



INSPIRE

Infrastructure for Spatial Information in Europe

INSPIRE Technical Architecture - Overview

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These are Dublin Core metadata elements. See for more details and examples <http://www.dublincore.org/>

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1 Foreword

The document is publicly available as a 'non-paper', as it does not represent an official position of the Commission, and as such can not be invoked in the context of legal procedures.

2 Overview

The INSPIRE Directive defines the technical elements of an infrastructure for spatial information to be comprised of "metadata, spatial data sets and spatial data services, network services and technologies." [INSPIRE Directive, Article 3.1]

2.1 *Scope*

The document provides a high-level overview of the current understanding of the technical architecture of INSPIRE. It illustrates the required elements within the infrastructure, their relationships and the responsible party for drafting the relevant specification. The document does not describe the technical specification of the individual elements.

This is work-in-progress and it will change as a result of further discussions.

2.2 *Purpose*

This document is intended to serve two purposes:

- 1) Support the discussion within and between the parties involved in the drafting of the technical specification of the individual elements (Commission, Drafting Teams, and Thematic Working Groups). Most of these specifications are written for adoption as Implementing Rules. The document will primarily be used to identify gaps in the current set of work items as well as identify needs for additional collaboration between parties specifying elements of the architecture with mutual relationships.
- 2) Help SDICs and LMOs to better understand the context of the different deliverables that are being created by the parties mentioned above and which will typically be sent to SDICs and LMOs for consultation as described in the Work Programme.

The following figure provides a simplified overview of key elements in the technical architecture of INSPIRE. The components and their relationships are further described in the subsequent sections of this document.

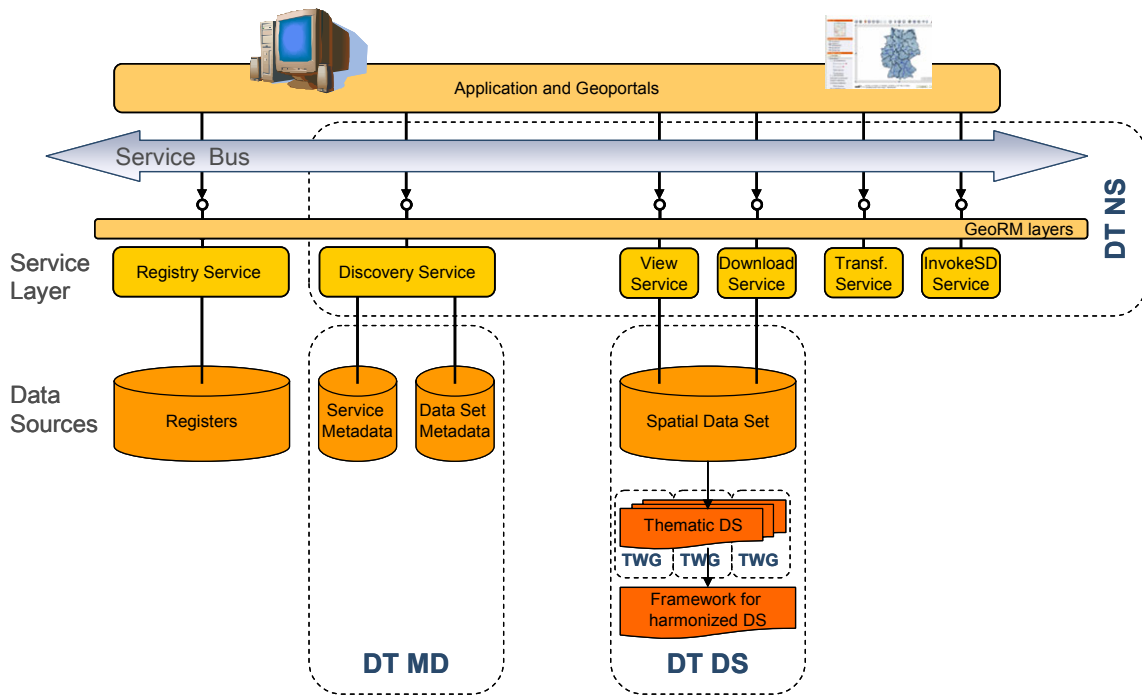


Figure 2-1: INSPIRE technical architecture overview

The core resource in the diagram is the actual content, i.e. the spatial data¹ in spatial data sets². All other resources shown in the diagram, e.g. data set metadata, are only needed to find, access, interpret or use the spatial objects³ in the spatial data sets that form part of the infrastructure.

