Digital National Framework (DNF) – Overview

Introduction to the DNF technical architecture and supporting documentation and services

Document Ownership

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Contents

Foreword

The Digital National Framework (DNF) enables and promotes the integration and sharing of location-based information from multiple sources. It supports the objectives of the UK Location Strategy and the rollout of the UK Location Information Infrastructure. It is being developed for use within the United Kingdom although concepts and principles could be applied elsewhere. It aims to be: (i) definitive by linking information from multiple sources to a definitive location reference through unique identifiers, (ii) inclusive by being open and adopting industry best practice, (iii) structured and formalised to the extent that data once created can be shared and used many times, (iv) reliable through the delivery of data integrity, (v) cost-effective through reduction in the costs of data from multiple sources and (vi) flexible by enabling information exchange and cross-business applications.

The basic principles at the core of DNF are as follows:

- The concept and methods shall be driven by the strategic needs of the wider geographic information (GI) community and the needs of the information industry;
- Data should be collected only once and then re-used;
- Base reference data should be captured at the highest resolution whenever economically possible;
- Information following capture may, where appropriate, be used to meet analysis and multi-resolution publishing requirements;
- DNF will incorporate and adopt existing *de facto* and *de jure* standards, wherever they are proven and robust.

DNF is being developed and promoted by an industry body with membership drawn from data providers, system vendors and integrators and users. Both the commercial and government sectors within Great Britain are represented. All members have a common interest in the integration, sharing and utilisation of geographic information. Direction and strategy comes from an Expert Group. This in turn oversees and approves the work of a Technical Group responsible for the development of all technical documentation including this document.

This document is one of a series of technical publications developed in support of DNF. Included in the series are data models, technical guides, guidelines, best practice, examples and case studies. Limited web-based services such as identifier registration have also been developed in support of this documentation although these will be superseded by those being delivered under the UK Location Programme.

Of major significance to DNF is INSPIRE the European Union (EU) Directive for the creation of a European spatial information infrastructure. This will lead to the provision of integrated spatial information services and will allow users to identify and access spatial or geographical information from a wide range of sources from local to European-wide. There is much commonality between the objectives of DNF and those needing to be met by UK in support of INSPIRE. Thus, DNF is working with, and supporting, the UK Location Programme. The Programme is a pan-government initiative to improve the sharing and re-use of public sector location information in UK. It was established following the publication of the UK Location Strategy. The aim of the Programme is to implement the Strategy and ensure the fulfilment of UK's obligations under the INSPIRE Directive. DNF has registered as a Spatial Data Interest Community (SDIC) and has participated in the review of INSPIRE documents. Through the UK Location Programme, DNF is ensuring that there is alignment between its documents and those of INSPIRE.

For more information on the Digital National Framework visit http://www.dnf.org .

If you have any comments or suggestions on this document, please e-mail contact@dnf.org , your response will be acknowledged.

Executive Summary

This document provides an overview to the technical architecture of the Digital National Framework (DNF) and a guide to the documentation and services being developed in support of the technical architecture. It is aimed at business readers wishing to gain a general understanding of the technical aspects of DNF and also other new adopters who need to understand the broader technical picture and seek guidance on where to look for more detailed information required for any implementation.

General concepts and principles underlying DNF are described and illustrated. The architecture which builds on the concepts is defined in terms of the main components and their relationships. A formal model in Unified Modelling Language (UML) is presented. This is followed by a description of the way in which the technical aspects of DNF are being defined and a summary what is needed to adopt DNF principles. The document concludes with a guide to documentation and supporting services.

Where there is overlap and alignment with INSPIRE the European Union (EU) initiative for the creation of a European spatial information infrastructure or, more specifically the UK Location Information Infrastructure, this is described.

1. Introduction

1.1 Purpose of the document

This document provides an overview of the technical architecture of the Digital National Framework (DNF) and a guide to the documentation and services developed in support of the technical architecture. Its purpose is to (i) equip the reader with a general technical understanding of the nature of DNF, (ii) enable the reader to appreciate whether this is applicable to their business or processes, (iii) indicate what may be required to adopt general DNF principles and (iv) act as a guide to how and where further technical information and services may be obtained.

The principles of DNF are applicable to a wide range of geographic or geospatial data; that is data that carries references, or relates to, locations on the Earth's surface. Although many of the principles are generic, they currently apply to data which references locations in United Kingdom.

The detailed documentation and supporting services are still being developed. Thus, this overview is an evolving document. Certain sections are incomplete or interim in nature. This is made clear in the text. Further, elements of the DNF architecture are being subsumed into the UK Location Programme. Similarly, web services developed or planned by DNF will also be subsumed into the UK Location Information Infrastructure when this is delivered by the UK Location Programme.

1.2 Document structure

Document scope and terms used are presented first. The general concepts and principles underlying DNF are then described and illustrated. The architecture which builds on the concepts is then defined in terms of the main components and their relationships. A formal model in Unified Modelling Language (UML) is presented. This is followed by a description of the way in which the technical aspects of DNF are being defined and a summary of implementation using DNF principles. The document concludes with a guide to documentation and supporting services.

2 Scope

This document forms the top-level of a hierarchy of DNF documentation describing the technical architecture which includes:

- Models or schemas;
- Technical guides to DNF;
- Examples and supplementary documentation supporting the technical guides;

- Guidelines and best practice for data maintenance, quality and classification.

The above are described in summary in this document which provides links to further more detailed information.

This document is particularly applicable to business readers wishing to gain a general understanding of the technical aspects of DNF. It is also applicable to other new adopters who want to understand the broader technical picture and need guidance on where to look for more detailed information required for any implementation.

Those seeking to construct business cases for the adoption of DNF principles should also consult the various case studies available at http://www.dnf.org/resources/.

Figure 1 shows the DNF Roadmap which sets out the main technical deliverables. These are described in summary form in this overview.

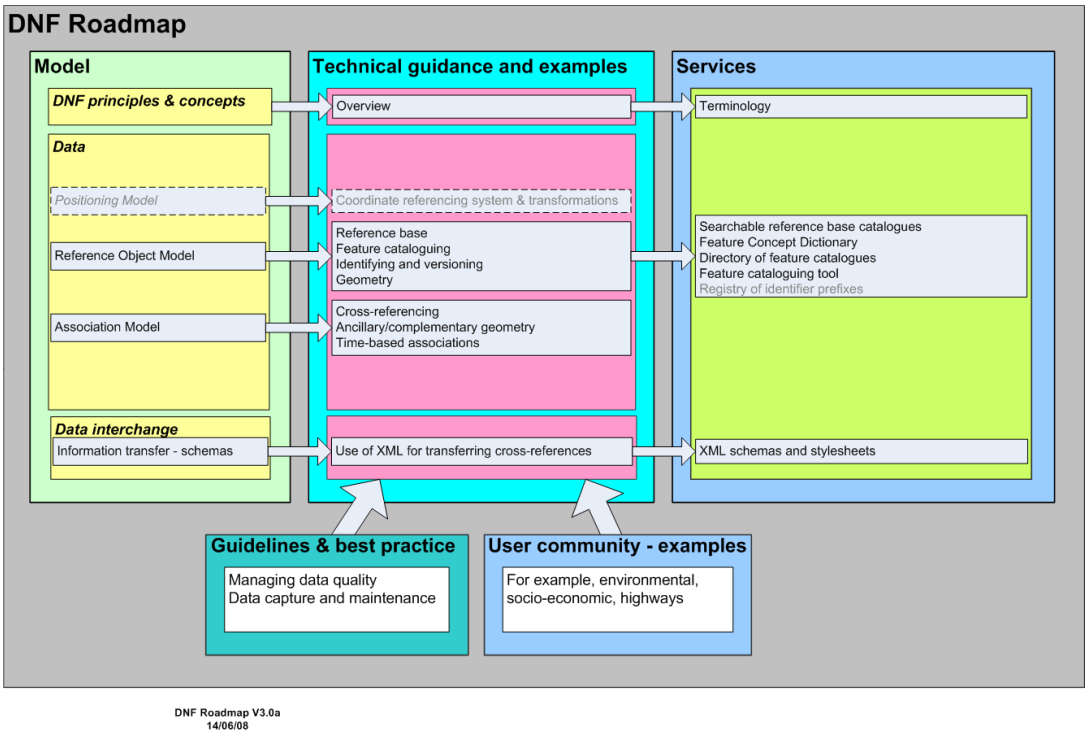

Figure 1: DNF Roadmap

Some models, technical guides and services which were originally in scope of DNF are now being overtaken by the work of the UK Location Programme and INSPIRE (see 4.3 for more details of this initiative). In particular, there are those relating to coordinate referencing. Pending the development of documentation and services by the UK Location Programme, the Technical Guide and web-based information will remain in place. Thus, they are shown by dashed boxes with greyed out names.

3 Definitions

3.1 Terms

The following terms, arranged in alphabetical order, are used in this document. Where definitions include terms defined elsewhere then these terms are shown in *italics*. Where definitions are derived from other sources then the source is given in brackets below the definition. See http://www.dnf.org/guides/terminology/ for a full and up-to-date list of terms used in the Digital National Framework.

3.1.1 Abstraction

Process of selecting only those *Real World Object*s and the *Attribute*s and behaviours of those objects which are relevant to a particular application

3.1.2 Association

In a DNF context, the relationship between a *Business Object* (or objects) and a *Reference Object* (or objects) or between a *Reference* Object and another *Reference Object* (or objects - including *Base Reference Objects*)

NOTE 1 This is a spatial relationship which can be simply expressed through cross-referencing or with more complexity. It may be qualified by the addition of other attributes and metadata.

