

# DETAILED SERVICES IN A SPATIAL DATA INFRASTRUCTURE FROM THE COMPUTATION VIEWPOINT

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## Abstract

The Commission on Geospatial Data Standards of the International Cartographic Association (ICA) is working on defining formal models and technical characteristics of Spatial Data Infrastructures (SDI). The Commission has already presented models of the Enterprise and Information Viewpoints from the ISO Reference Model for Open Distributed Processing (RM-ODP) standard. For the Enterprise Viewpoint, we identified six *actors* or stakeholders (*Policy Maker, Producer, Provider, Broker, Value Added Reseller* and *End User*) and six core components for an SDI (*Policies, Connectivity, Technology, Processing Tools, Metadata* and *Products*). For the Information Viewpoint, we identified seven classes, with *Product (Services or Data)* at the centre and the others being *Policy, Product Specification, Metadata, Catalogue, Information* and *Knowledge*.

The Commission has also modelled an SDI from the Computation Viewpoint, which describes how the different services of an SDI fit together. The interactions between

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these high-level services have been modelled using the Unified Modelling Language (UML) Component Diagrams. We present here these SDI services in greater detail.

We have identified six broad groupings of services: *Registry Services*, *Data Services*, *Processing Services*, *Application Services*, *Portrayal Services* and *Management Services*. We have also identified generalised services that cut across the activities in an SDI. We have modelled these service components in more detail, looking at both the detailed services that are performed within each of these components, and the roles played by these components in the different phases of establishing and using an SDI. The matrix of these detailed services is too large for inclusion in this conference presentation, but will be published elsewhere.

This presentation focuses on the roles of service components in an SDI, which we consider for each of the seven phases of the development and use of an SDI: *Initiation*, *Creation and Management*, *Locate*, *Access*, *Processing*, *Evaluation* and *Liaison*. We present a table summarising the specific services provided by each service component for each phase and describe the services in more detail.

## 1. Introduction and Fundamental Concepts Involved

The growing need to organise geospatial data across different disciplines and organisations has resulted in the development and implementation of spatial data infrastructures (SDI) and the theory and concepts behind them. An SDI is an evolving concept about facilitating and coordinating the exchange and sharing of spatial data and services between stakeholders from different levels in the spatial data community (Hjelmager *et al* 2008). An SDI provides metadata, data and services operating on the metadata and data – the *products* of the SDI.

The ISO Reference Model for Open Distributed Processing (RM-ODP) standard (ISO/IEC 10746:1995) defines five *viewpoints* for the design and description of distributed software and information systems:

- **Enterprise Viewpoint:** purpose, scope and policies for the system;
- **Information Viewpoint:** semantics of information and information processing incorporated into the system;
- **Computation Viewpoint:** functional decomposition of the system into a set of services that interact through interfaces;
- **Engineering Viewpoint:** mechanisms and functions required to support distributed interaction between the services and data within the system; and
- **Technology Viewpoint:** the specific technologies chosen for the implementation.

Previously, the Commission on Geospatial Data Standards of the International Cartographic Association (ICA) developed formal models of SDIs from the Enterprise and Information Viewpoints of RM-ODP (Hjelmager *et al* 2005; Hjelmager *et al* 2008).

We have also presented a formal model of an SDI from the Computation Viewpoint (Cooper *et al* 2007), for which we described the services using the Unified Modelling Language's (UML) component diagrams (Object Management Group 2005). In this paper we take this modelling of the Computation Viewpoint further, describing SDI service components and services provided by them in different phases of SDI development and use.

These models describe how the different parts of an SDI fit together in the viewpoints in question (a multi-perspective description of an SDI) and should be seen as a contribution towards the overall model of the SDI and its technical characteristics. SDI development should be considered from conceptual, technical, socio-technical, political, institutional and financial perspectives. Hence, designing, building, implementing and maintaining an SDI draws on many different disciplines and requires examination from various perspectives (Hjelmager *et al* 2008).