It is important to note that in INSPIRE all access to spatial data and metadata occurs via spatial data services⁴. All services are described by service metadata (service descriptions), allowing humans and software applications to discover specific service instances in the infrastructure. In the first implementation of INSPIRE the service descriptions may not be detailed enough to allow for an automatic binding to services based on the service metadata alone. A set of well-known, harmonised spatial data service types, prescribed by the INSPIRE Directive, are fully specified as network services (see Section 6).

Other spatial data services may be invoked from the infrastructure, too. The currently identified requirements for these services are that service descriptions according to the Implementing Rule on metadata are published as well as any additional requirement raised by the "invoke spatial services service" that could be specified by the technical arrangements for the interoperability and, where practicable, harmonisation of spatial services. In order to support the requirements, it is expected that taxonomy of the service types in the infrastructure will eventually be specified. Furthermore, it is expected that the service metadata or the technical arrangements for the interoperability and, where practicable the harmonization of spatial services will support the detailed description of the service capabilities and operations of the individual spatial data services for its invocation through the relevant INSPIRE Network Service.

The infrastructure will be built upon existing or emerging infrastructures in the member states and international organisations. In particular it has to be emphasised that changes to existing data capturing, updating and management processes within the member states and international

¹ **Spatial data**: any data with a direct or indirect reference to a specific location or geographic area [INSPIRE Directive]. *Note: The use of the word "spatial" in INSPIRE is unfortunate as the meaning goes beyond the meaning of "geographic" – which is understood to be the intended scope. Therefore, "spatial data" is understood as a synonym for the term "geographic information" as used in the ISO 19100 series of International Standards.*

² **Spatial dataset**: identifiable collection of spatial data [INSPIRE Directive]

³ **Spatial object**: an abstract representation of a real-world phenomenon related to a specific location or geographical area [INSPIRE Directive]. *Note: This term is understood as a synonym for geographic feature as used in the ISO 19100 series of International Standards.*

⁴ The implementation platform for these services is expected to be web services.

organisations are in general not foreseen by the implementation of INSPIRE. Instead, the INSPIRE Implementing Rules aim at providing access to existing spatial data in a harmonised way.

3 Spatial data

In principle, every spatial object in a spatial data set needs to be described by a data specification specifying the semantics and the characteristics of the types of spatial objects in the data set. The spatial object types provide a classification of the spatial objects and determine among other information the properties that any spatial object may have (be they thematic, spatial, temporal, a coverage function, etc.) as well as known constraints (e.g. the coordinate reference systems that may be used in spatial data sets). This information is, in principle, captured in an application schema using a conceptual schema language, which is a part of the data specification.

As a result, a data specification provides the necessary information to enable and facilitate the interpretation of spatial data by an application. However, in practice, a substantial share of existing spatial data sets is not well documented. Only spatial data sets that conform to data specifications for Annex themes that are adopted INSPIRE Implementing Rules will be considered fully integrated in the infrastructure⁵.

It is important to note that the logical schema of the spatial data set may and will often differ from the specification of the spatial object types in the data specification. In this case, and in the context of real-time transformation, a service will transform queries and data between the logical schema of the spatial data set and the published INSPIRE application schema on-the-fly. This transformation can be performed e.g. by the download service offering access to the data set or a separate transformation service.

The Drafting Team "Data Specification" develops the initial drafts that specify the framework for developing the Implementing Rules for the data specifications for the Annex themes. The conceptual modelling framework standardised in the ISO 19100 series of International Standards provides the basis for these developments.

In order to support the interoperability requirements given in the Directive, the data specifications will have to be the result of a harmonisation process based on existing data sets and, where available, requirements from environmental applications. A number of individual aspects, called data harmonisation components, have been identified that need to be addressed in this harmonisation process:

- Principles: The principles cited in recital (6) of the Directive are considered to be a general basis for developing the data harmonisation needs.
- Terminology: A consistent language, managed in a multilingual glossary, has to be used throughout INSPIRE.
- Reference model: A common framework for the technical arrangements in the data specifications is required to achieve a consistent structure across the individual themes.
- Rules for application schemas and feature catalogues: Application schemas and feature catalogues provide the formal specification of the spatial data and promote the dissemination, sharing, and use of geographic data through providing a better understanding of the content and meaning of the data. Across the individual themes common rules are required to achieve the required coherence.
- Spatial and temporal aspects: While the reference model specifies an overall framework, this aspect deals with the spatial and temporal aspects in more detail, for example, the

⁵ It may also be considered in how far the following cases are understood as part of the European spatial data infrastructure:

- Data specification exists: Spatial objects that are not covered by one of the INSPIRE data specifications, but for which a full data specification has been developed by a community or project and which has been published in an appropriate register in the infrastructure.
- Limited documentation: Spatial objects or just map layers that are not or not fully described by any data specification which is registered in the infrastructure. For example, some data files for which no documentation exists, but which are made available through a View Service.