NOTE 2 This is termed “Object Referencing” in INSPIRE i.e. “a consistent method of referencing spatial data to location using existing spatial objects”

3.1.3 Attribute

Property of a class of objects

NOTE By convention attributes are named. An instance within a class can hold a value within a defined range of values. In the case of a *Reference Object*, attributes may describe, for example, the geometrical, topological, or thematic characteristics

3.1.4 Base Reference Object

Type of *Reference Object* instances of which compose the *Reference Base*. A *Reference Object* to which other *Business Objects* and *Reference Objects* are ultimately associated within a particular domain

NOTE There is no single national set of *Base Reference Objects*. They are defined within a particular domain and can be readily associated with by *Business Objects* and *Reference Objects* within a range of applications

EXAMPLE Basic Land and Property Units, property (cadastral) parcels, river objects, land facets (within a land system)

3.1.5 Business Object

Object which is processed by an application and needs to be located relative to a *Geographic Object*

NOTE Business is used in a wide sense here to relate to any data and objects which are non-geographic. It is not specific to commercial data and can relate to any data such as environmental data that needs to be located

EXAMPLE Planning application referenced to a land parcel; census record referenced to a house; ecological record referenced to a Site of Special Scientific Interest

3.1.6 Complementary Geometry

Lines or areas used to qualify the relationship between a *Reference Object* and a *Base Reference Object* where the spatial relationship is not coterminous or where there is a need for greater precision

NOTE 1 The geometry i.e. the spatial properties in terms of points, lines and areas defined by coordinate positions must be consistent with that of the *Reference Base* and fit to it

NOTE 2 Previously termed “ancillary geometry”

NOTE 3 Not described in any detail in this document

EXAMPLE Additional line geometry created where a title extends beyond the physical boundary of a land parcel as represented by the *Base Reference Object*

3.1.7 Coordinate Position

Point on the Earth's surface defined by a coordinate value derived using a *Coordinate Reference System*

NOTE May be a two or three dimensional coordinate

3.1.8 Coordinate Reference

Position of a *Geographic Object* given using coordinates

EXAMPLE National Grid Eastings and Northings

3.1.9 Coordinate Reference System

Coordinate System that is related to an object by a datum
(ISO 19111)

3.1.10 Coordinate System

Set of mathematical rules for specifying how coordinates are to be assigned to points
(ISO 19111)

3.1.11 Cross-Referencing

Mechanism of holding links between objects which may be expressed through the use of identifiers

EXAMPLE Unique Property Reference Number (UPRN) of a Basic Land and Property Unit (BLPU) cross-referenced to an OS MasterMap Topographic Area

3.1.12 Domain

In a DNF context, a specific sphere of activity or field of study that has a set of common requirements and terminology and seeks common solutions to problems through the exchange of information

NOTE A user community that wishes to share information relating to location could define a *Domain* in this context

3.1.13 Feature

Abstraction of real world phenomena
(ISO 19101)

NOTE 1 A feature may occur as a type or an instance. Similar instances of particular phenomena can classified together as a type

NOTE 2 *Geographic Object* is used in preference to “feature” in DNF except in reference to data classification and feature cataloguing where the term "feature" is widely adopted

EXAMPLE The phenomenon named "Acacia Avenue" may be classified with other similar phenomena into a feature type "street"

3.1.14 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
(ISO 19101)

NOTE Feature and object are regarded as synonymous in this context

3.1.15 Feature Concept Dictionary

Dictionary that contains definitions of and related descriptive information about concepts that may be specified in detail in a feature catalogue
(ISO 19126)

NOTE A feature concept dictionary describes concepts that may be used to characterise *Real World Objects*. Feature types and their attributes may then be specified using these concepts and documented in a feature catalogue

3.1.16 Geographic Object

Abstraction or application view of a real world object which has a fixed and identifiable location on the Earth's surface

NOTE 1 Typically represented in data by points, lines or areas

NOTE 2 *Geographic Object* is used in preference to *Feature* in DNF except in reference to data classification and feature cataloguing where the term "feature" is widely adopted

NOTE 3 *Geographic Object* is equivalent to “Spatial Object” in INSPIRE. However, “Spatial Object” in the ISO standards refers to an “object used for representing a spatial characteristic of a feature” e.g. a geometric or topological object

EXAMPLE Building, street, land parcel

3.1.17 Geometry Primitive

Geometric object representing a single, connected part of space e.g. point, line or polygon

3.1.18 Location

Identifiable geographic place
(ISO 19112)

3.1.19 Position

Point fixed in relation to the Earth’s surface which is defined by coordinates

NOTE Coordinates may describe the position in two or three dimensions

3.1.20 Real World Object

Something which has existence, whether physical or otherwise, and is definable in some way through its attributes and behaviour

NOTE In the context of DNF real world objects will usually be related to *Geographic Objects* or *Business Objects.* Whereas the former will have a physical existence, the latter may not be tangible objects e.g. a planning decision

3.1.21 Reference Base

Type of *Reference Layer* forming a framework of reference composed of *Base Reference Object*s to which other *Reference Objects* within a domain are ultimately associated

NOTE 1 There is no single national *Reference Base* mandated by DNF

NOTE 2 This can be an existing dataset or a subset of same. The base could also be made up of objects from a number of existing datasets (and could include additional geometry)

3.1.22 Reference Layer

Aggregation of *Reference Object*s forming a partial or complete coverage of an area providing a coherent layer for the purposes of cross-referencing

NOTE This need not exhaust space nor have national coverage

EXAMPLES Land title dataset; protected sites (SSSIs) dataset, planning zones, Land & Property Gazetteer; Street Gazetteer.

3.1.23 Reference Object

Geographic Object which may be referenced by one to many *Business Objects* or one to many other *Reference Objects*.

NOTE Class or instance depends on the context, assume class unless otherwise stated

EXAMPLE Abstraction of an area of designated access land or the extent of a National Trust property, Basic Land and Property Unit (BLPU) in a land & property gazetteer; an abstraction of a street in a highways maintenance application; an Output Area used in census analysis; a land title extent in a Land Registry database.

3.1.24 Representation

In the context of DNF, the depiction of a *Geographic Object* using *Geometric Primitive*s defined by coordinates based on a *Coordinate Reference System*

NOTE Other forms of representation are possible such as images but these are currently out of scope of DNF

3.1.25 Unique Identifier

Means of uniquely identifying *Business* or *Reference Objects* which can be used in a DNF context

3.1.26 Uniform Resource Identifier (URI)

Type of identifier that uses a string of characters to identify a resource (or name) on the Internet.

NOTE 1 A URI allows interaction with representations of the resource over a network (typically the World Wide Web) using specified protocols

NOTE 2 A resource can include for example: documents, images, downloadable files, services, electronic mailboxes

3.2 Abbreviations

BLPU	Basic Land and Property Unit
DNF	Digital National Framework
GI	Geographic Information

GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
INSPIRE	INfrastructure for SPatial InfoRmation in the European Community
LLPG	Local Land and Property Gazetteer
OS	Ordnance Survey
UKLII	UK Location Information Infrastructure
UKLP	United Kingdom Location Programme
UPRN	Unique Property Reference Number
URI	Uniform Resource Identifier

4 Introduction to DNF

4.1 Basic concepts

As stated in the UK Location Strategy, “Everything happens somewhere” and this fact can be exploited to link the “everything” to the “somewhere”. This is the underlying philosophy of DNF.

Much data processed in applications is related or spatially referenced to locations - recognisable places - on the Earth’s surface. These locations are usually specific geographic objects or “things” in the real world (e.g. buildings, land parcels, streets). They do not have to be man-made, they can be naturally occurring (e.g. rivers, landforms).

Applications which are designed to process and analyse data which needs to be spatially referenced model a particular view of the world. The geographic objects are abstracted and represented in the application in many different ways. Spatial extents and shapes are often represented by geometric primitives such as points, lines, and areas. To avoid any ambiguity, position on the Earth’s surface can be related to a coordinate reference system such as the National Grid or latitude and longitude. The properties of the objects are reflected in their attribute values. Geographic objects may carry labels that identify their location (e.g. name, address). Other data about the objects may be included such as an identifier, date of capture, date of last change and so on.

These basic concepts are shown in a much simplified form in Figure 2. The “business objects” shown in the diagram can be any real world objects that need to be located; they are not restricted to those associated with human activity.

The geographic objects used to locate the business objects are referred to in a DNF context as “reference objects”. Frequently, they compose a whole layer of locational information referred to here as a “reference layer”.

The geometrical aspects and position of geographic objects can be derived in some way from a reference base independent of a specific application; traditionally this has been some sort of topographic map such as OS Land-Line®. Increasingly this is from sources using object-based models of the real-world such as OS MasterMap® which is rich in maintained and uniquely identified topographic objects. However, many other types of reference base are commonly used depending on the type of application and domain e.g. street gazetteers for highways or geology maps for the environment.