We have not attempted to model an SDI from the Engineering or Technology Viewpoints, as we consider these to be implementation-specific and our interest is in modelling the general case of the SDI.

## **2. Overview of the Enterprise and Information Viewpoints of an SDI**

In modelling an SDI from the Enterprise Viewpoint, we identified six *actors* (the stakeholders): *Policy Maker*; *Producer* (of data or services); *Provider* (of data or services); *Broker*; *Value Added Reseller* (VAR); and *End User*. For these stakeholders, we identified their tasks or activities (ie: use cases), where an actor's involvement can be *Active* or *Passive*. Using a UML Class Diagram, we identified six core components of an SDI as UML *Classes* and their interconnections as *Relations*. These are: *Policies*, *Connectivity*, *Technology*, *Processing Tools*, *Metadata* and *Products*, with Policies, for example, consisting of *Business Model*, *Business Agreements*, *Legal Constraints*, *Standards* and *Best Practices* (Hjelmager *et al* 2008)

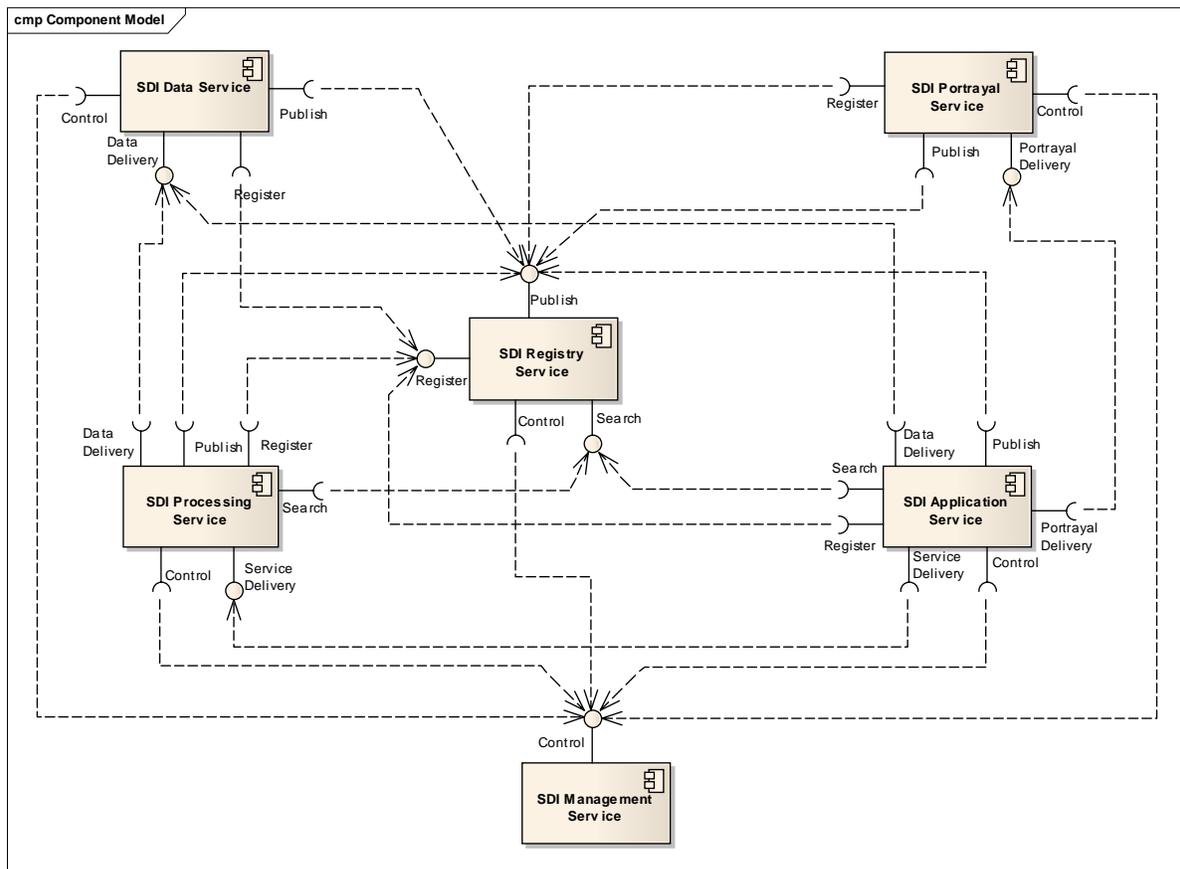
For the Information Viewpoint, we also used a UML Class diagram with the *Product* class (made up of *Services* or *Data*) being at the centre and the other classes being *Policy*, *Product Specification*, *Metadata*, *Catalogue*, *Information* and *Knowledge*. These classes were further sub-divided into *activities* and we identified the roles of the stakeholders in these activities (Hjelmager *et al* 2008).

