Pegaso Project
People for Ecosystem based Governance in Assessing Sustainable development of Ocean and coast

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Guidelines for building the PEGASO SDI

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Abstract

The PEGASO SDI is one of the main components of the ICZM Platform, and also a core part of the project. The success of the design and development of the SDI it will be highly dependant on the common understanding of the basic concepts and shared language.

An SDI is a complex infrastructure that encompasses many different components that need to be understood by the partners, in order to develop a common infrastructure under the same principles. Concepts as geoportal, geonode, metadata, geoservices and web map services are presented in the context of the PEGASO SDI. In addition, an overview of the future structure of the SDI within the project is presented.

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Executive Summary

The main goal of the PEGASO project is to construct a shared ICZM Governance Platform with scientists and end-users, linked with new models of governance. The PEGASO ICZM Platform will be supported by the development of a Spatial Data Infrastructure (SDI) and the suite of sustainability assessment tools required for making multi-scale integrated assessments in the coastal zone.

In the present document a set of concepts and definitions of principal components of the PEGASO SDI are presented to the Consortium, as part of a set of guidelines and training material to build capacity related to the building of the PEGASO SDI.

First of all, an introduction of the project and the SDI building scope is presented, highlighting the need of data sharing between partners and the necessity of sharing a common language to facilitate the common understanding of the SDI concept. After that, an introduction of basic concepts is presented with special attention to the main concepts of the SDI components and its implementation in PEGASO project. These elements include the geoportal, geonodes, and the SDI itself. After that, other important concepts related to the construction and exploitation of the SDI are presented: data harmonization concept, metadata and catalogues, web services, GIS functionalities and the concept of interoperability.

Finally, a summary of the main concepts and a figure of the SDI PEGASO concept is provided.

1. Introduction

1.1. Why to read this document?

All partners are committed to collaborate in the implementation of the PEGASO SDI. Depending on their capacities and roles in the project, the kind of tasks to be undertaken may vary. For the success of the PEGASO SDI development of common rules and definitions need to be agreed.

The present guidelines are oriented to introduce all stakeholders in the concepts, tools, possibilities, etc, related with the Spatial Data Infrastructures. In forthcoming documents more detailed technical information to implement several tools will be provided.

1.2. The need for data sharing

(From EnviroGRIDS project “Bringing GEOSS Services into Practice)

Every day we access an enormous and continuous flow of information and much of it refers to a position or a specific place on the surface of our planet. This information is therefore, and by definition, geo-referenced. Therefore, in the last 30 years, the amount of geo-referenced data availability has grown dramatically following the evolution of the communication means and due to the rapid development of spatial data capture technologies such as Global Positioning System (GPS), remote sensing images, sensors, etc (Philips et al., 1999).

Despite the fact that administrations and governments are recognizing that spatial information is important and must be part of the basic information infrastructure that needs to be efficiently coordinated and managed for the interest of all citizens (Ryttersgaard, 2001), this huge amount of geospatial data is stored in different places, by different organizations and the vast majority of the data are not being used as effectively as they should.

This means that there is a strong need for availability and access to appropriate information. The development of databases and exchange of information are the conditions for creating the basis for a sustainable development. They support the information management needs for implementing and monitoring sustainable development policies and goals like the UN Millennium Development Goals (UNGIWG, 2007).

However, geospatial information is an expensive resource, it is time consuming to produce, and for this reason it is of high importance to improve the access and availability of data, and promote its reuse. Many of the decisions that different organization need to make depend on good and consistent geo-referenced data, available and readily accessible (Rajabifard and Williamson, 2001).

Even if all technologies are ready, organizations and agencies around the world are still spending billions of dollars every year to produce, manage and use geographical data but without having the information they need to answer the challenges our world is facing (Rajabifard and Williamson, 2001). These authors also highlight the facts that most organizations and/or agencies need more data than they can afford, they often need data outside their jurisdictions, and the data collected by different organizations are often incompatible. This inevitably leads to inefficiencies and duplication of effort, and thus it is evident that countries can benefit both economically and environmentally from a better management of their data (UNGIWG, 2007; GSDI, 2004).
In consequence, it is now essential to make these data easily available and accessible in order to give the opportunity to the user to turn them into understandable information.