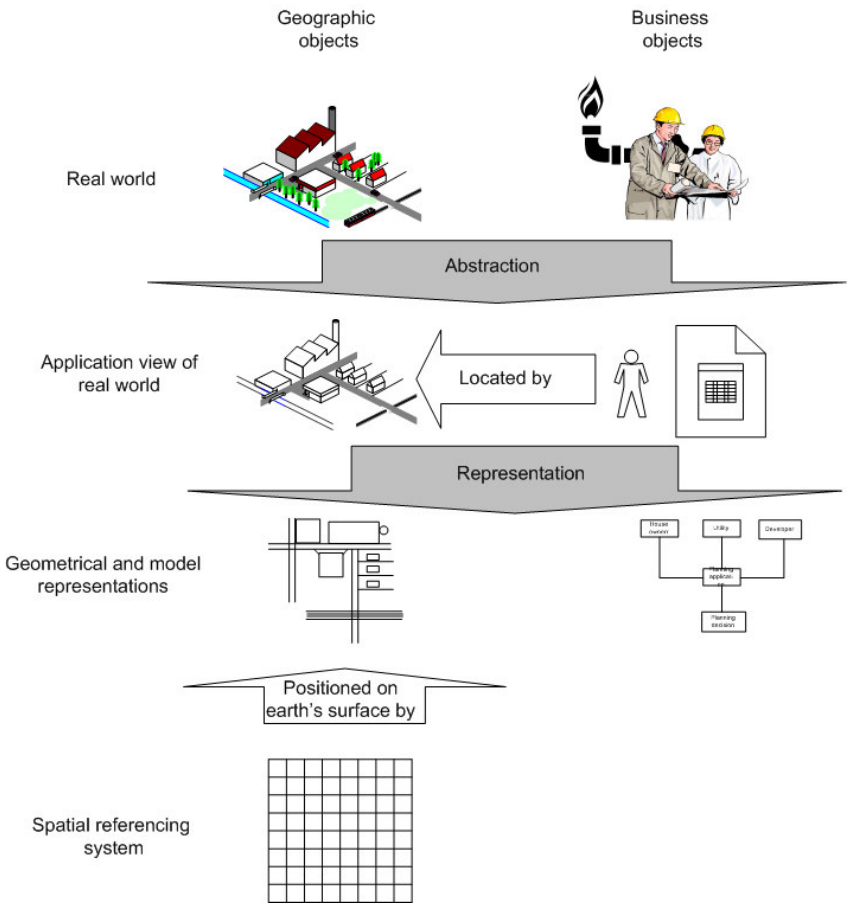

Figure 2: Abstraction and representation of geographic and business objects in an application for processing geographic information

See Figure 3 for an illustration of how a reference base may be used in the context illustrated in Figure 2.

Use of a reference base opens up the possibility of creating and maintaining permanent associations between the geographic objects (reference objects) used in an application, and geographic objects contained in the reference base (base reference objects). The advantages in doing this can be manifold:

~ it may be possible to relate the business objects directly to the reference objects present in the reference base thus obviating the need to maintain separate reference objects in the application;

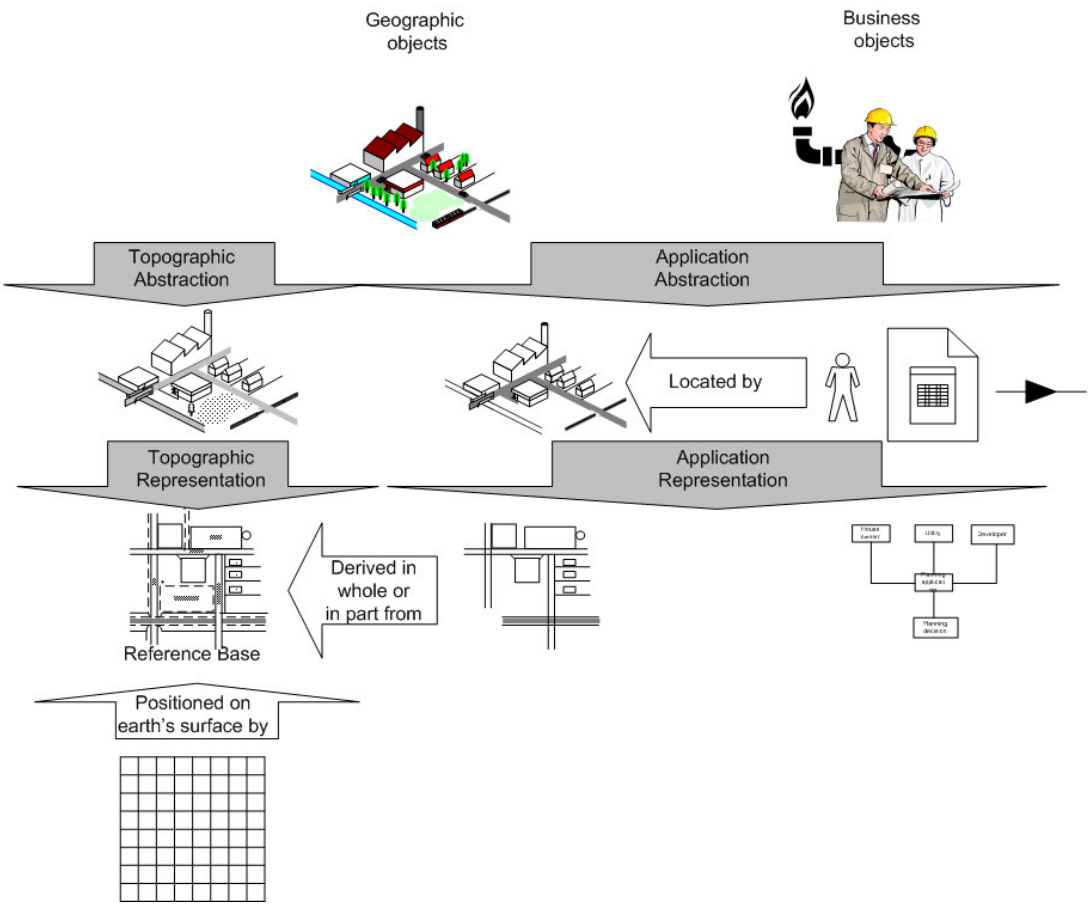

Figure 3: Abstraction and representation of geographic objects using a reference base

~ changes to geographic objects reflected in changes to the reference base can be used to trigger a review of those geographic objects and business objects modelled in the application;

~ conversely, the objects modelled in the application can be immune to minor changes to objects in the reference base;

~ deriving and then maintaining the geometry of the geographic objects represented in the application from a reliable, accurate and maintained reference base can lead to greater consistency and improved data integrity in the application;

~ by maintaining an association with a reference base which is also used by other applications a means is provided of associating the reference objects from different applications:

~ by maintaining an association with a common reference base and doing this in a consistent way, according to agreed practice, opens up the possibility of data sharing and interoperability.

These latter concepts are shown below in Figure 4.

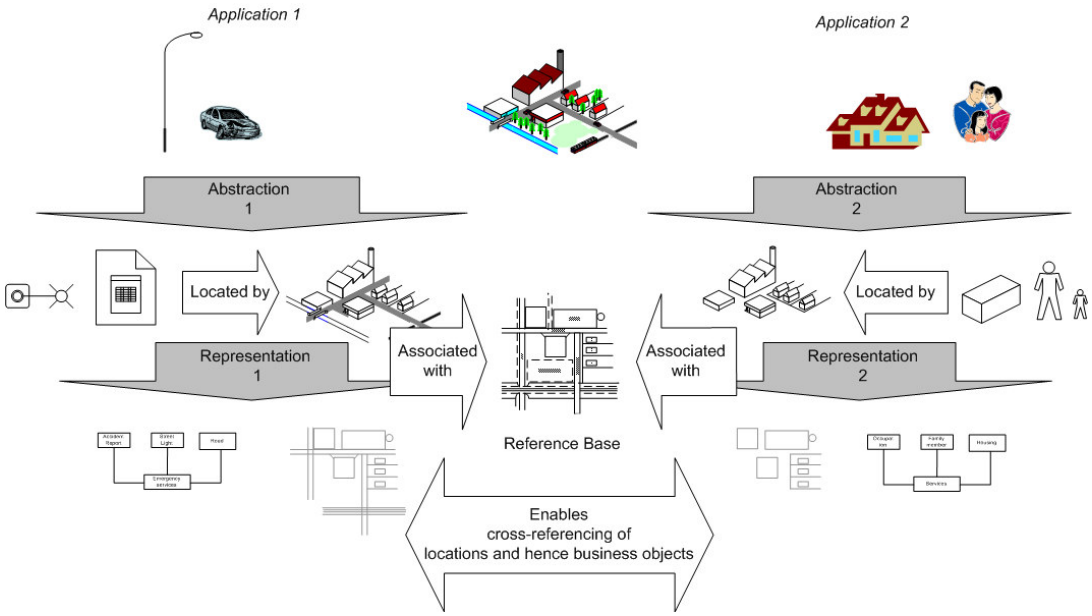

Figure 4: Diagram showing how applications can be associated with a reference base to enable cross-referencing

The nature of the association between the application reference objects and the base reference objects making up a common reference base will depend on a number of factors:

~ the closeness in views of the real world between the reference objects used in an application and any reference base – how similar or how dissimilar is the abstraction in terms of real world objects included or excluded;

~ the similarity of the abstraction in terms of attribution and geometric representation (e.g. as points, lines and areas) - this is about their degree of semantic similarity as well as their spatial "footprint";

~ the classification of the application's objects into different types;

~ the granularity in terms of spatial detail and attribution between the application's reference objects and the reference base;

~ the life-cycles and maintenance regimes of the application's reference objects and the objects making up the reference base.

There is unlikely to be a complete geometrical, temporal and semantic "fit" between the application's reference objects and the base reference objects, therefore any association may need to be qualified in some way through some additional geometry and other attribution applied to the association itself. However, this depends on how close a spatial association is required. For many applications, a simpler association unqualified by additional geometry may be quite sufficient.

In an ideal world, one reference base would suit all applications. Unfortunately, such is the diversity of potential reference objects and applications in different domains, it is not possible to derive base reference objects that will adequately meet all requirements. However, user communities in particular application domains will find considerable benefit from agreeing a common reference base which, in turn, may be associated with other reference bases employed by other user communities even if a complete "fit" between the two bases cannot be achieved.

4.2 The Digital National Framework

The concepts described above are core to DNF. In essence DNF is about how you can associate or cross-reference geographic objects used in different applications to a common reference base and, by so doing, provide a means of relating different business objects used in the applications where they are referenced to the same, or a very similar, location. As more applications use this approach so the range of business objects that can be cross-referenced increases.