The minimum documentation requirement for a spatial data set in the infrastructure is that it has to be possible to generate the required service descriptions to publish the data.

types of spatial or temporal geometry that may be used to describe the spatial and temporal characteristics of a spatial object.

- Multi-lingual text and cultural adaptability: Rules for the support for multi-lingual information in data specifications.
- Coordinate referencing and units of measurement model: Specification of the conceptual schema for spatial and temporal reference systems as well as units of measurements – including the parameters of transformations and conversions.
- Object referencing modelling: Rules for the specification of the spatial characteristics of a spatial object based on already existing spatial objects, typically base topographic objects, rather than directly via coordinates.
- Data transformation model / guidelines: Rules for the transformation from an existing data model to an INSPIRE application schema and vice versa. Transformations are required for data and for queries.
- Portrayal model: Schema for portrayal rules for data according to a data specification.
- Identifier management: Specification of the role and nature of unique object identifiers based on existing national identifier systems.
- Registers and Registries: See chapter 5.
- Metadata: Guidelines for documenting metadata for data sets as well as spatial objects on the levels discovery, evaluation, and use.
- Maintenance: Guidelines for the maintenance of spatial data sets within INSPIRE.
- Data & information quality: Guidelines for the publication of quality information, e.g. on completeness, consistency, currency and accuracy.
- Data transfer: Guidelines for encoding data based on the conceptual model in the data specification.
- Consistency between data: Guidelines for the consistency between the representation of the same entity in different spatial data sets (for example along or across borders, themes, sectors or at different resolutions).
- Multiple representations: Best practices for the aggregation of data across time and space and across different levels of detail.
- Data capturing rules: Guidelines *which* entities are to be represented as spatial objects in a spatial data set. For INSPIRE data specifications it is in general not relevant, *how* the data is captured by the data providers.
- Conformance: Rules for the description of abstract conformance tests in data specifications.

The data specifications for the spatial data themes, which will be adopted as Implementing Rules, will be drafted by Thematic Working Groups based on four documents:

- a description of each spatial data theme given in the Annexes of the Directive;
- a Generic Conceptual Model providing requirements, recommendations and explanations for each of the data harmonisation components to be applied in a data specification;
- a methodology for the development of data specifications supporting the harmonisation process based on the data harmonisation components;
- and guidelines for the encoding of spatial data.

4 Metadata

A spatial data set is described by data set metadata providing information supporting the discovery – and to a certain extent also the evaluation and use – of spatial data sets for specific usages.

Service metadata provides basic information about a service instance to enable the discovery of spatial data services. The description of a service includes the service type, a description of the operations and their parameters as well as information about the geographic information available from a service offering.

To support discovery a search will in general require support for keywords or other simple search criteria describing key characteristics of the resource (e.g. about the topics or spatial object types that

are covered by the spatial data set)⁶. In addition, search criteria have to support searching based on spatial and temporal extents.

Metadata must be kept consistent with the actual resource. I.e. a change in the resource has to result in an (automatic or manual) update of the associated metadata document describing the resource.

The Drafting Team "Metadata" develops the initial drafts of the Implementing Rule of data sets and services metadata for discovery.

5 Registers

In addition to the actual spatial data sets a number of resources describing the data need to be maintained properly and must be made available online in order to allow for a correct processing and interpretation of the data. These resources are maintained in registers, which have to have a clear and well-defined governance model. The register contents are made available in form of a registry⁷.

Currently, it is the assumption that registers and registries will not be part of the INSPIRE Implementing Rules.

It is a key characteristic of a register that it keeps track of changes so that data created in the past can still be interpreted completely and correctly; i.e. superseded or retired register items will remain in the register.

A key characteristic of a register is that every item in the register is associated with a unique, unambiguous and permanent identifier.