2. An introduction to basic concepts

(From the PEGASO Project Description):

A key objective of PEGASO is to set up a good **Spatial Data Infrastructure (1)** (SDI), where all data and indicators from PEGASO participants can be shared, using the different services which will be offered through its **geoportal (2)**. The idea is to build a functional network of **geonodes (3)** with all partners, supporting capacity in the southern countries to co-develop and support existing geonodes and to build local/regional or national geonodes if requested by stakeholders. Data then will be easily accessible through a web portal that will also help in managing communication and dissemination of results amongst partners and the Shared ICZM platform components. PEGASO will support **harmonization of data (4**) and **metadata (5),** which are key components to build assessment tools (WP4) and to support the regional assessment (WP5).

Thus PEGASO will construct such an infrastructure by drawing on existing SDIs from project participants, such as SEXTANT from IFREMER, African Marine Atlas of ODINAFRICA network at IODE Project Office (IOC-UNESCO) and EMODNET managed by VLIZ, and extend their capabilities via easy Internet access to data. The PEGASO SDI will allow simple **GIS manipulation (6)** by all users and the **downloading (7)** of relevant data for more detailed local analysis. In order to further build capacity, special effort will be dedicated in the Project to support SDI and geonode construction amongst the participants, which require it.

The partners of PEGASO are highly involved in network for data harmonization and SDI creation (INSPIRE, GEO-GEOSS, ICAN, EMODNET, EIONET, etc), a network that will greatly facilitate data harmonization and in as much as possible **interoperability (8).**

2.1. Spatial Data Infrastructure

2.1.1 Definition, concepts and rationale

The term Spatial Data Infrastructure (SDI) is often used to describe the mechanisms or the enabling environment that supports easy access to, and utilization of, geographical data and information (UNECA, 2005). This definition is quite reductive as it gives the idea that SDIs are essentially technical. The primary objective of SDIs is to provide a basis for geospatial data discovery, evaluation, and application for users and providers within all levels of government, commercial and the non-profit sectors, academia and citizens (GSDI, 2004).

This means that SDIs are more than just data repositories. SDIs store data and their attributes, and their related documentation (metadata), offering a means to discover, visualize, and evaluate their fitness to different purposes, and finally provide access to the data themselves. In addition to these basic services, there are often additional services or software supporting the use of the data. Finally, to make an SDI work efficiently, it is necessary to include all the organizational agreements needed to coordinate and administer it.

In consequence, following Masser (2005) and GSDI (2004), we can give a more complete definition of what SDIs are:

- “A spatial data infrastructure supports ready access to geographic information. This is achieved through the co-ordinated actions of nations and organizations that promote awareness and implementation of complementary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organizational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the national and regional scale are not impeded in meeting their objectives”.

2.1.2 Objectives

Following Masser's definition (2005) and the different considerations highlighted in the previous section we can list different objectives underpinning SDIs:

The overall objective of an SDI is to maximize the reuse of geospatial data and information.

- SDIs cannot be realized without coordination (especially by governments).
- SDIs must be user driven, supporting decision-making for many different purposes.

- SDIs implementation involves a wide range of activities, including not only technical topics such as data, standards, interoperability, and delivery mechanisms, but also institutional arrangements, policies, financial and human resources.

The term infrastructure is used to promote the idea of a reliable and supporting environment, analogous to a road or a telecommunication network, facilitating the access to geo-information by using a minimum set of common practices, protocols, and specifications (GSDI, 2004). This allows the movement of spatial information instead of goods.

SDIs encompass the sources, systems, network linkages, standards and institutional issues involved in delivering spatially-related information from many different sources to the widest possible group of potential users.

2.1.3 Components

In order for data to be used, people need to know that the data exist, and where to obtain it.
- Users need to be authorized to access and use the data.
- Users need to know the history of the data capture, in order to interpret it correctly, trust it and be able to integrate it meaningfully with data coming from other sources.
- Users need to know if the data depends on other data sets, in order to make sense of data.

Consequently, to leverage the full potential of geospatial data, an SDI must be made of different components to allow users to find, discover, evaluate, access and use these data, namely:

- A clearly defined core of spatial data.
- The adherence to known and accepted standards and procedures.
- Databases to store data and accessible documentation about the data, the so-called metadata.
- Policies and practices that promote the exchange and reuse of information.
- Adequate human and technical resources to collect, maintain, manipulate and distribute geospatial data.
- Good communication channels between people/organizations concerned with geodata, allowing the establishments of partnerships and shared knowledge
- The technology for acquiring and disseminating data through networks.
- Institutional arrangements to collaborate, co-operate and coordinate actions.