The overall aim of the DNF is to enable and promote the integration and sharing of location-based information from multiple sources. The "Framework" in the name is a set of guidelines, examples of good practice, case studies and other documentation and services in support of this aim.

The creation of a national framework of data which, in time, would lead to definitive datasets or "core reference geographies" adopted and used without modification (e.g. land ownership parcels, river network) as reference bases is the role of UK Location Information Infrastructure.

What distinguishes DNF is that it does not just use position, as expressed through coordinate values, to establish the "somewhere" but identifies specific geographic objects as defining location in the way described in 4.1.

To fulfil the DNF aims we are defining:

- a set of basic models to provide the theoretical underpinning;
- technical guidance for implementing the models;
- examples of implementations within particular applications and domains;
- guidelines and best practice on wider issues such as a data quality and data maintenance which are required for successful implementation;

~ a set of common terms for ease of communication.

The range of technical topics that are embraced by DNF are illustrated in the package diagram expressed in UML (Unified Modelling Language) in Figure 5. For an explanation of the conventions used see Appendix A. The boxes looking like file symbols represent the main technical components of DNF and dashed arrows show the dependencies between the components, the component depended upon e.g. Association depends on Object Identifiers, Reference Objects and Business Objects. The packages are described in more detail in Section 5.

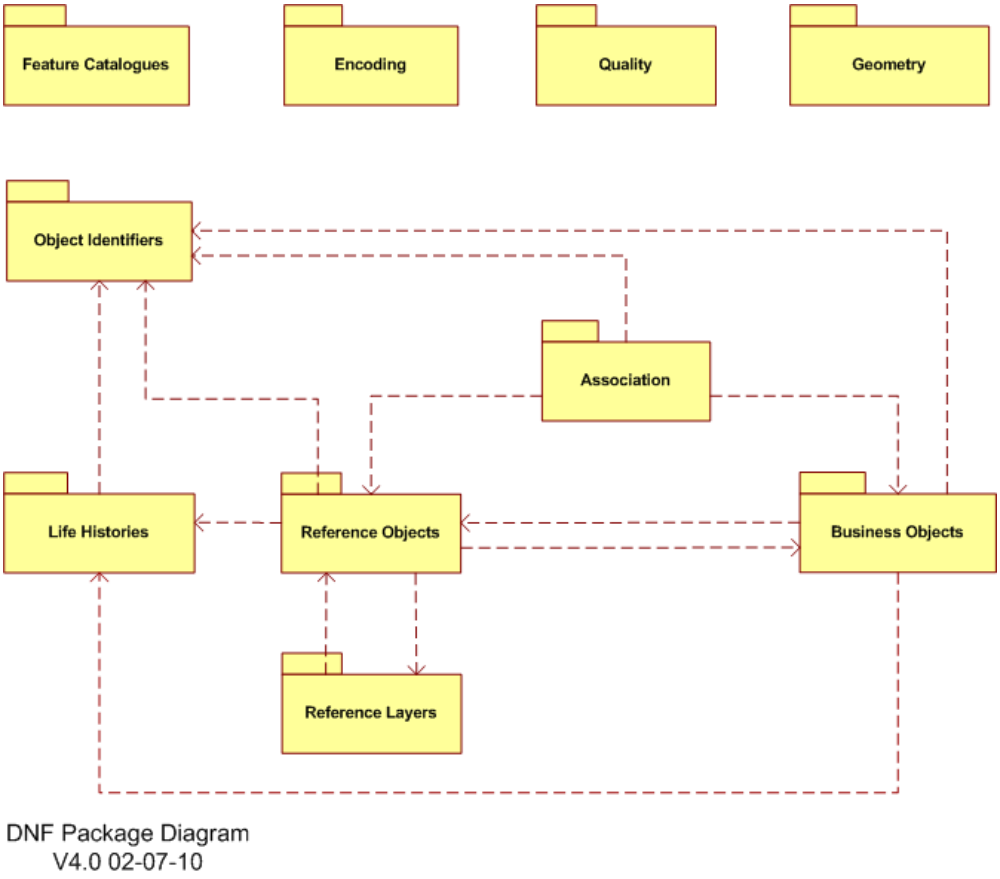

Figure 5: Diagram in UML of the packages or technical topics within scope of DNF

4.3 INSPIRE and DNF

The INSPIRE Directive for establishing an infrastructure for spatial information in Europe to support Community environmental policies and other policies or activities which may have an impact on the environment was enacted in May 2007. It has since been transposed into UK legislation.

The infrastructures for spatial information established and operated by the 27 Member States of the European Union are the basis for INSPIRE. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules[1]. Within UK the developments required to conform to the INSIRE Directive come under the umbrella of the UK Location Programme[2].

INSPIRE has defined many concepts that parallel those of DNF in particular, "object referencing" that is the, "consistent method of referencing spatial data to location using existing spatial objects". The benefits or so doing are stated to be:

- "reuse" of referenced spatial (geographic) objects by a third party e.g. a road centre-line might reference base topographic objects maintained by a different organisation. In turn a third party might then reference their application view, e.g. highways maintenance programme to the centre-line network and so on;

- providing an unambiguous linkage to the same spatial (geographic) object also promotes reuse of information;

- as a result of the above, object referencing significantly enables improvements in data integrity and reliability[3].

The DNF work programme is now oriented towards the objectives of the UK Location Strategy and the rollout of the UK Location Information Infrastructure and hence, INSPIRE.

The overlap between the DNF and INSPIRE is illustrated below in Figure 6. This shows the INSPIRE interoperability components and the degree of alignment with DNF.

[1] See http://inspire.jrc.ec.europa.eu/ for further details.

[2] See http://location.defra.gov.uk/ for further details

[3] See: INSPIRE (2008) Generic Conceptual Model, D2.5 V3.1, Section 13

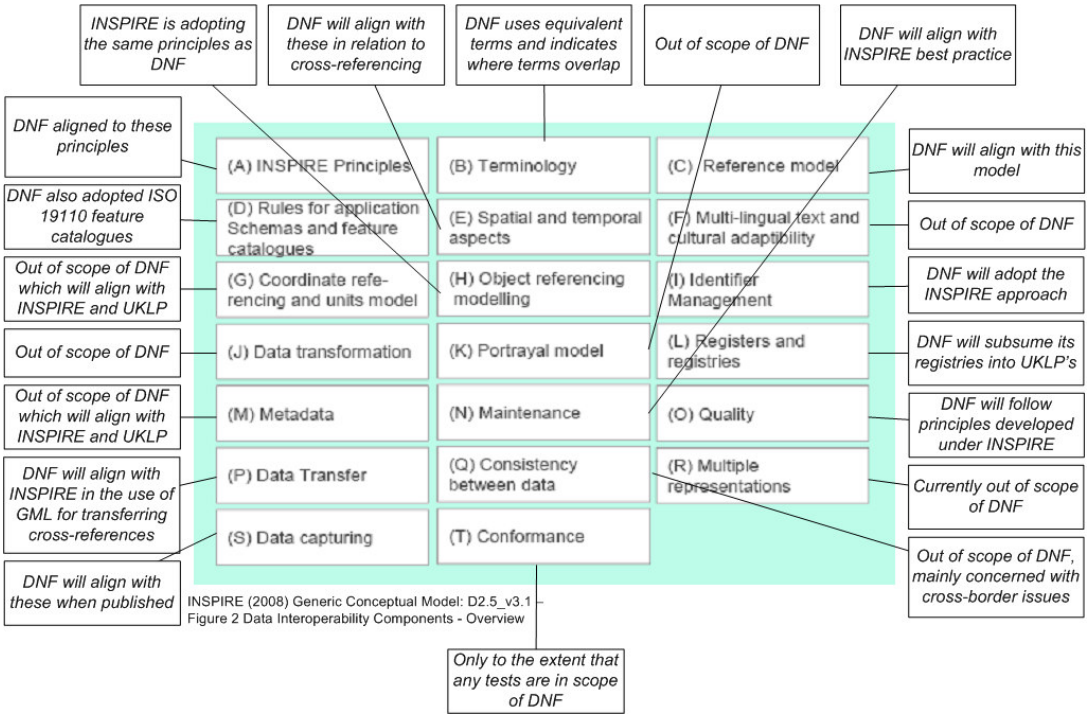

Figure 6: INSPIRE interoperability components and their relationship to DNF

5 Technical architecture of DNF

5.1 Description of the components

5.1.1 Introduction to the components

The Digital National Framework takes the basic concepts set out in 4.1 and builds a coherent technical architecture on these.

For application data to be used in a DNF context the application needs to model not just *Business Objects* but defined and identified *Reference Objects* which may form one or more *Reference Layers*. There also needs to be agreement within a domain or user community on a common *Reference Base*. The locations of the *Business Objects* can be related to the *Reference Objects* by creating *Associations* with them. These *Reference Objects* then have *Associations* with the *Base Reference Objects* which make up the *Reference Base*. In the simplest case, the geographic objects used by the *Business Objects* are the *Base Reference Objects* i.e. the *Business Objects* relate to the *Reference Base* directly.

The *Business Objects* and *Reference Objects* are identified by unique *Object Identifiers* which persist through the *Life Histories* of the objects (i.e. from creation to deletion or removal). *Reference Objects* are represented by *Geometry* which indicates their position and may also indicate their configuration and extent depending on the type of representation.

To be able to share and interoperate with other applications, there need to be mechanisms for (i) neutral data interchange of data about associations, (ii) communicating the nature of the objects and (iii) describing their quality.

The transfer of data about *Associations* needs to use a process of *Encoding* and the application of encoding rules to provide a neutral data interchange based on agreed standards.

Feature Catalogues can be used to define and describe the nature of *Reference Objects* and their attributes.

The value of the *Associations* to users will depend on the *Quality* of the data employed in creating the association, its completeness, positional, temporal and thematic accuracy and its logical consistency.

