Methodological approach for the development of an Algerian NSDI according to international standards (ISO, W3C, OGC, OMG) enriched by a spatial dictionary adapted

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Abstract. The establishment of a National Spatial Data Infrastructure represent significant added value as leader initiative, to facilitate access to spatial data beyond the boundaries between organizations (public and private); ensure the diffusion and promotion of geographic information; sharing of expertise; acquisition and provision of geographic products and databases; the identification of existing spatial data and metadata; and improving accessibility and interoperability ...etc.
Beyond the inescapable statutory definition, this approach is part of a dynamic pooling, which will have a significant impact on the way will be used geographic information systems identified within the producer organisms of geospatial data.
The National Institute of Cartography and Remote Sensing (INCT) as the largest producer of Geographic Information in Algeria, has initiated a national reflection around the NSDI through the organization of the first National Conference in October 2012. Many recommendations were adopted, of which the necessity of establishing a National Spatial Data Infrastructure was strongly solicited.
To consolidate this initiative, an ambitious project on the definition of a methodological approach of the development of Algerian NSDI, was recently launched and registered as a research project in the INCT. This research presents the results of works on the definition of a methodological approach for the development of a NSDI according to international standards (ISO, W3C, OGC, OMG) enriched by a space dictionary adapted and the establishment of a geoportal around the open source software as (Easy SDI, Geoserver and Geonetwork).
The work was carried out in two phases: the first phase is to understand the anatomy of the SDI and adapted it by creating an Algerian profile based on an architecture which defines a full life cycle of a project including all phases and activities according the unified process (openUP) using the metamodel SPEM (Software Process Systems & Engineering Metamodel) and UML. The second phase has led to the development of an application using Open source software.

Keywords: INCT, ISO19115, NSDI of Algeria, Opensource, SPEM, openUP

1. Introduction

Nowadays several projects of Spatial Data Infrastructure (SDI) emerge at different territorial levels. These initiatives facilitate the exchange and use of geographic information in a perspective of knowledge and sharing.

The establishment of a spatial data infrastructure represents an added value to facilitate access to spatial data across the borders of organizations.

This solution guarantees:

- The inventory of existing spatial data and the improvement of accessibility and interoperability;

- The dissemination and promotion of geographic information;
- The sharing of know-how;

1. components

A geospatial data infrastructure includes spatial data sets, metadata, and network services that enable research, evaluation, visualization, and judicious use of shared data.

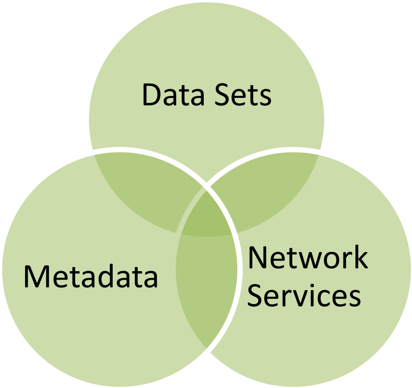

Figure 1. Components of an SDI

Figure 2 provides a simplified overview of the key elements of the technical architecture of a SDI. Being the central resource content (Spatial Dataset), ie geospatial data available as datasets. All other resources shown, like metadata, is only necessary to find, access, interpret and use objects in spatial datasets as part of the infrastructure [INSPIRE 2007].

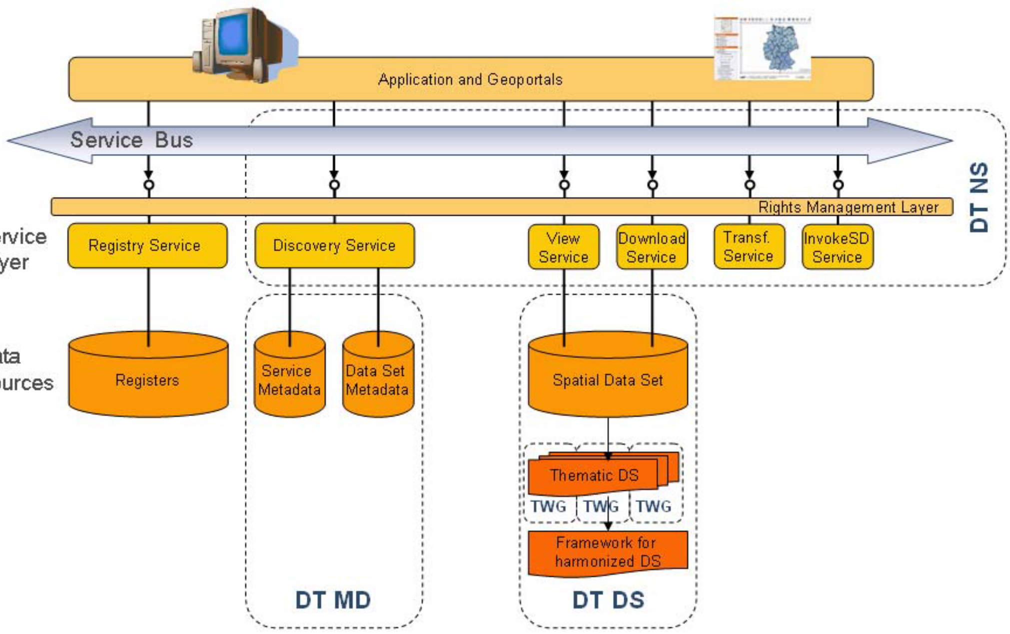

Figure 2. Technical architecture diagram of a SDI [INSPIRE 2007]

1.2. Datasets

In a data set each spatial object must be described by specifications defining its semantics and characteristics. The types of spatial objects provide their classification, and determine all other properties (thematic, spatial, temporal, etc ...) that any spatial object may have, as well as a number of known constraints. In principle, this information is captured in an application schema conforms to the specifications of the [ISO19109] standard and formalized in a conceptual schema using the [OMG / UML] notation.