The main material components are:
- *Catalogue of metadata (of data and services)*
- *WMS Client (viewer to access the geodata, to consult and download it, etc.)*
- *Web Map Server with WMS/WCS/WFS and other functionalities*
- *The network of accessible Web Map Severs, described by services metadata and containing geoinformation described by data metadata*

In order to meet the requirements of all stakeholders involved, an SDI must (Coleman et al., 1997): be widely available, be easy to use, be flexible.

Implementation in PEGASO

Two types of SDI's can be considered within PEGASO:

- **Local SDI's**: Some of the partners already have an operational SDI, and others would have the opportunity to set up their own SDI within this project. The elements that encompass a local SDI are:
  - Their own geoinformation, accessible in Web Map Servers and with WMS/WFS services
  - A WebMapClient connecting to the own information and accessing to other external data sources (geonodes).
  - A Catalogue with the own metadata and metadata from other organization participating in the SDI

- An organization giving support to the participants in the SDI, promoting several activities and assuring the data updating and the sustainability of the system

These SDI's, in the framework of the project, will be running at a local level (for example, VLIZ, IFREMER, UAB, DDNI, etc) but also a global or common PEGASO SDI will be set up.

- **Global SDI:** Gathering the contributions of all the partners and complementing them with several services and applications available, as a basic component of the ICZM governance platform, a Global or common SDI will be built to match the PEGASO Project requirements.

2.2. Geoportals

A **geoportal** is a web application offered by an organization that allows a standard access to its own geoinformation by means of a WMS Client (viewer), and also to other geoinformation available from external WebMapsServers, which the SDI allows to connect to. It can include a Catalogue of metadata related to its own geodata.

Implementation in PEGASO

Most of the partners will be able to create a Geoportal, which ensures accessibility to their information by the WMS/WCS/WFS services through their own WMSClient, this includes the ability to connect to other external data sources, local or international, to be merged and combined with their own data.

In summary, a Geoportal requires the following components:

- Web Map Server with OGC WMS/WCS/WFS services to make the data and services available in the Internet
- WMS Client (view and download the provider's geoinformation)
- WMS Client to access to external data sources
- Metadata of data and metadata of services
- Web site of the Geoportal

Metadata could be stored in an appropriate own Catalogue or be managed in an external Catalogue (for example, the Global SDI PEGASO Catalogue)

Examples: Links to European Geoportals (see catalogues, map viewers, metadata, geoservices, etc,)

www.geoportal-idec.cat/en
www.inspire-geoportal.eu
http://bio.emodnet.eu/
http://www.ifremer.fr/sextant/fr/web/guest/

2.3. Geonodes

Every provider of geoinformation has to offer it by means of an Internet geoservice, which can be achieved by using a Web map server, with Standard connections based on OGC Specifications. These services will allow the users to access the geoinformation by means of a WMS Client, to visualize it or to download it (under conditions defined by the provider). A provider can have one or more Web Map Servers containing each one several Services. The different services have to be described by the correspondent Services Metadata, which will be published in a Web Catalogue.

Every provider of geoinformation has to be considered as a "node" within the network of web MAP Servers which form a particular SDI.

Implementation in PEGASO

It will be desirable that most of the partners build a Geonode, implementing a Web Map Server with the OGC services WMS/WCS/WFS containing the geoinformation used in the generation of the indicators and other information related with their geographical area of responsibility.

This service can be implemented in the same technical environment of the partner or it can be hosted in an external (local) organization, or, when needed, in the PEGASO leader resources (to be agreed and discussed with the partners).

For those partners who create a geonode, a description of the geoinformation provided by their geonodes and related accessibility (visualization and download) services need to be described in the necessary registers of metadata of data and metadata of services, according with the application scheme which will be defined for the project.

In summary, a Geonode development needs the following services:

— Web Map Server with OGC WMS/WCS/WFS services to make data&services available
— Creation of Metadata of data and metadata of services

2.4. Data harmonization

"Harmonization is to create the possibility to combine data from heterogeneous sources into integrated, consistent and unambiguous information products, in a way that is of no concern to the end-user"

According to INSPIRE definition:
"The process of developing a common set of data product specifications in a way that allows the provision of access to **spatial data** through **spatial data services** in a representation that allows for combining it with other harmonised data in a coherent way."

NOTE: This includes agreements about coordinate reference systems, classification systems, application schemes, etc.