The core data components[4] specific to DNF are described in more detail below.

[4] Components of the architecture are given in italics for ease of reference. Definitions are given under 3.1 Terms.

5.1.2 Business Objects

In a DNF context *Business Objects* are abstractions of real world objects which are not themselves geographic objects but which need to be referenced to specific locations on the Earth's surface.

As the term "business objects" would suggest, they are modelled by an application because they are involved in processes within scope of that application. As discussed earlier, this is not just human activity but can be natural processes. Typical examples of business objects are abstractions of planning applications, land titles, census returns for an address, highway maintenance records for a street, traffic flow counts, water quality in a river reach.

To be usable in a DNF context, *Business Objects* need to be identifiable and carry some form of unique identifier.

5.1.3 Reference Objects

As previously discussed, a *Reference Object* is a geographic object to which business data or *Business Object*s are related or referenced (e.g. to a BLPU or a land title extent) for the purposes of location. Some classes of *Reference Object*s may not be what most would regard as real-world objects (e.g. title extents, or post code areas) and their representations do not need to exhaust space. They must have some sort of spatial or geographic expression, be capable of consistent definition, have a defined life-cycle or *Life History* (however simple) and be uniquely identifiable using unique *Object Identifiers*. They must be capable of being represented by points, lines or areas using some form of *Geometry* based on a coordinate referencing system.

In some types of application several layers of *Reference Objects* may be used. The *Business Objects* may be referenced directly to certain application-specific geographic objects. These objects may themselves reference *Reference Objects* in another *Reference Layer*. The commonest example of this is where geographic objects defined in a particular application are cross-referenced to a land and property or street gazetteer. The BLPUs or Streets are then associated with a *Reference Base* (or may themselves compose the reference base).

The position of *Reference Objects* on the Earth's surface, usually with reference to a coordinate reference system, is also essential in the establishment and maintenance of associations. This is not described explicitly here but it is an implied component of DNF.

5.1.4 Reference Layer

A *Reference Layer* [5] is formed of *Reference Object* instances. These may form a complete coverage of an area but do not have to – it depends on the nature of the abstraction from the real world.

Where the *Reference Layer* is represented by areas and lines then these should be defined by coordinates that are based on a recognised coordinate referencing system.

An application may have a number of *Reference Layer*s where a number of classes of geographic objects are needed to locate different classes of *Business Object*s. For example in a local authority with a corporate application which integrates information from a number of departments, then each department may have its own classes of business and geographic objects.

5.1.5 Base Reference Object

Base Reference Objects are a type or specialisation of *Reference Objects* which have characteristics which make them particularly suitable or usable across a number of applications within a domain, or possibly across a number of domains. They are the fundamental reference objects which together make up a *Reference Base*. A *Base Reference Object* is represented geometrically by a point, line or area and positioned by a widely recognised coordinate reference system.

5.1.6 Reference Base

A *Reference Base* is an aggregation of instances of *Base Reference Object*s. It is a specialisation or type of *Reference* Layer forming the base to which all *Reference Objects* are eventually associated. There can be a direct association between *Business Objects* and *Base Reference Objects* where there are no existing *Reference Objects* relating to a particular application or the *Reference Objects* for that application form the *Reference Base*.

There is no single assemblage of *Base Reference Objects* composing a *Reference Base* which will serve all domains and user communities nationally or locally. They need to be chosen - usually but not necessarily - from datasets which are widely used and common to a particular domain or group of domains. *Base Reference Objects* drawn from a dataset such as OS MasterMap Topography Layer or the National Land and Property Gazetteer are likely to have wide application but will not be adequate for certain environmental domains for example.[6]

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[5] This could be an INSPIRE theme for example

[6] The *Reference Base* could include additional geometry to meet the needs of particular domains or communities where the geometry relating to objects in existing datasets lacks the required precision or resolution. However, this carries the overhead of capture and then maintenance of this additional geometry in tandem with the existing dataset.

5.1.7 Object identifiers

A central concept of DNF is that the *Associations* between *Business* and *Reference Objects* are created, stored and maintained using unique *Object Identifiers.* Ideally these are globally unique but at the very least they must be unique within the domain in which data is to be shared.

Strictly it is the objects i.e. the abstractions of the real world objects which are given the identifiers not their geometrical representations since it is the former that are associated. However, because of their lineage, some datasets are a mixture of abstractions of real world and cartographic features e.g. OS MasterMap and compromises have to be made.

5.1.8 Life Histories

In the real world, objects are created, evolve and suffer some sort of demise over timescales ranging from nanoseconds through to eons. Most of the objects within scope of DNF are likely to have lives reckoned in years if not tens, hundreds, thousands or millions of years. Likewise their abstractions will have life histories as well which may be very simple i.e. creation and deletion or may involve amendment as expressed through a change of properties, position or extent. The implication of this is that (i) the life histories need to be abstracted with clear rules about how changes are to be recorded and maintained and (ii) there needs to be a means of identifying each or the phases through which an object passes whilst still regarded as the same object i.e. objects need to be versioned. Thus to uniquely identify an instance of an object at a point in time will require a unique *Object Identifier* and a version where the *Life Histories* allow for change within a life beyond creation and deletion.

In practice the life histories of objects modelled in an application may include certain non-real world events such as error correction.

5.1.9 Association

The *Association* encompasses the way that *Business Objects* and *Reference Objects* (including *Base Reference Objects*) are related or associated. In UML terms it forms an association class which carries attributes quite separate from those describing the *Reference Objects*. The *Association* is expressed in any implementation through the cross-referencing of the unique identifiers of objects being associated.

There are many types of association at the object and geometry levels. Of principal concern in a DNF context are spatial associations, that is associations relating to location, and the ways that the association can be established, for example through addresses[7] or by position.

[7] A way of referencing a geographic object for identification and location, it does not have to be a postal address. It could be a street name and locality for example

5.1.10 Geometry

Reference Objects can be represented spatially by *Geometry*. At the simplest, this can be a representative point indicating a position within the object's footprint e.g. a building. A line can represent a road alignment or river course and a polygon an areal extent such as a building outline, extent of a road carriageway or river channel. The *Geometry* can also extend into the third dimension. The coordinates of the points, lines or polygons need to be related to an established and shared coordinate reference system such as the National Grid.

In order to establish spatial relationships or *Associations* between *Reference Objects* using position requires the comparison of the geometries of the different *Reference Layers*.

5.1.11 Encoding

To promote data sharing and interoperability between applications there needs to be a neutral mechanism for the transfer of data. This can be done by the use of encoding rules based on an existing standard such a XML or its geographic extension GML (Geographic Markup Language).

In the context of DNF the purpose of such encodings is to allow the exchange of *Associations* based on the Association Model (see Figure 10). The *Associations* are likely to form only part of a larger transfer set. In the case of GML for example, the schema for the association is likely to be an element of a wider application schema[8] which is used for the transfer of other data forming the transfer set.

5.1.12 Feature catalogues

The nature of the *Reference Objects*, particularly the *Base Reference Objects*, is best expressed through a *Feature Catalogue*. This contains the definitions, descriptions and attributes types of all the feature types or geographic objects within a dataset.

Such a catalogue is a considerable asset in turning data into usable information and in promoting the sharing and use of geographic data. Principally, it provides a better understanding of the content and meaning of the data.

Although not currently developed within DNF, it is also possible to construct a feature concept dictionary containing definitions and related descriptive information about concepts that may be used to characterise real world objects such as buildings, roads, rivers, woodland which are then specified in detail in a feature catalogue.

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[8] An application schema is a model which defines the content and structure of data and specifies the operations for processing data by an application. It exists to provide a computer-readable data description so that mechanisms for data retrieval, management and manipulation can be undertaken automatically.

5.1.13 Quality

If data is to be shared and used, possibly for purposes for which it was not originally collected, it is essential that users have an understanding of the quality of the data i.e. the "totality of characteristics of a product that bear on its ability to satisfy stated and implied needs[9]" or in simple terms, "its fitness for purpose".

Quality can be described in non-quantitative and quantitative terms, the former are useful in giving a context to the data by describing the purpose for which the data was originally collected, the usage to which it has been put and its lineage or history. Quantitative descriptions can also be used to give a measure of the actual performance of the data against its specification e.g. positional, thematic and temporal accuracy, completeness (omissions and commissions) and logical consistency.

5.2 How the components are combined

The relationship between the main components is illustrated in Figure 7.

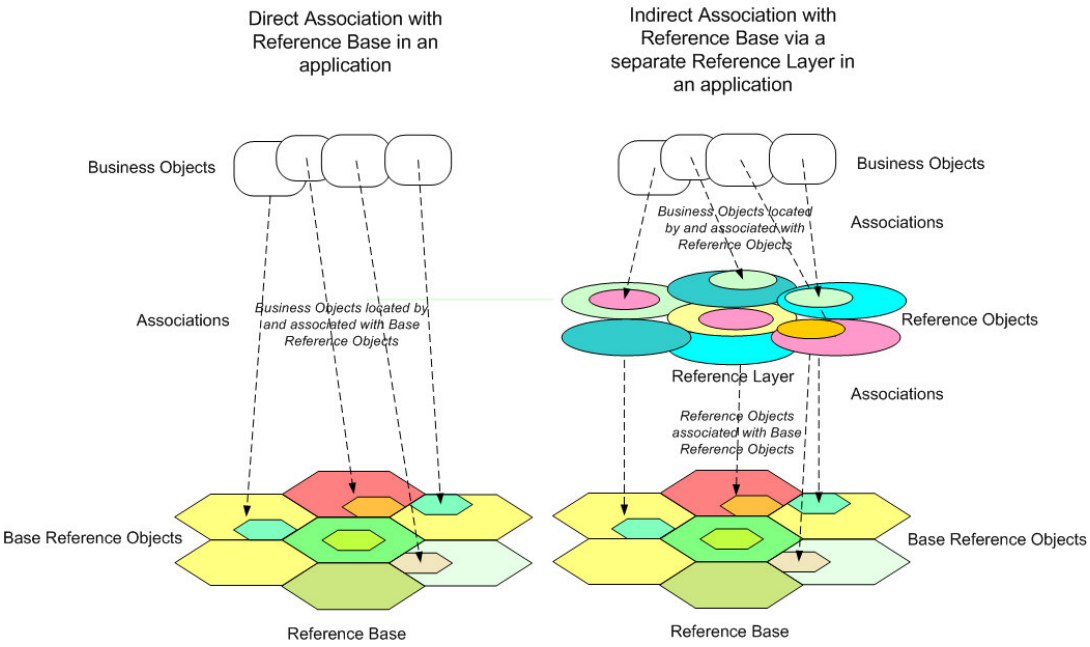


Figure 7: Relationship between the main components of the DNF technical architecture

If within a user community there is agreement on a common *Reference Base* then by associating the *Reference Layers* within a number of applications to this common *Reference Base* it will be possible to associate the business objects across all the applications through their common locations. See Figure 8.