The technical specifications of the datasets are prepared in accordance with [ISO19131] and [ISO19131/Amd1].

1.3. Network Services

Network services are necessary for sharing spatial data between stakeholders in a SDI. Therefore, the interoperability problems must be defined in advance to allow services to interact without repetitive manual intervention.

To achieve this goal, the technical specifications of the SDI's network services must define the interfaces by which different parts of the infrastructure will communicate. In principle, this is done by a conceptual schema, defining a web service, conforms to the specifications of the W3C/WSDL [WSDL 2.0] and the [ISO19119] standards and using the [OMG / UML] notation.

1.4. Metadata

Metadata provide information necessary to discover and spatial data sets they describe.

In addition, the metadata service provides basic information about a service instance. The service description includes the type of service, a description of the operations and their parameters as well as information on the geographic data available.

The technical specifications are formalized as a metadata profile derived from the [ISO19115] and [ISO19119/Amd1] standards in a conceptual schema using the [OMG / UML] notation.

1.5. Process model selection

1.5.1. classification of processes

A process is a sequence of tasks and activities designed for the development of a software intensive system. To choose the appropriate process model we have to compare the features of the current project with the characteristics of different process models and choose the most appropriate one. Table-1 lists the characteristics of projects by combining them to a well known process models.

	Agile	Plan- Driven
Features [Booch et al. 2007]	- Project is small (5–10 people). - Experienced teams with a wide range of abilities and skills take part. - Teams are self-starters, independent leaders, and others who are self-directing. - Project is an in-house project, and the team is co-located. - System is new, with lots of unknowns. - Requirements must be discovered. - Requirements and environment are volatile, with high change rates. - End-user environment is flexible. - Relationship with customer is close and collaborative. - Customer is readily available, dedicated, and co-located.	- Project is large (more than 10 people). - Teams include varied capabilities and skill sets. - Teams are geographically distributed and/or outsourced. - Project is of strategic importance (e.g., an enterprise initiative); scope crosses the organization. - System is well understood, with a familiar scope and feature set. - Requirements are fairly stable (low change rates) and can be determined in advance. - System is large and complex, with critical safety or high reliability requirements. - Project stakeholders have a weak relationship with the development team. - External legal concerns (e.g., contracts, liability,

	- High trust environment exists within the development teams, between the development teams, and with the customer. - Rapid value and high-responsiveness are required.	formal certification against specific industry standards) exist - Focus is on strong, quantitative process improvement. - Definition and management of process are important. - Predictability and stability of process are important.
Examples	- eXtreme Programming (XP) - Scrum - DSDM - OpenUP	- Personal Software Process (PSP) - Team Software Process (TSP) - Rational Unified Process (RUP) - Source [Wikiversity.org, 2012]

Table 1. Agile and Plan-Driven Project Characteristics

Given the foregoing, we considered that the use of an agile model, especially OpenUP, is most suitable for the definition of a Geospatial Data Infrastructure development process, object of this work.

1.5.2. OpenUP

OpenUP is an agile development process, minimal and sufficient, containing a core set of best practices. It applies the phases of the Rational Unified Process (Inception, Elaboration, Construction, and Transition). Figure 3 illustrates the sequence of the OpenUP delivery process. [Balduino 2007]

In addition, OpenUP is extensible, and serves as a base process upon which additional process content can be built.

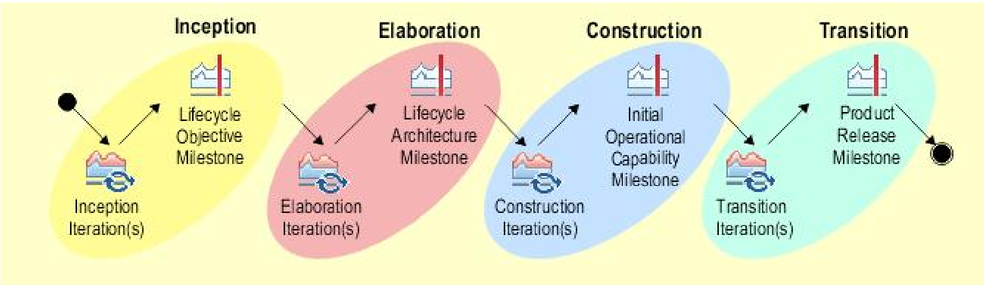

Figure 3. OpenUP delivery process [Balduino 2007]

2. Definition of the IDGProcess

The development process IDGProcess, defined in the context of this work has been formalized in an [OMG/SPEM] notation, taking into consideration all the specifications issued by ISO / TC 211, OGC and W3C.

The life cycle of the various components of a geospatial data infrastructure, including data, metadata and services, was highlighted in the process with, for each phase, the detailed definition of the tasks to be performed.

2.1. Inception

The inception phase is used to initiate the project and to identify its requirements. It aims to understand the main needs (what will be built), the identification of the key features of the system, determining at least one possible solution as well as the analysis of cost, time and risk associated with the project.

Figure 4 below shows the tasks proposed for the IDGProcess inception Phase.