Therefore, in the PEGASO project harmonizing data procedures need to be undertaken. A harmonization guidelines document will be also produced, including technical details such as coordinate reference systems, mapping scale or resolution, recommended extent, administrative units to refer to, etc, and including also the common data models when available. The harmonisation process will consist of different steps:

— Define common data models for the geoinformation which has to be used
— Define every partner data model for these geoinformations
— Make the mapping between both models. Create matching tables
— Prepare the transformation processes from the partner 's data model to the common data model

Examples:
http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2

2.5. Metadata and metadata Catalogues

2.4.1. Metadata

Metadata is data about data. Metadata describes how and when and by whom a particular set of data or a service was collected or prepared, and how the data is formatted or the service is available. Metadata is essential for understanding information stored in and has become increasingly important.

Metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource. Metadata is often called data about data or information about information.

Metadata is also data about services. Metadata describes the content, quality, condition, and other characteristics of a data set or the capabilities of a service. Creating metadata or data documentation for geospatial data sets are crucial to the data development process. Metadata is a valuable part of a data set and can be used to:

— Organize your data holdings (Do you know what you have?).
— Provide information about your data holdings (Can you describe to someone else what you have?).
— Provide information to data users (Can they figure out if your data are useful to them?).
— Maintain the value of your data (Can they figure out if your data are useful 20 years from now?).

In the geographical domain we can have a description of spatial data (spatial data metadata), a service (service metadata) or a special analysis process (process metadata). Most for the standardization work is done for data metadata, however service and process metadata is becoming increasingly important.
Metadata is used in discovery mechanisms to bring spatial information providers and users together. The following mechanisms are recognized:

— **Discovery:** which data source contains the information that I am looking for?
— **Exploration (or evaluation):** do I find within the data sources the right information to suit my information needs?
— **Exploitation (use and access):** how can I obtain and use the data sources?

Each mechanism has its own use of metadata. The selected standards should fulfil the needs to carry out services using these mechanisms. Metadata is required to provide information about an organisation's data holdings. Data resources are a major national asset, and information of what datasets exist within different organisations, particularly in the public sector, is required to improve efficiencies and reduce data duplication. Data catalogues and data discovery services enable potential users to find, evaluate and use that data, thereby increasing its value. This is also becoming important at the European level. In addition, metadata received from an external source requires further information supplied by metadata in order to process and interpret it.

2.4.2. Metadata and Catalogue Standards

The International Organisation for Standardisation (ISO) includes ISO/TC 2112, which is an international, technical committee for geographic information. TC 211 has created a strong, globally implemented set of standards for geospatial metadata: the baseline ISO 19115; ISO 19139 for implementation of data metadata and the ISO 19119 for services metadata.

These open standards define the structure and content of metadata records and are essential for any catalogue implementation.

— ISO 19115: describes all aspects of geospatial metadata and provides a comprehensive set of metadata elements. It is designed for electronic metadata services, and the elements are designed to be searchable wherever possible. It is widely used as the basis for geospatial metadata services. However, because of the large number of metadata elements and the complexity of its data model, it is difficult to implement.

The INSPIRE DIRECTIVE applies these standards and specifications in its implementation. Within the PEGASO project the standard ISO metadata 19115/19139 (for data) and 19119 (for services) application schemas will be used.

2.4.3. Catalogue services

A Metadata Catalogue Service is a mechanism for storing and accessing descriptive metadata and allows users to query, for data items based on desired attribute, the catalogue service that stores descriptive information (metadata) about logical data items.
The Open Geospatial Consortium (OGC) has created the Catalogue Service for Web (CS-W) standard to enable discovery from a catalogue node.

Catalogue services support the ability to publish and search metadata for data, services, and related information. Metadata in catalogues can be queried and presented for evaluation and further processing by both humans and software. Catalogue services are required to support the discovery and binding to published web map services.

The CS-W standard is extremely rich. In addition to supporting a query from a user, it can support distributed queries (one query that searches many catalogues) and the harvesting of metadata from node to node.

Example: http://www.inspire-geoportal.eu/index.cfm/pageid/321

2.6. GIS functionalities

A GIS gives the ability to merge different existing information from different sources, facilitating collaboration for creating and analyzing data. Due to these new possibilities of reusing existing data and working on collaboratively greater scale, new challenges arise.

When someone wishes to create a new information layer based on different data sets or different formats, with different terminology, and perhaps different projection, it is quite difficult to bring them together. Harmonizing geodata is a complex, costly and time-consuming task, but could be achieved by agreeing among data capturers before the work begins.

The growing recognition that once a geodata set has been created it could be used for public and private sectors (Ryttersgaard, 2001), reinforces the need to store data into databases that are made accessible for different purposes (Philips et al., 1999). This leads to the concept that geodata could be a shared resource, which will be maintained continuously.