It is worth to note that this architecture basically separates content in one of two categories:

- Spatial objects representing phenomena in the real-world (the "data")
- Other items of spatial information (data describing, referenced by or related to the spatial objects, i.e. "metadata", but in a wider sense than geographic information metadata is understood by ISO 19115)

The number of registers that eventually will be required in the infrastructure can be significant. As a result, a clear and sustainable operational model forms a key part of the setup of the infrastructure. An initial list of potential registers, i.e. kinds of spatial information items, includes:

- Data specifications: Detailed description of one or more data sets that will enable it to be created, supplied to and used by another party.
- Feature catalogues: Catalogues containing definitions and descriptions of the spatial object types, their attributes and associated components occurring in one or more data sets, together with any operations that may be applied. Part of a data specification.
- Application schemas: Conceptual schema for data required by one or more applications. Part of a data specification and specified in a formal conceptual schema language (UML in INSPIRE).
- Code lists: Dictionary describing the attribute value domains for selected property types in a feature catalogue / application schema. Unlike enumerations, the value domain is not fixed in the feature catalogue / application schema, but is managed separately. I.e. this establishes a controlled vocabulary outside of the application schema.
- Coordinate reference systems and operations: Dictionary of coordinate reference systems, datum, coordinate systems and coordinate operations which are used in data sets.
- Units of measurements: Dictionary of units of measurement which are used in data sets.

⁶ An objective for the future might be to support ontology in the discovery service (or its clients) to support searches on related terms where possible relations between two vocabularies may include identity, specialisation, aggregation, exclusion, etc. However, this is a research topic and out-of-scope for INSPIRE for at the moment.

⁷ In the geo-community the term "catalogue" is also used quite often. For the purpose of this document, we will make the following difference between a catalogue and a registry: a registry (and its register contents) is a specific type of catalogue that conforms to ISO 19135.

- Spatial object identifier namespaces: A mechanism is required to guarantee uniqueness of object identifiers across various content providers. One approach is to use existing "local" identifiers of the provider, but define namespaces to distinguish between different providers (and between different offerings of a provider). These namespaces need to be managed.
- Service types: List of service types (service taxonomy).

For additional registers it is currently unclear, whether they are needed as registers in the initial INSPIRE implementation:

- Thesauri: Similar to code lists with additional information how terms of the vocabulary relate to each other (hierarchies, etc).
- Portrayal rules: Rules that are applied to a feature to determine the portrayal of a feature in a map.
- Symbols: Depictions to be used in portrayal rules to describe the styling of features in a map.

6 Network services

Network services are necessary for sharing spatial data between the various levels of public authority in the Community. For these services interoperability is requested by the Directive, which means the possibility for services to interact, without repetitive manual intervention. To reach this goal the INSPIRE Network Services Definitions define the interfaces by which the different parties of the European Spatial Information Infrastructure will communicate. Thus, the INSPIRE Network Services can be seen as the protocol being used to realise a pan-European geo spatial service bus (see fig. 6-1):

- Different *SDI providers* who contribute INSPIRE-conforming services (access only)
- INSPIRE Network Services expose services for machine-to-machine communication. At least a workflow that follows the "publish – find – bind" design pattern should be possible. However, users do not necessarily have to follow this pattern; they can also invoke services directly.
- INSPIRE Applications solving specific tasks by involving INSPIRE services.
- INSPIRE geo-portal at Community level and further Member States access points offering INSPIRE functions to the different user groups (usage of INSPIRE services). A user can access services on an EU level via the INSPIRE geo-portal but also on a MS level – usage on the EU level offers the advantage to access data that integrates seamlessly data from different member states.

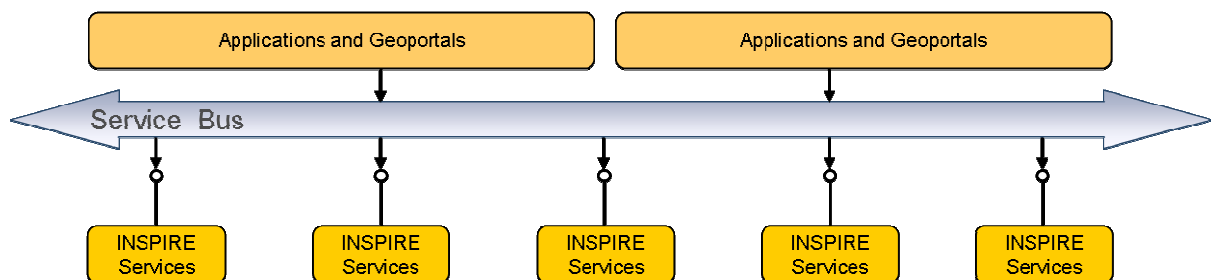


Figure 6-1: INSPIRE Network Service bus

It is important to note that for INSPIRE it is assumed that all kind of data and metadata access and processing is performed using web services. All services are described by service descriptions (service metadata, as part of the INSPIRE metadata), allowing humans and software applications to discover specific service instances in the infrastructure and invoke them automatically.