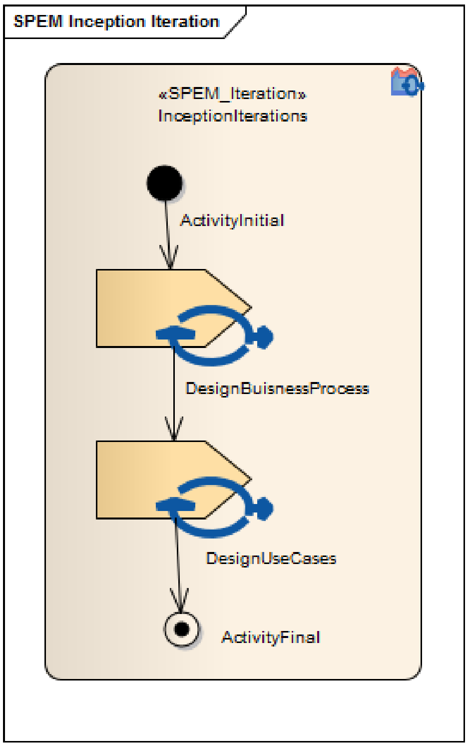

Figure 4. Inception Iteration - SPEM Diagram

Phase "inception" includes two tasks namely:
- Design BPMN diagrams.
- Design use case diagrams.