[9] ISO 19113: 2002 Geographic information – Quality principles

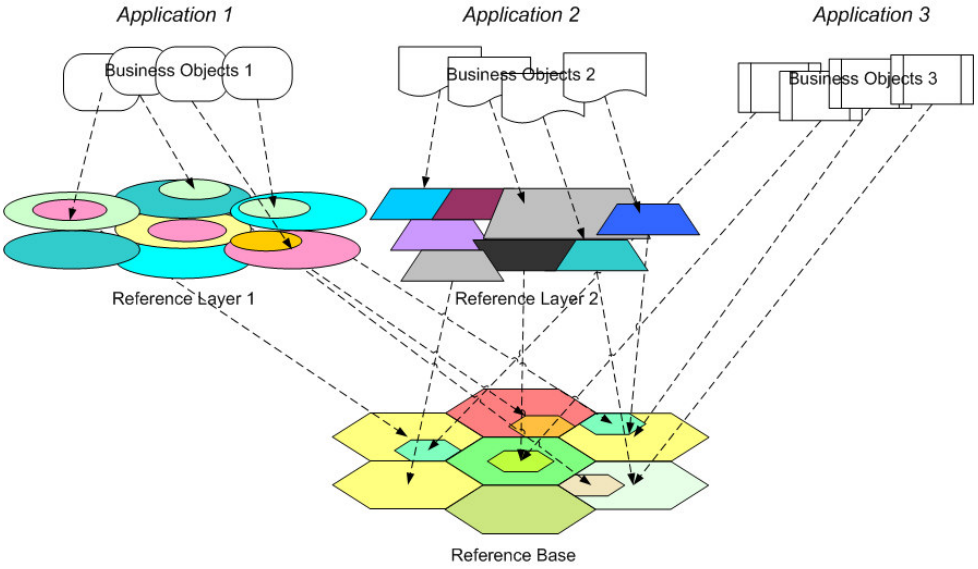


Figure 8: Using a common reference base to establish relationships between business objects in different applications

Taking this further, if users want to share data across a number of domains then it may be possible to establish associations across domains as illustrated in Figure 9.

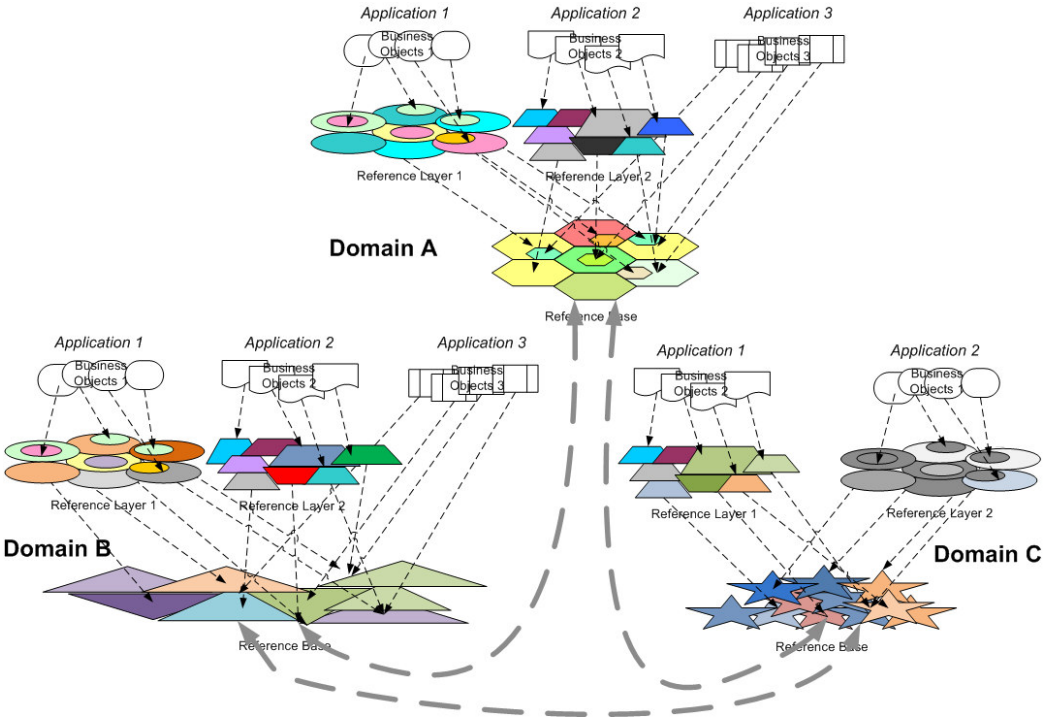


Figure 9: Associating a number of reference bases to establish wider relationships between business objects in different domains

How practical this is will depend on the nature of the *Reference Bases* in the different domains and the feasibility of establishing *Associations.*

The relationships between the objects illustrated in Figure 7 and Figure 8 can be expressed more formally in the following Unified Modelling Language (UML) class diagram (the Association Model). The conventions used in these models are given in Appendix A. This presents the simplest case, not all possible relationships are modelled.

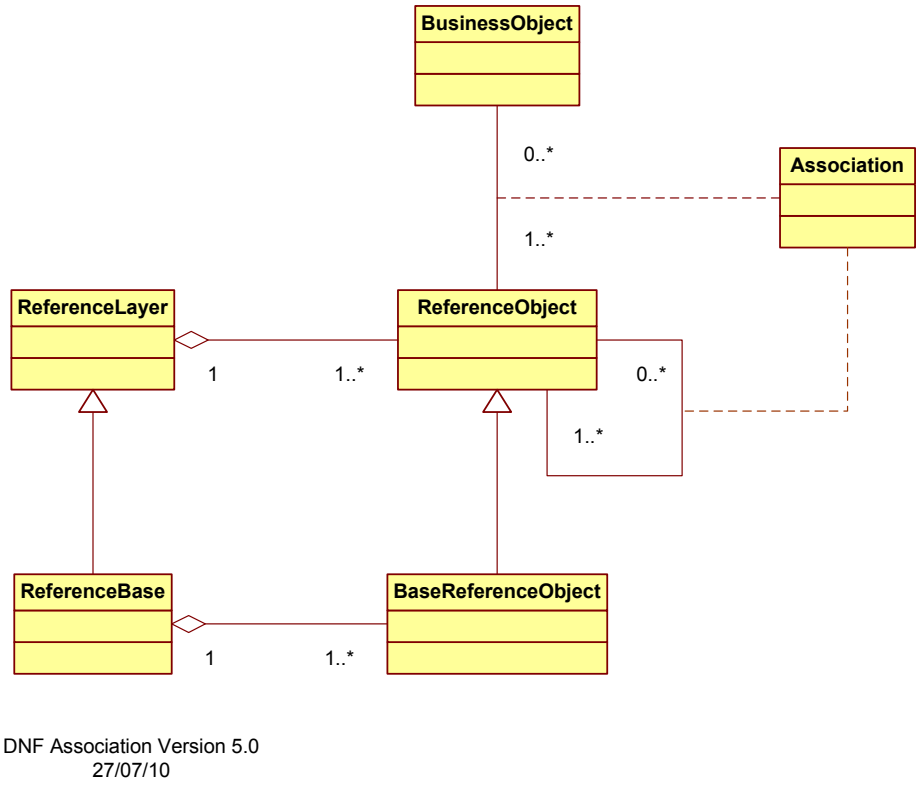


Figure 10: Simplified UML class diagram showing the relationships between the main components of DNF (the Association Model)

The model expresses the following - starting from the top:

- A *Business Object* is located by an *Association* to one or more *Reference Objects*;
- A *Reference Object* may be referenced by any number of *Business Objects* or none;
- A *Base Reference Object* is a type of *Reference Object;*
- A *Reference Object* may not reference any other *Reference Objects* or it may have an *Association* with one or more other *Reference Objects* (which may be *Base Reference Objects*);
- *Reference Object*s are part of to a *Reference Layer*;

~ *Base Reference Object*s aggregate into a *Reference Base* which is a sub-type of *Reference Layer*;

5.3 Service architecture

Although there is the potential to develop a complete service architecture around DNF, this is not currently envisaged. However there are a number of enablers which it is planned will be provided as deliverables from the UK Location Information Infrastructure.

~ Metadata and an associated catalogue service for discovery of datasets;

~ Directory of feature catalogues;

~ Feature concept dictionary;

~ Data interchange mechanisms principally in the form of XML.

6 Implementing DNF

6.1 From theory into practice

Sections 4 and 5 describe the concepts underpinning DNF and the components of the data architecture but not the mechanisms to enable benefits to be derived from adopting these concepts.