Another view on the INSPIRE Network Services is to see them as a mediator between the services provided by the member states or offered by third parties and their EU-level usage for example via the INSPIRE geo-portal. Here "INSPIRE geo-portal" means an Internet site which provides access to the

services referred to in Article 11(1): discover, transform, view and download spatial data, invoke spatial data and e-commerce services.

The figure 6-2 sketches the mediator perspective:

- Member state services – whether conforming to the INSPIRE Network Service Definitions or not – can be used as input for the Member States infrastructures and portals. Be aware, that Member State services do not have to conform to the INSPIRE Network Service Definitions but only the INSPIRE Network Services which are provided through the Member State access points.
- In addition to MS INSPIRE Services for the communication between EU and Member State level the Member State access points may provide a specific client (portal). However, it is not required that a member state provides a portal of its own. In addition, organizations of the member states can provide MS INSPIRE Services which can be used directly within the INSPIRE geo-portal or by EU level users.
- The INSPIRE services are used by the INSPIRE geo-portal as well as by applications / users which directly use the INSPIRE services on EU level. INSPIRE Services can be provided directly conforming to the INSPIRE Network Service specification or can be realized by a façade which cascades to the original MS services.

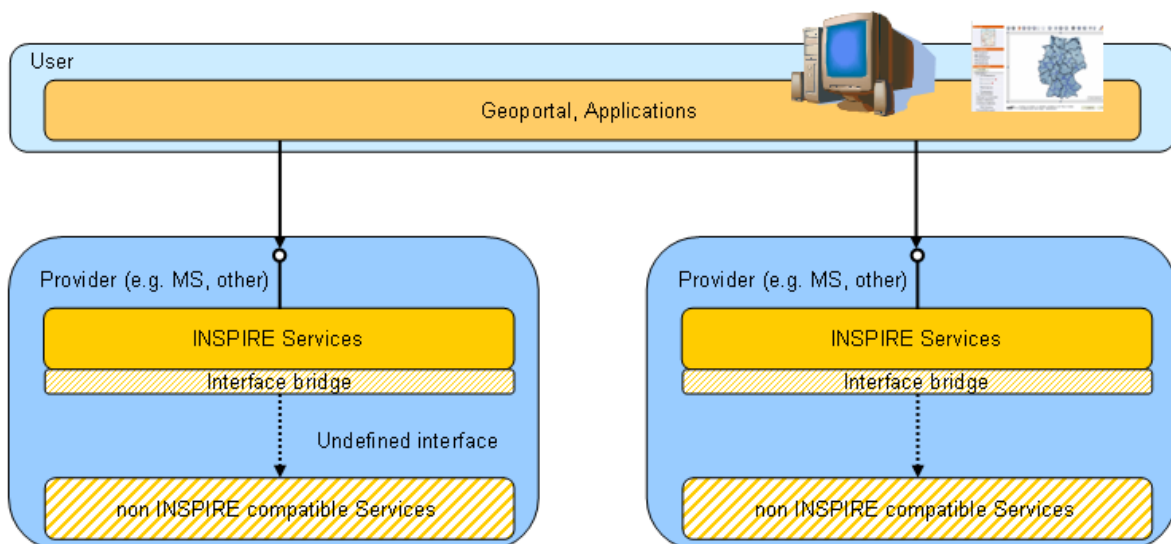


Figure 6-2: Network Service Definitions as a mediator between member states INSPIRE and non INSPIRE services and EU level users

The architecture of INSPIRE as well as of the INSPIRE geo-portal can be seen as multi tier architecture (see figure 6.3) which separates between:

- the INSPIRE user layer (human as well as machine users),
- the INSPIRE service layer representing all the INSPIRE services which can be accessed on the EC level for example by the INSPIRE geo-portal and
- the different member state services which can be accessed from the EC level by cascading but also directly on EC level if the service interface is conformant to the INSPIRE Network Service definitions.