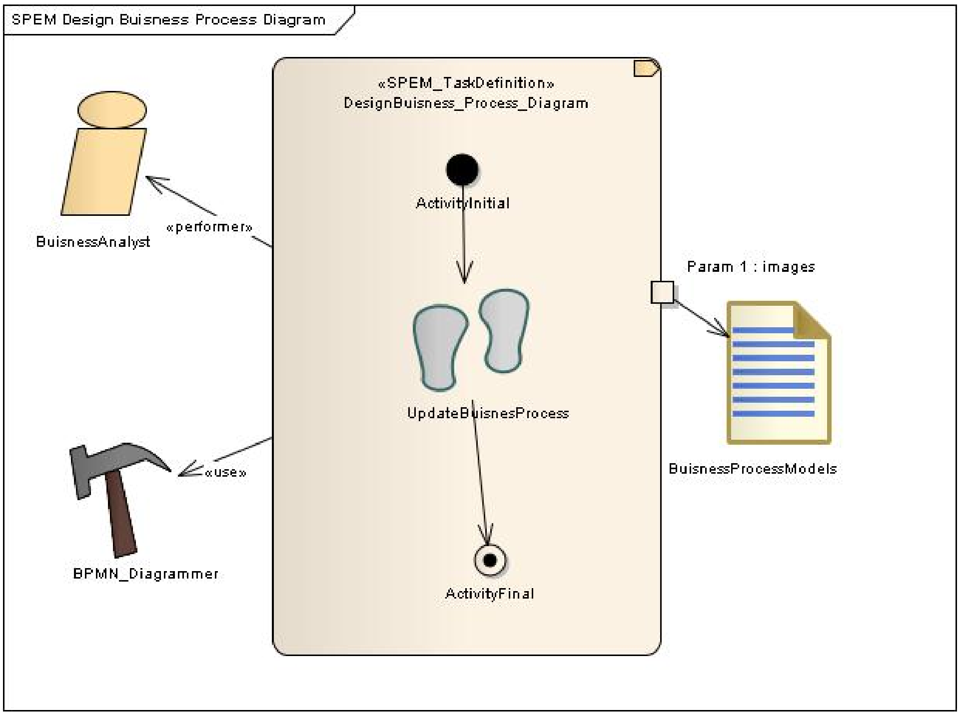

Figure 5. Inception Iteration “Design business process diagram”- SPEM Diagram

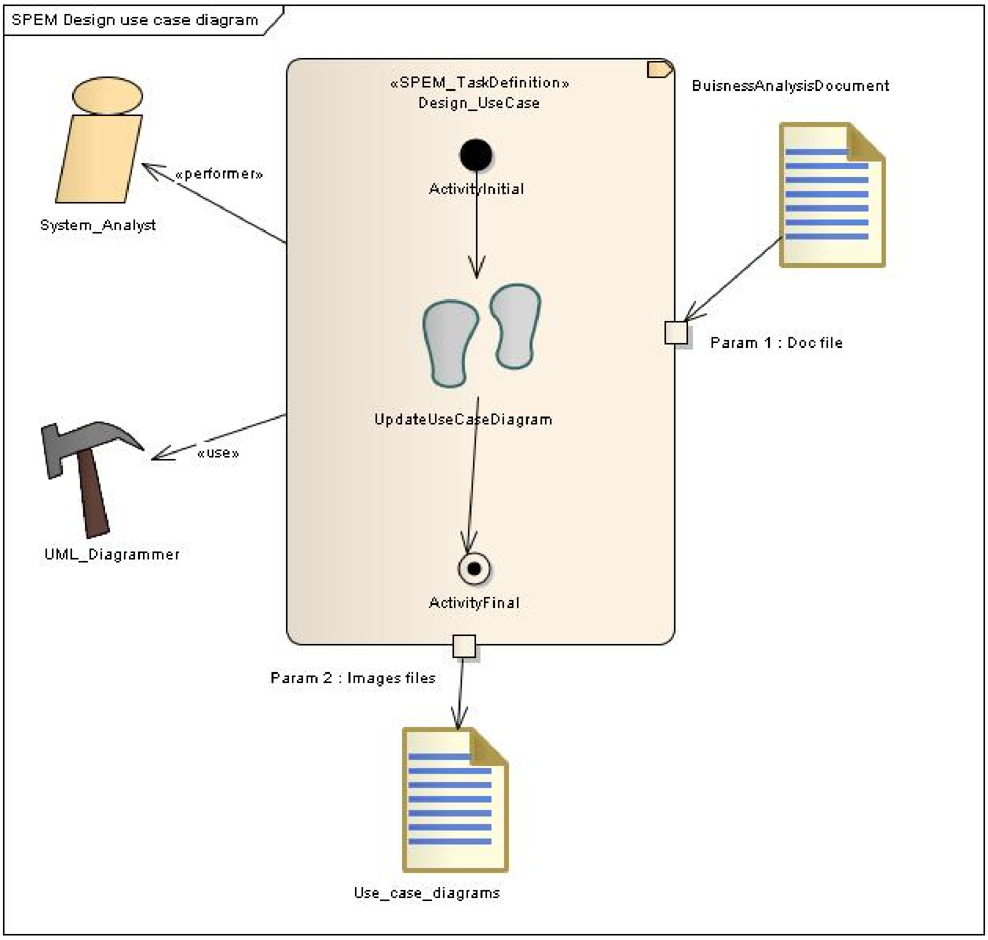

Figure 6. Inception iteration "Use case diagram" - SPEM diagram

2.2. Elaboration

The elaboration accurately identifies the system requirements and defines its architecture. A preliminary solution is developed and tested at this stage. At the end of this phase, project managers must be able to plan activities and to estimate the resources required to complete the project.

The objectives of this phase are:

- Develop a more detailed understanding of the requirements;
- Design, implement, validate, and test a basic architecture;
- Mitigate essential risks, and produce a clear timetable estimate costs.

Figure 7 below shows the tasks proposed for the IDGProcess Elaboration phase.

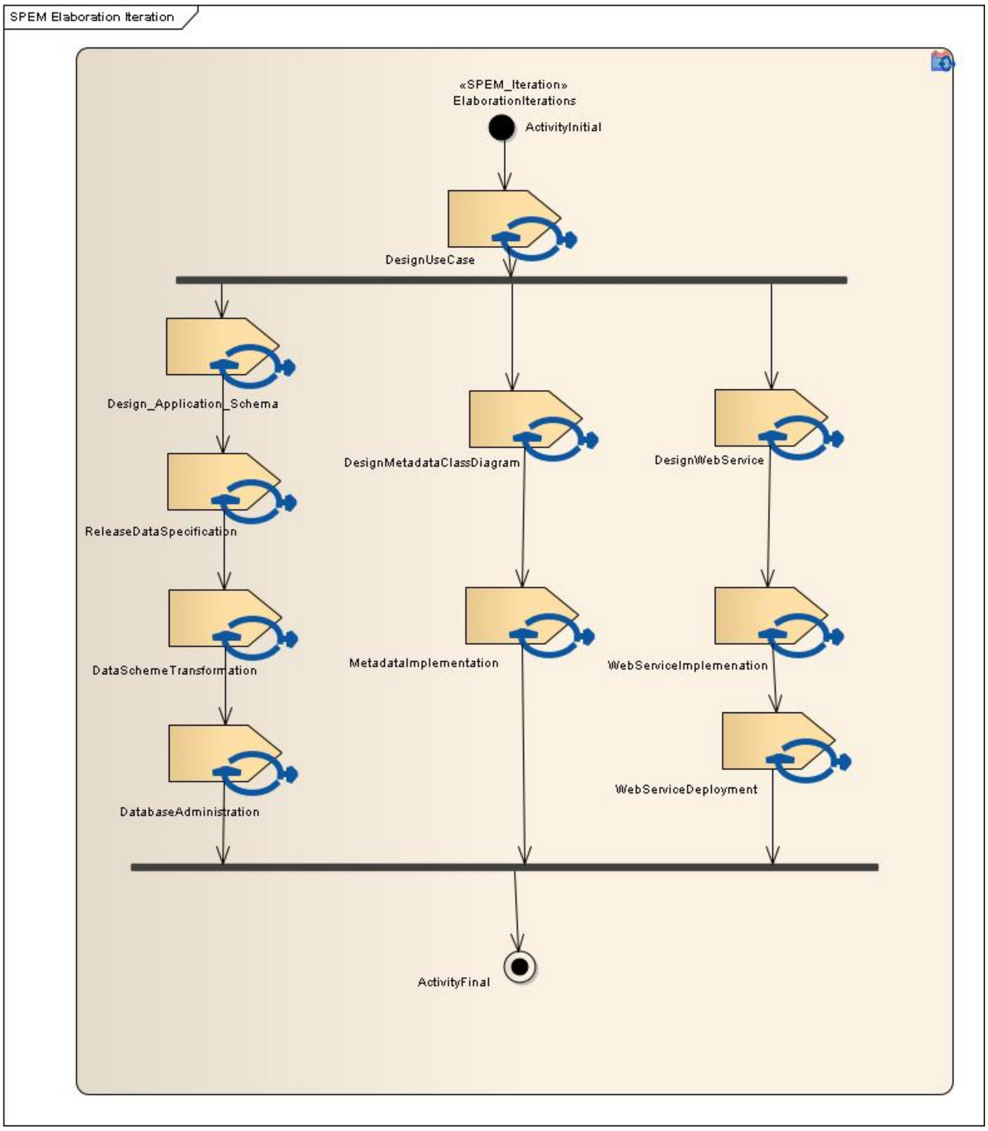

Figure 7. Elaboration iteration - SPEM diagram

The "elaboration" Phase includes several tasks divided into three parallel lines, each one representing a component of the SDI to develop, namely the data, metadata and services.