## **3. Overview of the Computation Viewpoint of an SDI**

The Computation Viewpoint captures the details of the SDI services and interface definitions without regard to their distribution (ie: where they actually are in the world), as this is covered by the Engineering Viewpoint. The Computational Viewpoint

prepares the environment for distribution just by decomposing the system. We used the UML Component Diagram as it shows the structural relationships between the *Components* of a system: autonomous, encapsulated units within the system that provide one or more interfaces and are strictly logical. The four basic elements of a Component Diagram are:

- *Component* (rectangle with small symbol in upper right corner);
- *Provided Interface* (connector with circlet);
- *Required Interface* (connector with arc); and
- *Dependence* (dashed arrow).



**Figure 1.** Computational View of Service Component Diagram of SDI (from Cooper *et al* 2007)

We identified six service components for an SDI, based largely on RM-ODP, which are illustrated in the UML Component Diagram in Figure 1 (Cooper *et al* 2007):

- (1) *Registry Services*: register other services, publish them, and later allow users to search through them;

- (2) *Data Services*: provide access to collections of data in repositories and databases shared and registered on the Internet;
- (3) *Processing Services*: provide data processing services such as coordinate computation or projection system transformation;
- (4) *Application Services*: provide all processes necessary to meet the needs of users;
- (5) *Portrayal Services*: display the results of application services; and
- (6) *Management Services*: monitor and manage the overall functionality of the SDI.

These components can be viewed from different aspects:

- Services contained or concentrated in each component, and
- Roles played by these components in the different phases of SDI establishment and use.

We have already modelled both of these points of view. We have identified 183 detailed services within an SDI and mapped these into a matrix of the seven classes and their component activities in the Information Viewpoint against the six components of the Computation Viewpoint. However, this matrix is too large for inclusion in this conference presentation, but will be published elsewhere. Hence, we concentrate here on the second point of view in this paper.

#### **4. Functions of service components in an SDI**

The development and use of an SDI can be divided into seven broad processes:

- *Initiation*: includes the initial idea for the SDI, assembling the relevant stakeholders, developing the framework for the SDI and motivating for it and for the required funding.
- *Creation and Management*: establishing the SDI (once it has been initiated), populating it and performing its ongoing management.
- *Locate*: includes finding and using metadata and finding data matching the user's required product specification.
- *Access*: covers accessing data, including production of customised maps.
- *Processing*: includes transforming, integrating and modelling data.
- *Evaluation*: assessing the functioning of the SDI and the quality and utility of the data, metadata and services offered by the SDI.
- *Liaison*: maintaining relationships with stakeholders.

These processes represent different ways of interacting with an SDI and in this regard, have different needs for services provided by individual service components. These processes are described below and our results are summarised in Table A. In this table, the rows represent each SDI process and the columns represent each service component. In the intersection of a row and a column are listed all the relevant services provided by

the given service component (of that table column) in the given SDI phase (of that table row).

#### **4.1. Initiation**

During *Initiation*, the strategy, concept and rules for the proposed SDI are developed. The *Management* services component plays an important role in this process: it should provide the necessary *Development* service. Further, all service components should afterwards implement this strategy, this concept and these rules through the provided *Implementation* services in this phase.