The association between *Business Object* and *Reference Object* is at the core of DNF. This is implemented through the cross-referencing of the identifiers of the object instances within scope. If information on *Business Objects* is to be shared and exchanged with other users, then this cross-referencing has to be extended to an agreed *Reference Base*. The assumption in what follows is that applications already exist within a domain or user community in which *Business Objects* are referenced to location in some way and there is a requirement to share information and interoperate.

To go beyond individual applications there are a number of steps that will need to be taken to exploit the benefits of object referencing. These include:

1. Agreement within a user community on the use of a *Reference Base* (unless there is such a base already in common use or a user has taken the lead);

2. Specifying and defining what constitutes the *Reference Base* and the documenting of this in a feature catalogue;

3. Provision of access to the *Reference Base* and agreement on how it is to be maintained and who is to maintain it;

4. Agreement within a user community on the use of a common coordinate reference system;

5. Deciding on how *Business Objects* are going to be associated with the *Reference Base* i.e. directly or via existing *Reference Objects*;

6. The unique identification and life histories of the objects being associated;

7. The form of the cross-reference and how this is qualified (i.e. its attributes or properties);

8. The establishment and maintenance of cross-references;

9. Setting up mechanisms for the sharing and transfer of cross-references and any other information within user communities.

There are likely to be other requirements such as acceptable quality levels.

The above describes some of the main technical pre-requisites, clearly other issues will have to be dealt with (e.g. establishing the business case for adopting this approach – evaluating the benefits and costs; overcoming any commercial obstacles – licensing and IPR).

6.2 Properties of Reference Objects

Reference Objects in general need to meet certain basic requirements if associations using DNF principles are to be established. They should:

- have some sort of spatial or geographic expression;
- be capable of consistent definition;
- have a defined life-cycle (however simple – for example creation/deletion);
- be uniquely identifiable;
- capable of being represented by points, lines or areas (a minimum would be a representative point);
- use a coordinate reference system that is fully defined by published parameters[10].

6.3 Establishing a Reference Base and Base Reference Objects

A *Reference Base* and the constituent *Base Reference Objects* are likely to be derived from an existing dataset but necessarily so.

Candidate datasets should:

- be captured and maintained in conformance with a published data specification accessible to users (e.g. conforming to ISO 19131);
- use a consistent approach to the classification of object or feature types and their documentation using a feature catalogue (e.g. conforming to ISO 19110);
- provide as complete coverage of an area as is required by the user community. Use vector geometry and a recognised coordinate referencing system to represent objects;
- be captured to a resolution commensurate with the requirements of the users in the domain – generally, the higher the resolution the greater the suitability;
- be freely available to all users (if not available free);
- meet published quality levels.

[10] See DNF (2007) DNF Reference Objects Principles for selection and their application to OS MasterMap - Technical report at http://www.dnf.org/guides/documents/C9/

Candidate *Base Reference Objects* should:

- be an abstraction (view) of a real-world (geographic) object;
- be discernible – i.e. generally visible and identified or perceived as geographic objects in the real world;
- be based on a clear definition – i.e. a lack of ambiguity in the definition of the object such that its consistent recognition and representation is assured;
- have as fine a granularity as is required within the domain – in general, more atomic units should be favoured over the less atomic - the finer the granularity and homogeneity the better;
- be complete - where an object type is defined as being present in a dataset, then most object instances within scope should be in the dataset;
- have a defined life-cycle - the life cycle of objects should be documented and maintained;
- be uniquely identified - object instances should carry a unique identifier and, where they have a life cycle more complex than create and delete, a version number;
- be represented geometrically by an area (polygon), point or line with sufficient positional accuracy for applications in the domain.

For example, where applications need to reference land and property or other topographic features, candidates as *Reference Object*s could be OS MasterMap Topography Features. However not all OS MasterMap Feature Types are suitable as *Reference Object*s. The OS MasterMap Topography Layer still carries a large cartographic baggage in the form of symbols, cartographic text. Further, in order to close off areas or polygons and create usable reference objects where there is no physical boundary in the real world, the limits of some topographic objects are inferred using pragmatic rules e.g. on open-plan estates or between streets. Thus there is a need to be selective in the choice of OS MasterMap objects as *Base Reference Object*s and also to be aware of the derivation of some geometry where this is inferred.

A further consideration in defining a *Reference Base* could be the existence of a *Reference Base* in another user community and whether there is any requirement to interoperate and share information with that community.

Although not dealt with further in this Overview, additional or *Complementary Geometries* may be created and maintained to better define or qualify the spatial relationship or *Association* between *Reference Objects* and the *Base Reference Objects* e.g. where the “fit” is not precise enough to meet the needs of the application or user community.

6.4 Types of Association

The way that *Business Objects* are referenced to location will vary from application to application. In a DNF context an *Association* can be either:

- Direct – *Business Objects* are directly associated with *Base Reference Objects* without the involvement of any intermediary *Reference Objects*;

- Indirect – the association between the *Business Objects* and *Base Reference Objects* is through one or more other *Reference Objects* which may be in one or more *Reference Layers*.

See Figure 7 for an illustration of this.

Direct associations can result from (i) the existing application using the agreed *Reference Base* already or (ii) an application being changed to directly associate with a *Reference Base* once agreed.

The association once created is expressed and maintained through cross-referencing of identifiers. The minimum set of attributes and metadata needed to qualify this association has to be defined (e.g. dates, versions). Where a specific point along, or within, the *Reference Object* needs to be indicated e.g. chainage along a street, then this will also be an attribute of the *Association*.

Other spatial and temporal issues (e.g. imperfect spatial match[11], differing maintenance regimes) between an application's *Reference Object*s and *Base Reference Objects* also need to be resolved.

6.5 Unique identifiers and life-cycles

The association between *Business Objects* and *Reference Objects* is implemented by the use of object identifiers. These identifiers need to be unique at least within a domain or user community but preferably nationally or internationally if they are to be used, for example, within INSPIRE.

DNF has advocated the use of an identifier for *Reference Objects* which is formed in the following way:

<organisation prefix><local identifier>

The resulting identifier is a character string, formed by concatenating the two constituent parts. The <organisation prefix> is a four-character, lower-case code identifying the organisation that created the identifier. The <local identifier> is alpha-numeric identifier, allocated by and guaranteed to be, unique within the organisation identified by the prefix. The exact form of the latter is up to the organisation.

The organisation prefix can be registered on the DNF website see:
http://www.dnf.org/registry/identities/

[11] Possibly by the use of *Complementary Geometry.*

Under INSPIRE this concept has been extended to make the identifier unique across the European Community by the addition of country or multinational organisation codes (see INSPIRE (2008) Section 14.2).

There are now moves towards the use of Uniform Resource Identifiers (URIs)[12].

Currently, there is no specific guidance relating to the identification of *Business Objects*, however they require a system of unique identification also.

Objects abstracted within an application have life-histories resulting from (i) changes in the real-world or (ii) application induced changes e.g. error correction. When an object is created in an application it needs to be given a unique identifier. Depending on the object's life history it may retain the identifier through several versions of the object. At the simplest, the life-history can be create/delete i.e. every time there is a change from whatever cause, the object "dies" and a new unique identifier allocated – there are no versions. If life-histories are more complex then several versions of the object can occur through time. To uniquely identify an instance of an object at a particular point in time, then a system of versioning and date-stamping will have to be adopted.

6.6 Form of the cross-reference

At their simplest cross-references need to carry the unique identifiers of the objects being cross-referenced. However, there are other properties of the association between the objects which may be usefully recorded. These could include:

- The date the association was made;
- The versions of the objects being cross-referenced (depends on their life histories);
- The quality or qualities of the association e.g. the degree of spatial "fit".

6.7 Establishment and maintenance of cross-references

Cross-references between *Reference Objects* can be established in a number of ways but primarily this will be either:

[12] Ordnance Survey has begun to issue data with URIs as linked data resources. To date it has published two separate data resources: the 1:50 000 Scale Gazetteer and the administrative gazetteer for Great Britain. See http://data.ordnancesurvey.co.uk/ and also http://data.gov.uk/ .

1. Through a comparison of relative positions e.g. overlay of *Reference Layers* and searching for objects that are partly or wholly co-extensive or, if one *Reference Layer* has objects represented by points then by using point in polygon searches;

2. Through a comparison of other geographic references such as address.

Maintenance of cross-references will involve mechanisms for detecting change e.g. a change in the *Reference Base* may require a change to some cross-references or *vice versa* when there is a change in a *Reference Layer*.

6.8 Sharing and transfer of associations and cross-references

A mechanism is needed to support the transfer of associations and cross-references between users. In general terms this means defining a standard form of encoding.

Preliminary work has been done to show how Geography Markup Language (GML) can be used to support this requirement. GML is advantageous because it is XML based and provides support for geographic data types which may be needed to qualify some associations.

6.9 Linked data

The potential for using the “semantic web” (i.e. methods and technologies to allow machines to understand the meaning - "semantics" - of information on the World Wide Web) is beginning to be realised in the context of location. The mechanism advocated is “Linked Data” - using the Web to connect data that is related in some way (e.g. common location) but not previously linked, or using the Web to ease the linking of data already linked through other mechanisms.

More specifically, Linked Data refers to mechanisms for exposing, sharing, and connecting pieces of data, information, and knowledge on the Web using Uniform Resource Identifiers (URIs) and the Resource Description Framework (RDF)[13]. Currently most of the data on the Web is presented to users in human readable form - HTML encoded - documents. Linked Data uses the concept of (i) publishing the data structured so that machines can read it and (ii) establishing links between disparate data resources so that machines can navigate the links and use the Web like a single database[14].

[13] Method for conceptual description or modelling of information contained within resources on the Web.

[14] See http://linkeddata.org/ for further information.