The main tasks of this phase are:

1. The data:

- Design the ISO19109 conformant application schemas;

- Release the ISO19131 conformant data specifications;

- Transform the application schemas to implementable data models (object oriented, relational or xml);

- Administrate the implemented database and test some data.

2. The metadata:

- Design the [ISO19115] and [ISO19119/Amd1] conformant class diagrams of the Metadata profile;

- Implement the metadata profile in the chosen geo-catalog.

3. The services:

- Design the W3C/WSDL and [ISO19119] conformant class diagrams of the web services;

- Implement the web services with the chosen programming language;
- Deploy the web services on the application server.

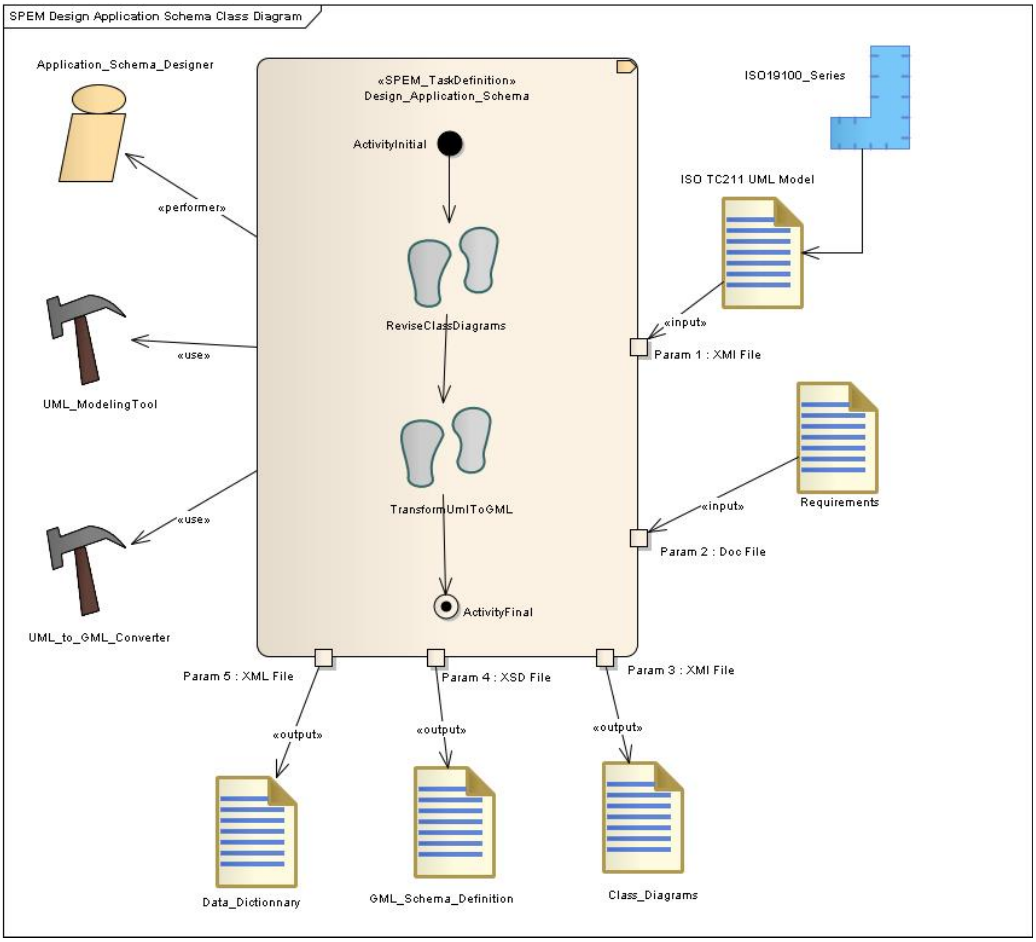

Figure 8. Elaboration Iteration “Design application schema diagram” - SPEM Diagram

The figure below illustrates the process adopted for the preparation of the data specification document for external use.