In the INSPIRE user layer we find the usage of the INSPIRE services by the INSPIRE geo-portal client for human users, as well as the INSPIRE applications which use different INSPIRE services to fulfil their specific tasks. The different INSPIRE applications can be understood as “INSPIRE machine users” - in this way machine-to-machine communication on the European and International level is supported by INSPIRE.

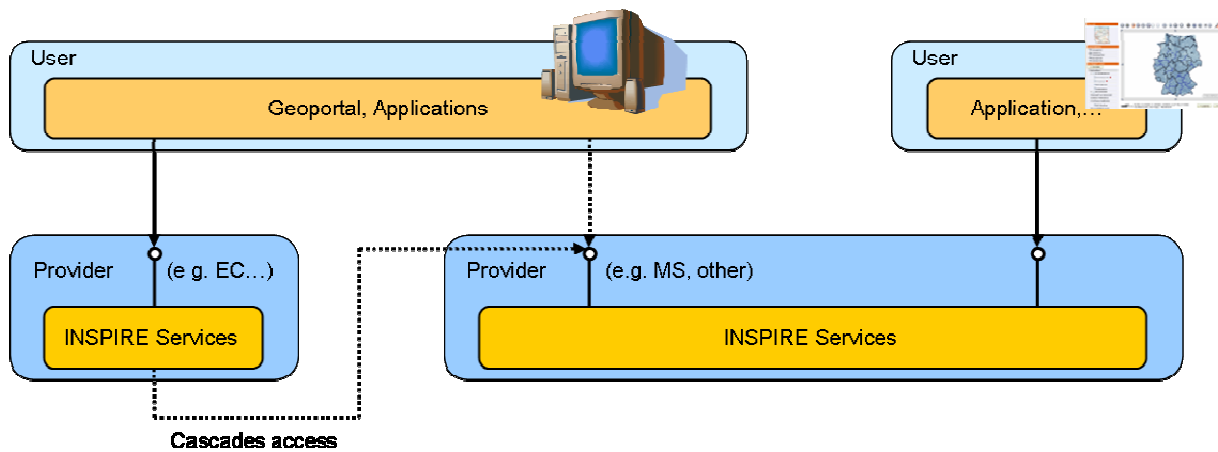


Figure 6-3: Conceptual two tier architecture of the INSPIRE Geo-portal

The other layers are service layers, which represent services and service cascades. Every service layer (see figure 2-1) typically consists of:

- The GeoRM layer as the overall workflow control, consisting of authentication, authorization, pricing, billing, licensing and possible further global aspects.
- The service layer, which consist of the different INSPIRE servers (services) supporting the different INSPIRE service types.
- All these Servers / Services use either cascaded services or data which is provided locally by different data sources.

Although INSPIRE services can be used in many variations, the regular underlying process model reflects the fundamental publish-find-bind pattern. Figure 6-4 depicts the process phases and the related services.

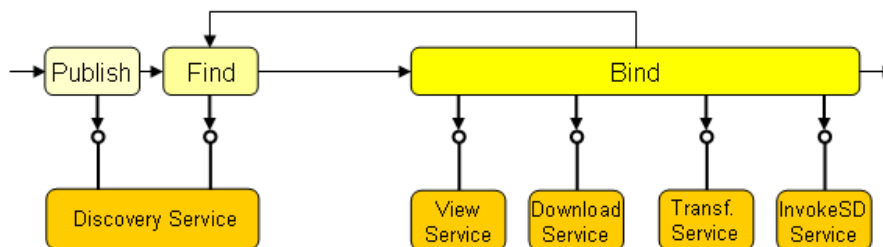


Figure 6-4: Publish-Find-Bind pattern

7 Simple usage scenario

The cross-border roads between France and Italy, for example the motorway from Nice to Genoa, pass through mountainous areas and feature many tunnels and viaducts making them particularly susceptible to hazards that block the road since it is not possible to easily by-pass or remove the blockage due to access difficulties. Roads can be disrupted (e.g. blocked) by a number of different events, for example: direct surface rupture or liquefaction caused by an earthquake, landslides (however caused), fire (forest or otherwise), floods.