#### **4.2. Creation and management**

The main goal of this process is to create the SDI and start the management of it. Services provided by components in this process are much richer and differ substantially from service component to service component.

The *Management* services component should provide a *Scheduling* service. The *Registry* services component should start to register *Products*, *Metadata*, *Registers*, etc. The *Data* services component will provide services focused on *Storing* data sets. The *Processing* services component should start *Harvesting*, *Capturing*, and *Reporting* on metadata. The *Portrayal* services component will provide a *Design* service to support the production and use of products. The *Application* services component will support *Capture* and *Reporting* functionalities. However, all components will support the *Update* services to help maintain the SDI.

#### **4.3. Locate**

The *Locate* process bears on the use of the SDI by users. That is why its activities (and the services provided) concentrate mainly on the *Registry* and *Data* services components.

The *Registry* services component will support the *Searching*, *Sampling*, *Extraction* and *Publishing* of metadata and *Products* while the *Data* services component will support *Sampling*, *Extraction* and, primarily, *Delivery* to support the use of data. The *Processing* and *Application* services components play important roles too – they support the *Delivery* services which deliver *Metadata*, *Catalogues*, and *Products* to users.

#### **4.4. Access**

This process of the SDI development and use is supported by *Access* services allowing access to the *Product*. These services are provided by *Data* services, *Processing* services, and *Application* services components. The *Portrayal* services component

provides the *Representation* service and the *Management* services component provides the *Adherence* service.

#### **4.5. Processing**

This process is supported mainly by the *Processing* services and the *Application* services components. Both provide *Transformation* services, the later one also provides *Application* and *Chaining* services.

#### **4.6. Evaluation**

The *Management* services component provides the widest suite of services in this process. This component takes care of *Monitoring*, *Survey*, *Assurance*, and *Auditing* services. The *Data* services, *Processing* services, and *Application* services components provide the *Assessment* service. Additionally, the *Register* services component supports the *Classification* service, and the *Processing* services component provides the *Calibration* service.

#### **4.7. Liaison**

Only the *Management* services component acts in this process. It provides the *Relationship* management service.

### **5. Summary & Conclusions**

The ICA's Commission on Geospatial Data Standards has been developing formal models of SDIs, using the RM-ODP Viewpoints. Presented here are the first detailed models of the RM-ODP Computation Viewpoint of an SDI, modelled using UML. We have concentrated on the general services provided by each service component in the different processes of SDI development and use.

We will develop more detailed specifications of the identified services in the near future.

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Finally, we wish to dedicate this to our dear colleague, Alexander Martynenko, who passed away in September 2007.

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<b>Processes in an SDI</b>	<b>Registry services</b>	<b>Data services</b>	<b>Processing services</b>	<b>Portrayal services</b>	<b>Application services</b>	<b>Management services</b>
<b>Initiation</b>	<i>Implementation</i>	<i>Implementation</i>	<i>Implementation</i>	<i>Implementation</i>	<i>Implementation</i>	<i>Development Implementation</i>
<b>Creation &amp; Maintenance</b>	<i>Registration Updating</i>	<i>Storing Updating</i>	<i>Capture Reporting Updating Harvesting</i>	<i>Design Updating</i>	<i>Capture Reporting Updating</i>	<i>Updating Scheduling</i>
<b>Locate</b>	<i>Searching Sampling Extraction Publishing</i>	<i>Sampling Extraction Delivery</i>	<i>Delivery</i>		<i>Delivery</i>	
<b>Access</b>		<i>Access</i>	<i>Access</i>	<i>Representation</i>	<i>Access</i>	<i>Adherence</i>
<b>Processing</b>			<i>Transformation</i>		<i>Transformation Application Chaining</i>	
<b>Evaluation</b>	<i>Classification</i>	<i>Assessment</i>	<i>Calibration Assessment</i>		<i>Assessment</i>	<i>Monitoring Survey Assurance Auditing</i>
<b>Liaison</b>						<i>Relationship Management</i>

Table A: Generalised functions of the SDI components in the different processes of SDI development and use.