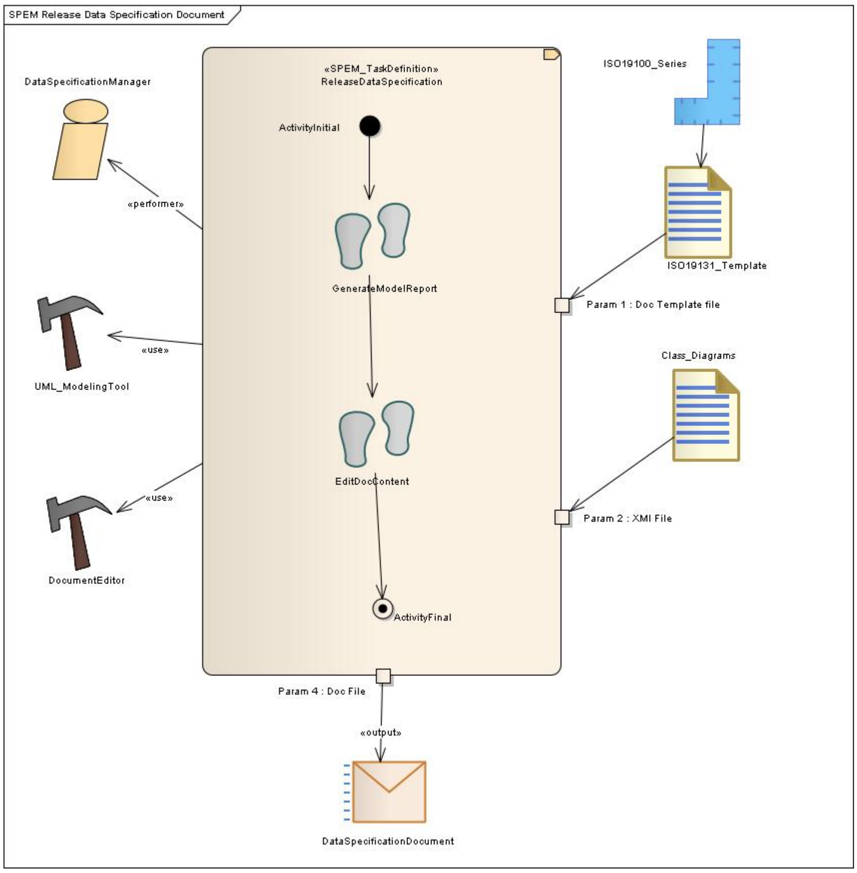

Figure 9. Elaboration Iteration “Release data specifications document” - SPEM Diagram

The figure below illustrates the process adopted for the administration of the databases.

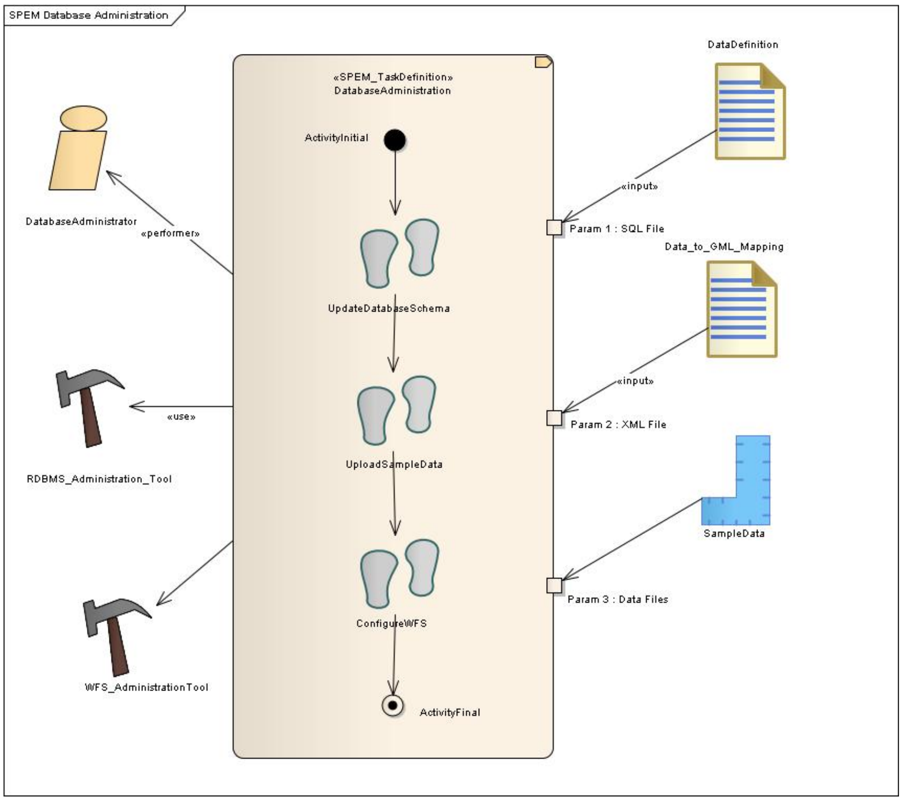

Figure 10. Elaboration Iteration “Data Base Administration” - SPEM Diagram

The figure below illustrates the process used to develop the metadata XML schema (XSD).

