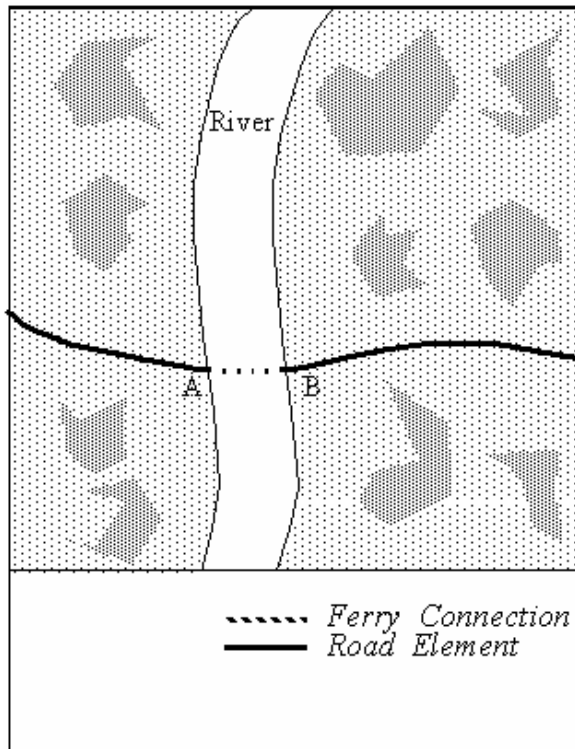


Figure 30 — Example of Ferry Connection joining two terminals

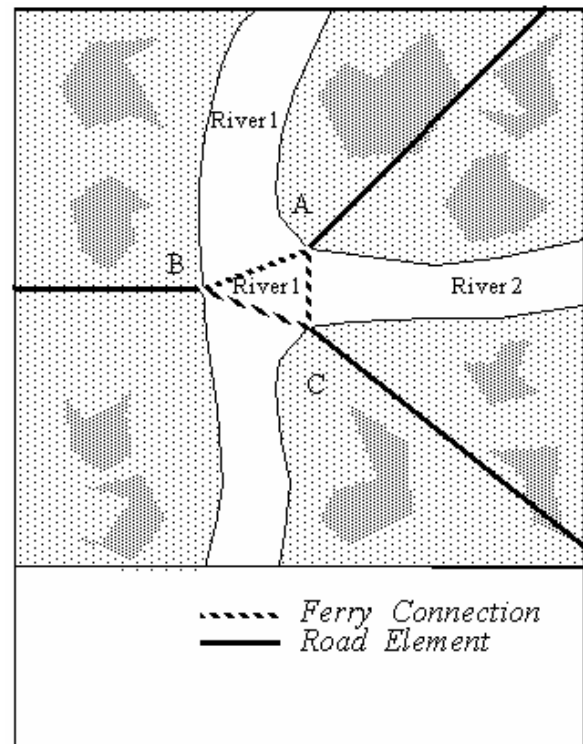


Figure 31 — Example of Ferry Connections joining three terminals

6.2.8 Interchange

6.2.8.1 Definition

An Interchange is a collection of road sections, slip roads and/or carriageways dedicated to facilitating the movement of traffic through a crossing between two or more road ways.

6.2.8.2 Description

An Interchange is a Complex Feature composed of all the Road Elements and Junctions forming a crossing.

EXAMPLE 1 Interchanges between Motorways or Freeways, composed of a collection of slip roads and the carriageways which connect these.

EXAMPLE 2 Interchanges between Motorways or Freeways and non-Freeways composed of a collection of slip roads and the carriageways which connect these.

EXAMPLE 3 Interchanges between multi- or single carriageways at grade. These can have the form of a simple crossing without slip roads, a crossing containing slip roads and a crossing in the form of a roundabout.

Distinct Interchanges may not share Road Elements but they may share Junctions. Thus an Interchange may cover more than two crossing roads when one of its slip roads leads to more than one road.

Two interchanges close together may share carriageways. In such a case, the two interchanges should be combined into one Interchange so that a single carriageway belongs to at most one interchange.

6.2.9 Intersection

6.2.9.1 Definition

The Level 2 representation of a crossing. An Intersection can be part of a Level-2 network by bounding Roads and/or Ferries. It is a Complex Feature composed of one or more Level 1 Junctions, Road Elements and Enclosed Traffic Areas.

6.2.9.2 Similarities and differences between Intersection and Junction

At Level 2, the Feature Intersection plays a similar role as the Feature Junction does at Level 1. Generally, it bounds Roads and Ferries and joins them to other ones. The difference between an Intersection and a Junction lies in the degree of generalisation; where a multi-element crossing will be described at Level 1 by many Road Elements and Junctions; it may be represented at Level 2 by one single Intersection.

Rules for formation of Intersections may be found in Annex F.

6.2.10 Junction

6.2.10.1 Definition

A Feature that bounds a Road Element, a Pathway, an Address Area Boundary Element, or a Ferry Connection.

6.2.10.2 Description

A Road Element, a Pathway, an Address Area Boundary Element, or Ferry Connection always forms a connection between two Junctions, and a Road Element, a Pathway, an Address Area Boundary Element, or Ferry Connection is always bounded by exactly two Junctions. A Junction Feature represents the physical connection between its adjoining Road Elements, Pathways, Address Area Boundary Elements, and Ferry Connections.

6.2.10.3 Valency of a Junction

The number of Road Elements, Pathways, Address Area Boundary Elements, and/or Ferry Connections joining at a Junction is termed the Valency of a Junction.

EXAMPLE A Junction that connects a total of two Road Elements is called a two valent Junction.

The occurrence of Junctions that bound only two Features classes from Road Elements, Pathways, Address Area Boundary Elements, and Ferry Connections is generally restricted to the following situations:

- An extra Junction must be defined at the end of a dead end road which further continues as a Ferry Connection.
- An extra Junction may be used if two Road Elements or two Pathways have at least one different Attribute Value or participate in at least one different Relationship. Figure 32 uses the example of traffic restrictions.
- An extra Junction must be used to avoid a Road Element or a Pathway having the same Junction at the start and at the end, as shown in Figure 33.