As a result of the previous considerations, the concept of the SDI was developed in order to facilitate and coordinate the exchange and sharing of geospatial data (Rajabifard and Williamson, 2001), encompassing the data sources, systems, network linkages, standards and institutional issues involved in delivering geodata and information from many different sources to the widest possible group of potential users (Coleman et al., 1998).
The vision of an SDI incorporates different databases, ranging from the local to the national, into an integrated information highway and constitutes a framework, needed by a community, in order to make effective use of geospatial data (UNECA, 2005).

Different web applications may be part of the services offered by an SDI, similar to most used and know functionalities that are common in any GIS software (thematic maps, buffering, spatial analysis, etc). Some services providers can also offer other GIS functionalities as Web Processing Services (WPS). These types of services are growing fastly in the SDI domain.

2.7. Downloading of data

A key outcome of SDI is that geospatial data become more easily accessed. It is important to understand the traditional workflow involved in using geospatial data in order to appreciate why this outcome offers considerable efficiencies.

A GIS user or business system traditionally receives geospatial data as a file on a DVD or other media. In order to use any of that geospatial data, the whole file has to be loaded onto the user's system. One of the characteristics of spatial information is that it tends to be voluminous so this could involve the transfer of several Gigabytes of data. Moreover, the data may have to be translated from the supplier's format into a format understood by the user's system. This can be a time-consuming, processor-hungry activity.

From this, it can be seen that a file download (using a mechanism such as file transfer protocol) offers little advantage over DVD delivery. Indeed, from an ICT perspective, the surge in bandwidth required to download whole files of geospatial information can be seen as a significant disadvantage.

Using a current web services approach, the GIS user or business system can directly connect to the service and thus directly consume the content into their system. This offers a number of advantages. Perhaps most important is that there is no precursor to using the data which offers the opportunity for the GIS or business system to be used more directly as a tool; the effectiveness is improved. In systems terms, the user is able to access just the extent of data required to conduct their task. This reduces processing and bandwidth terms; the efficiency is improved.

The Open Geospatial Organization (OGC) has worked for many years to establish a range of open standards for the web service delivery of spatial content. A wide range of rich standards are available for use.

In particular, the OGC WFS (Web Feature Service) is the standard service which allow to download vector data from any standard Web Map Server, while OGC WCS (Web Coverage Service) is the preferred standard service to deliver raster data. Environmental analysis are usually performed using raster data (e.g. Salinity, Temperatures, and even Habitats or Land cover layers are usually preferred in raster format for analysis purposes

Web Map Service (WMS)
OGC Web Map Service Specification: http://www.opengeospatial.org/standards/wms

The Web Map Service defines an interface that allows a client to retrieve maps of georeferenced data. In WMS context, a map means a graphical representation (jpeg, gif or png files) of a geospatial data meaning that a WMS service does not give access to the data itself. It is used for mapping purposes and can be combined with other WMS services.

Web Feature Service (WFS)
OGC Web Feature Service specification: http://www.opengeospatial.org/standards/wfs

The Web Feature Service defines an interface that allows a client to retrieve and update features of georeferenced data).
The main difference between WMS and WFS is that WFS gives direct access to the geometry and the attributes of a selected geospatial data, meaning that a user can work with a dataset provided by WFS. In brief, the WFS is the specification to access vector datasets.

Web Coverage Service (WCS)
OGC Web Coverage Service specification: http://www.opengeospatial.org/standards/wcs

Like the WFS allows a client to access vector datasets, the Web Coverage Service allows a client to access raster datasets. By rasters we mean data that are represented as a matrix of cells in continuous space organized in rows and columns where each cells contains a value. Thus WCS service provide access to different types of gridded data such as Digital Elevation Model (DEM), remote sensing imagery, etc... It must be noted that WCS gives only access to the raw data and does not have transactional capabilities.

2.8. Interoperability

Interoperability is “the ability of a system or a product to work with other systems or products without special effort on the part of the customer” (OGC, 2004). This means that two or more systems or components are able to transmit or exchange information through a common system and to use the information that has been exchanged. Another definition is: “The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units [ISO 19118]”.