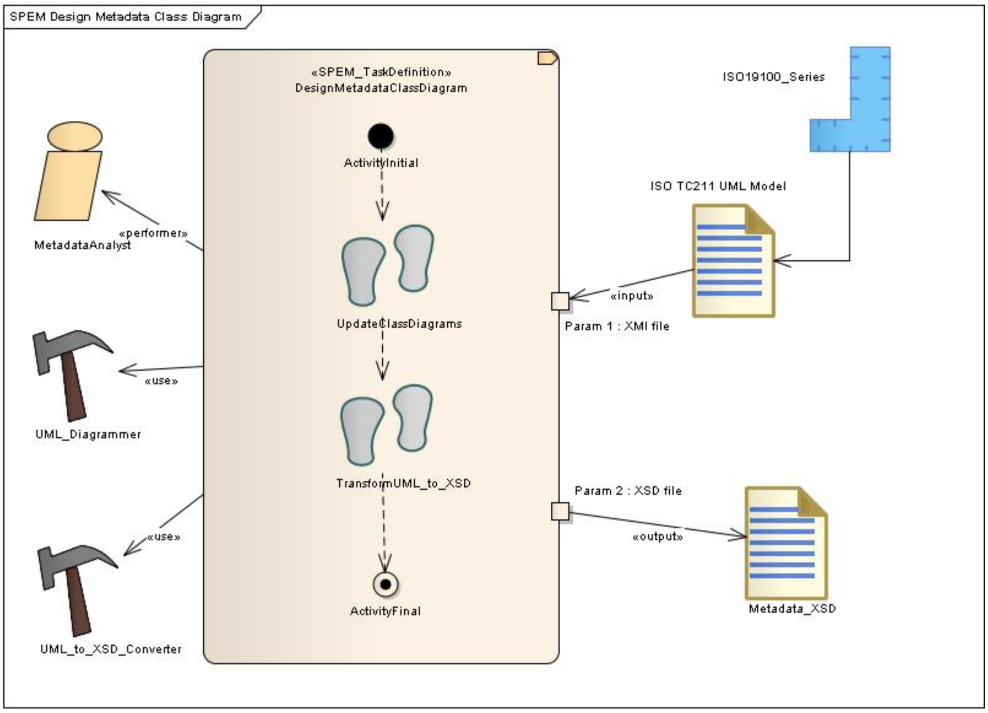

Figure 11. Elaboration Iteration “Design metadata class diagram” - SPEM Diagram

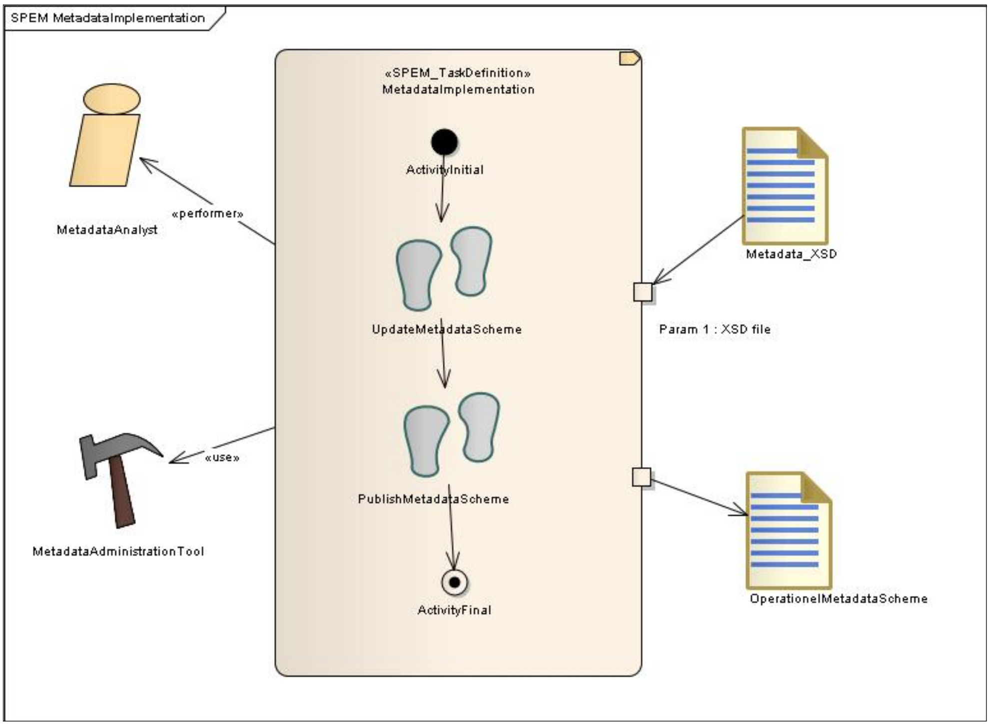

Figure 12. Elaboration Iteration “Metadata implementation” - SPEM Diagram

The figure below illustrates the process adopted for the development of web services specifications according to the W3C standards.