This scenario helps to develop a system to enable the analysis of knock-on effects (in terms of cost and time) due to the disruption of a route. This will be useful to government transport agencies so that they can perform 'what if' type analysis to estimate the effects of possible events. The results of this type of analysis will be useful in decision making concerning the need to construct new tunnels and also evaluate the impact of knock-on effects of potential blockages (e.g. increase road traffic on other roads). Also large users of roads (e.g. haulage companies) may wish to estimate their additional costs

due to the blockage of a road. They can then plan to pass these extra costs onto their customers or absorb them in another manner, e.g. through taking out insurance.

In this scenario,

- routes cuts by a possible geological event are located;
- the possible event is defined by an expert user according to local geology and historical events;
- After the routes cuts are identified, the system tries to find alternative routes.

The users of the system are experts in risk management. The system enables them to estimate the characteristics of an event according to all data available on a specific area and to analyse the consequences of this event on the road network.

The scenario involves the creation of metadata for spatial data sets and services and involves the following services: discovery services, View service, transformation service, invoke spatial data services

1. Create and publish metadata for spatial data sets and services

Spatial data sets and services are initially described in a commonly agreed way that comply to the INSPIRE Implementing Rules on metadata. In the case of the specific scenario metadata are created for the road network, geological events, hazard maps, etc. by the competent authorities and organizations responsible for the creation and maintenance of the spatial data sets and services.

The metadata are subsequently published to a metadata catalogue so that they can be found by the users.

Note that since the specific scenario is taking place in a cross-border area it may involve catalogues from both France and Italy.

2. Discovery of relevant data sets (Discovery Service)

The user searches for data and services about earthquakes, landslides, geology, and the road network on the French-Italian border region. He discovers relevant metadata in catalogues from both France and Italy or through the INSPIRE geoportal, by defining the geographic area of interest, keywords (geology, geological maps, hazard maps, risks events, earthquakes, landslides, road network) and other specific search criteria. The full descriptions of these data sets and services can subsequently be read by the users.

Through this process the user identifies all the data sets and related services that are relevant to the specific scenario.

3. Request maps (View Service)

Once all the relevant services, for example view services, have been identified in the previous step, the user, may request and view maps of data layers in a map viewer client application available for example in the INSPIRE geoportal. The map layers are

- a geological map,
- a map of historical events: earthquakes and landslides,
- hazards map,
- and road network

Should the data from France and Italy be using different Coordinate Reference Systems (CRS), the INSPIRE Transformation service will need to be used to transform the French and Italian data to the same CRS.

4. Request information on a feature

Once the view service has sent the map to the map viewer client application, the user may ask for information about features she points out on the map (geologic unit, landslide, and earthquake).

5. Define the possible event

Thanks to all available data, the user can simulate an event and draw the area that is potentially affected by this event.

6. Define the affected area

Instead of drawing the affected area, the user may ask for a map showing the historical events (e.g. earthquakes) in the selected area and the user then selects one and subsequently request a map showing the macro-seismic intensity points (e.g. points where the earthquake caused damage to structures) for the selected event; these intensity points are then processed to return an estimated area within which the road network could be damaged by a recurrence of the event. The following steps need to be performed:

- First, all event data have to be downloaded using the same application schema and their coordinates must be transformed into the same CRS, the user has to discover the services enable transform the data (Transformation services);
- These features collection are processed by a spatial data service able to create intensity iso-curves (Invoke spatial data services service). The user asks for polygon with an intensity > 7 for example (referring to the region within which damage is expected). This service has to invoke normalize data service, interpolate service data and draw iso-lines service

7. Find alternatives routes

Given the end points of the route(s), and the polygon defining the affected area, the user discovers and asks a spatial data service (Invoke spatial data services service) to find an alternative route and to create a map with route interruptions and the alternative route(s). This service has to invoke a service to find any road cut by the event, a service to compute the new route and a service to draw this new route

8 Acronym List

CRS	Coordinate Reference System
DS	Data Specifications
DSS	Data and service sharing
DT	Drafting Team
EC	European Commission
EU	European Union
GCM	Generic Conceptual Model
GeoRM	Geographic Rights Management
INSPIRE	INfrastructure for SPatial InfoRmation in Europe
IR	Implementing Rule
IT	Information Technology
JRC	Joint Research Centre
LMO	Legally Mandated Organisations
MD	Metadata
MR	Monitoring and Reporting
MS	Member State
NS	Network Services
SDI	Spatial Data Infrastructure
SDIC	Spatial Data Interest Community