Linked Data mechanisms can be equally well applied to locational information as any other e.g. to express the relationship between a business “thing” and its location “object”. Although the approach is very different from that described above, there are clear analogies to DNF concepts namely, the use of unique and persistent identifiers – in this case URIs; the ability to create, identify and reuse relationships (associations) and then extend them.

For further information see the UK Location Programme (2010)[15].

[15] See, for example, UK Location Programme (2010) Linking information and location. A guide to the benefits of Linked Data and the UK Location Strategy at http://location.defra.gov.uk/2010/05/a-guide-to-linked-data-and-the-uk-location-strategy/

7 Guide to documentation and services

7.1 Preamble

A series of documents is being developed to provide users with a complete technical guide to DNF. Examples relating to particular types of application and user communities will also be provided. A registry is also being developed on the DNF website to provide documentation services and support related operations such as the registration of identifier prefixes (soon to be transferred to the UK Location Information Infrastructure).

The purpose of this section is to provide a guide to where further technical information can be found and how it can be used. A document hierarchy is being populated progressively according to the DNF Roadmap at Figure 1. This is provisional and likely to change as documentation is developed and issued.

To aid users, a brief summary of each document is provided below, together with a link to the documents where these have been published.

7.2 Models and Technical Guides for data

The purpose of these documents is to provide a definitive description of the DNF principles and concepts – the models and practical guidance on their implementation – the Technical Guides.

7.2.1 DNF Positioning

Coordinate referencing systems and transformations

Technical Guide DNF 0020 explains the different coordinate referencing systems in common use in Great Britain, the transformations between these systems and how they support DNF. Links to authoritative and detailed sources of information are provided. Satellite positioning, map projection systems on land and offshore systems are in scope.

This document is intended to provide the general reader with an overview. The professional reader is provided with sources of definitive information for the execution of projects and the development of applications.

This Technical Guide will be withdrawn when information becomes available via the UK Location Information Infrastructure.

To access this document go to: http://www.dnf.org/guides/documents/C8/

7.2.2 Reference Object

Model

Not available.

Reference Base

This Technical Guide is not available yet. It will describe how a Reference Base is constructed and its main characteristics at the dataset level. However there is a Technical Report on Reference Objects and the principles for their selection (also their application to OS MasterMap).

To access this document go to: http://www.dnf.org/guides/documents/C9/

Feature cataloguing

Technical Guide 0054 provides guidance on the creation of feature catalogues and the requirements for creating a feature catalogue conforming to DNF principles. Specifically, it sets out mandatory requirements for a catalogue of Base Reference Objects. In addition, these requirements can be taken as guidelines for catalogues of application data used for data sharing in a DNF context. The general purpose of this guide is to assist feature catalogue authors in creating feature catalogues for DNF but it is also more widely applicable.

To access this document go to: http://www.dnf.org/guides/documents/C8/

Unique object identifiers

Technical Guide DNF 0011 outlines the fundamentals of dealing with nationally unique identifiers within DNF and provides rules and recommendations for their use, storage and allocation. It will be developed into a more general guide to identifying and versioning DNF Reference Objects.

The current guide is applicable to those organisations creating maintaining or owning geographic data which they wish to the use in the context of DNF.

To access this document go to: http://www.dnf.org/guides/documents/C8/

This document is due to be withdrawn and replaced by an updated version aligned to INSPIRE and the UK Location Information Infrastructure.

7.2.3 DNF Association

Model

Association Model DNF 0004 presents the principles and concepts used within the Digital National Framework (DNF) for associating geographic objects used in applications and base reference objects which comprise a reference base. The principles and concepts are expressed in words illustrated by diagrams as well as in a formal model in a recognised modelling language (UML – Unified Modelling Language). A logical view, not an implementation view is presented.

The geographic objects in scope are those used to provide a location for the business information within an application. Predominantly these are objects such as land parcels, property, streets and river reaches but they can also be larger units such as census and administrative areas. The reference base is described in relation to OS MasterMap topographic objects but could be related to objects in other standard bases meeting DNF principles.

This document is intended to be read by data suppliers, application programmers and data users.

To access this document go to: http://www.dnf.org/guides/documents/C8/

This document is due to be withdrawn and replaced by an updated version.

Cross-referencing of geographic objects

This Technical Guide is in preparation. It will describe simple and qualified cross-referencing between Reference Objects and Base Reference Objects.

7.3 Guidelines and best practice for data

The purpose of these documents is to provide general guidance and best practice in object classification, data quality and DNF conformance.

7.3.1 Managing data quality

Not available.

7.3.2 Data capture and maintenance

Not available.

7.4 User community – examples

There are a number of Case Studies relating to the environment, land and property, transport and utilities available at http://www.dnf.org/resources/ .

7.5 DNF Services

The DNF documentation is support by a number of services available on the DNF website. These include a registry service and downloads.

7.5.1 Registry

Registry of identities

This provides for the registration of organisation prefixes. It allows organisations to register 4-character codes that are unique to them. On publication of DNF-compliant datasets, identifiers can be prefixed with these codes in order to guarantee uniqueness within the Digital National Framework.

To access this service go to http://www.dnf.org/registry/identities/

This service is planned to be transferred to the UK Location Information Infrastrucuture.

Directory of feature catalogues

A feature catalogue of OS MasterMap objects which can be used as base or other reference objects is available on the website. This is viewable and searchable and includes inset maps and photographs to illustrate the different objects. All the objects are defined and their attributes given. The catalogue conforms to ISO 19110, the International Standard for feature cataloguing methodology.

This service is intended to be used by all those who wish to register their reference objects in feature catalogue form.

This service is at: http://www.dnf.org/registry/feature_catalogues/

Terminology

Terms, their definitions and some examples and notes are given for those specialist term used within DNF. There is a search facility to enable the user to look up any terms. This is the most up-to-date source of terms and definitions

This service is at: http://www.dnf.org/guides/terminology/

7.5.2 Downloads

Feature catalogue tool

This tool which is based on Microsoft® Access has been developed to facilitate the creation of feature catalogues conforming to ISO 19110. It is capable of exporting the catalogue in XML. The tool is available upon application to contact@dnf.org.

XML schemas

Not available.

Documents

All documents described as available above are downloadable from the DNF website.

Document templates

Available on request.

8 Bibliography/References

2006	British Standards Institution	BS 7666-0, Spatial datasets for geographical referencing. Part 0: General model for gazetteers and spatial referencing
2008	Defra	UK Location Strategy
2008	INSPIRE	D2.5: Generic Conceptual Model
2002	International Organization for Standardardization (ISO)	ISO 19101, Geographic information – Reference model
2005	International Organization for Standardardization (ISO)	ISO 19110, Geographic information – Methodology for feature cataloguing
2007	International Organization for Standardardization (ISO)	ISO 19111, Geographic information – Spatial Referencing by Coordinates
2002	International Organization for Standardardization (ISO)	ISO 19113, Geographic information – Quality principles

2009	International Organization for Standardization (ISO)	ISO 19126:2009 Geographic information -- Feature concept dictionaries and registers
2007	International Organization for Standardization (ISO)	ISO 19131, Geographic information – Data product specification
2010	UK Location Programme	Linking information and location. A guide to the benefits of Linked Data and the UK Location Strategy

Appendix A: UML Modelling Conventions

The following diagrams show the conventions used in the UML models presented in this document.

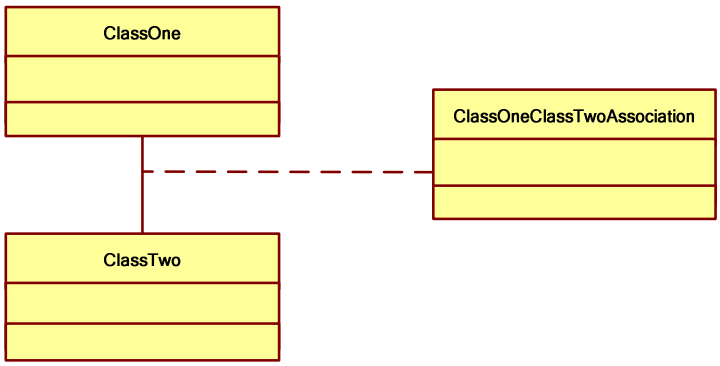
For a full explanation of UML please consult a suitable text.

Packages are UML concepts that enable the organisation of model elements into groups. Packages may contain other packages and UML classes. If two classes, each in a different package, interact then a dependency relationship must exist between the parent packages. In the example below, Package One depends on Package Two.

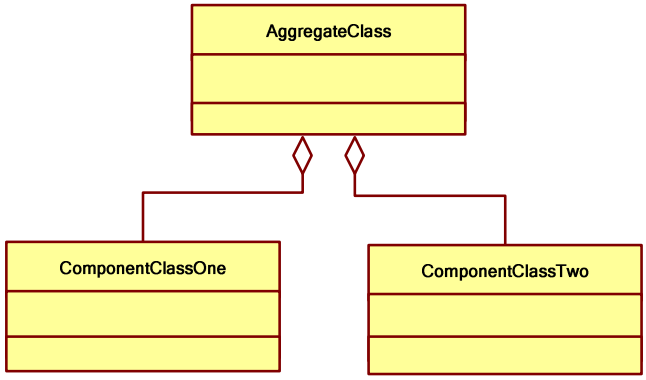
Classes may be associated with one another. An association drawn as a single line is considered to be bidirectional – i.e. in the example below, it is possible to navigate from ClassOne to ClassTwo and *vice versa*.

If navigation is unidirectional, then this is shown using an arrow indicating the direction of navigation. In the example below it is possible to navigate from ClassOne to ClassTwo but not from ClassTwo to ClassOne.

Association Class



Aggregation of classes



Diamond in arrowhead indicates an aggregation i.e. part-whole association

Class inheritance