When systems are interoperable, they enable users to:

- find what they need,
- access it,
- understand and use it,
- have goods and services responsive to their needs

There are two types of interoperability (OGC, 2004):

- syntactic (or technical): when two or more systems are capable of communicating and exchanging data, they are exhibiting syntactic interoperability. Specified data formats and communication protocols are fundamental. In general, XML or SQL standards provide syntactic interoperability. Syntactical interoperability is required for any attempts of further interoperability.
- semantic: beyond the ability of two or more computer systems to exchange information, semantic interoperability is the ability to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of both systems. To achieve semantic interoperability, both sides must refer to a common information exchange reference model. The contents of the information exchange requests are unambiguously defined: what is sent is the same as what is understood (i.e. explaining why INSPIRE is producing data specifications).

Services play an essential role in the use of SDI. The selection, presentation, transformation and integration of data are all done by services. A service is a component with a standardized task that communicates by a standardized interface. A simple service is the presentation of a spatial dataset on a standardized way. Services can also be combined to form a new service. This is called service chaining. For the description of a service the ISO 19119 standard is used (service metadata). The OGC has been active in the formulation of implementation specifications for services.

SUMMARY

- Most of the partners will contribute as geonodes, offering accessibility to their WMS/WCS/WFS Services containing their geo-information. They will create metadata that will be stored in other local Catalogues, in their own Catalogues or in the Global Catalogue (PEGASO).

- Some partners will set up geoportals, meaning a website offering a Web Client to visualize and download their geo-data, and accessing to other external geo-data. They will create metadata which will be stored in their own local Catalogue or in the Global Catalogue.

- Some partners can already offer a functional SDI, and some other would build new ones within the project, with the components described before.

- The PEGASO project will offer a Global SDI, gathering the contributions of all the partners and complementing them with several services and applications already available, as a basic component of the ICZM governance platform.

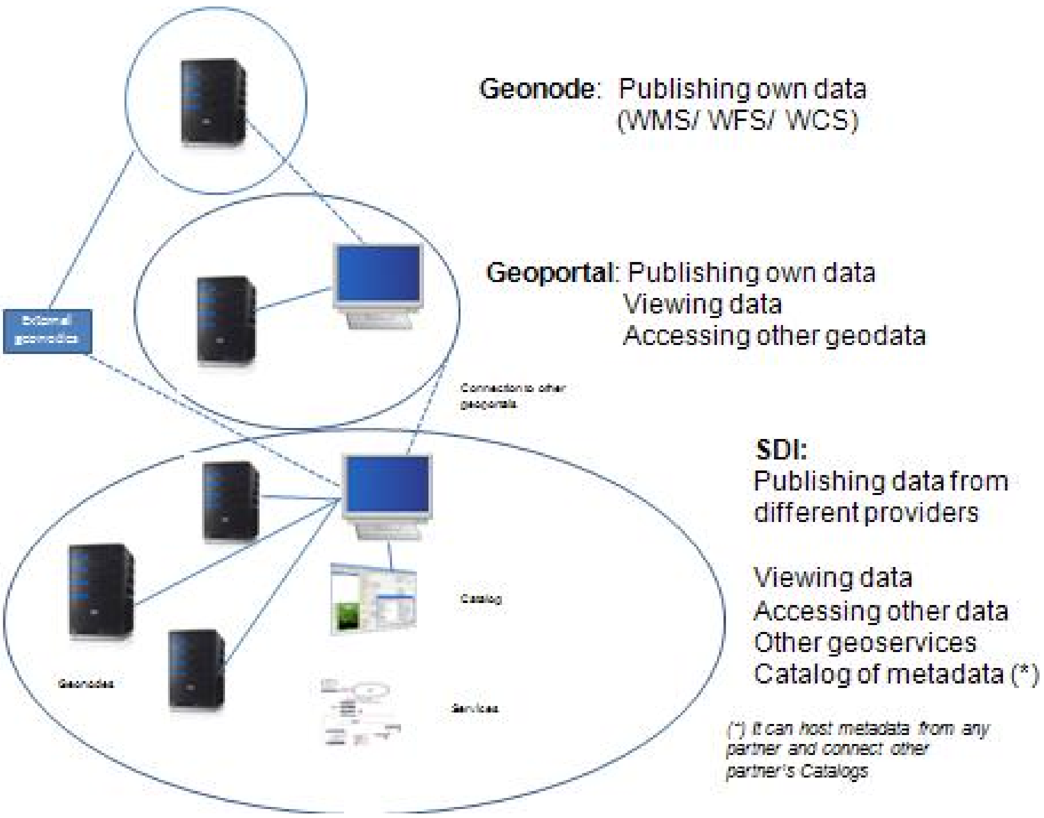

Figure 1. PEGASO SDI structure

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