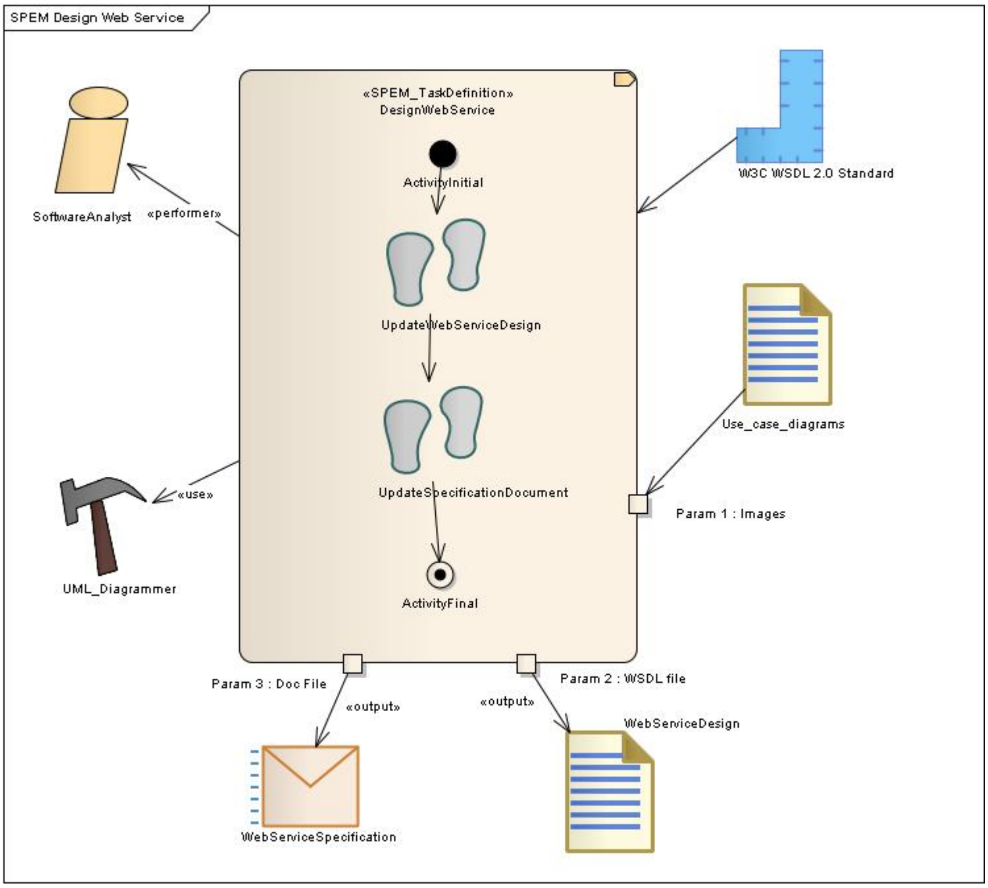

Figure 13. Elaboration Iteration “Design web Service” - SPEM Diagram

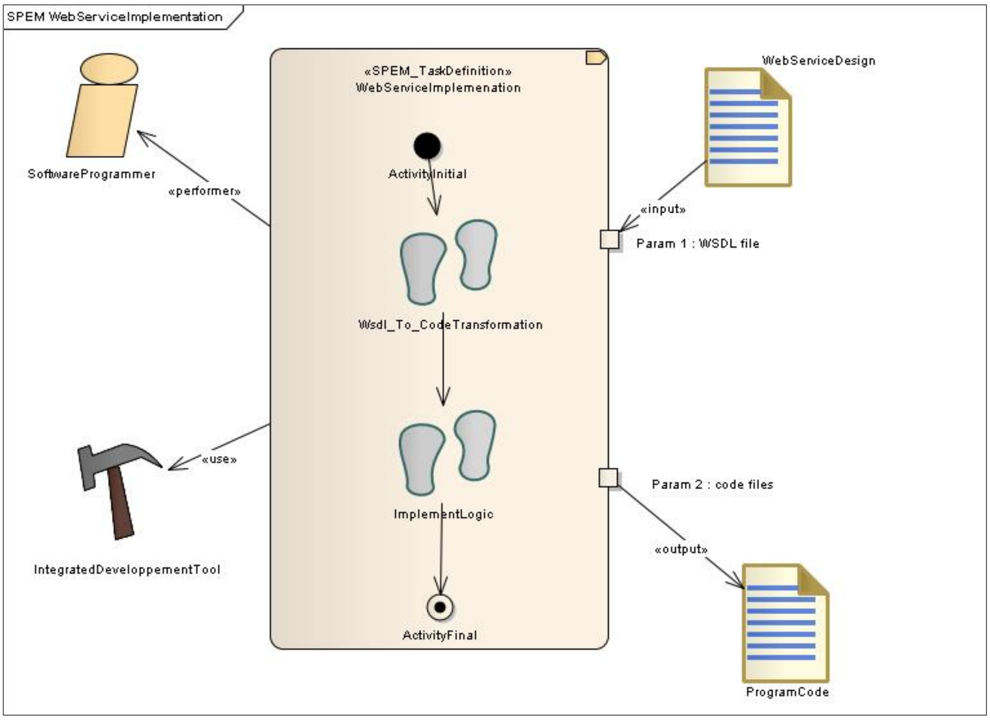

Figure 14. Elaboration Iteration “Webs service implementation” - SPEM Diagram

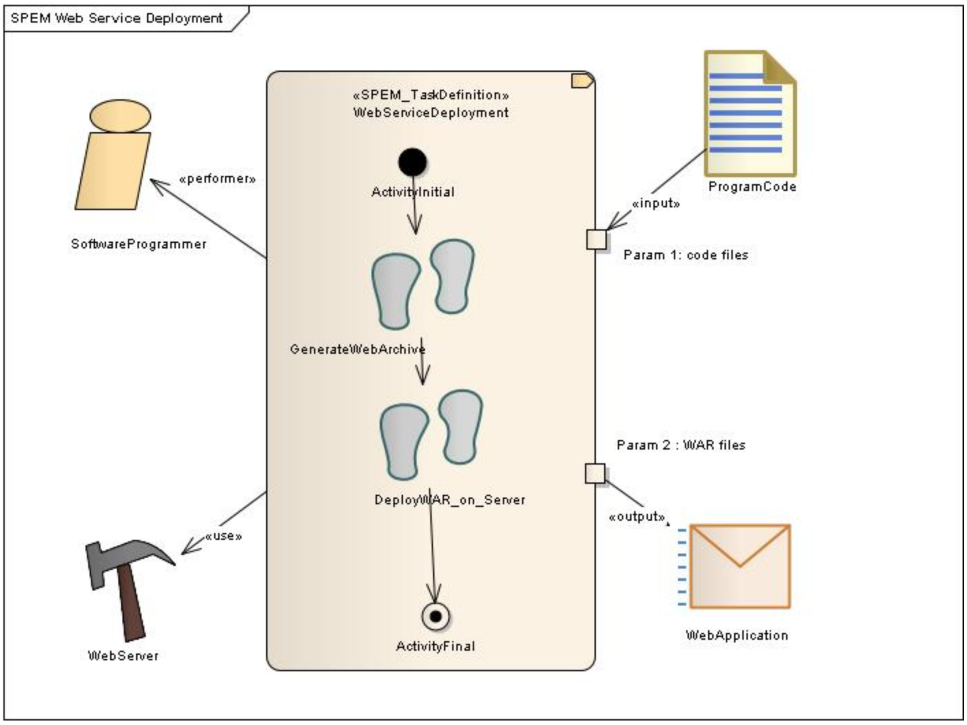

Figure 15. Elaboration Iteration “Webs service deployment” - SPEM Diagram

2.3. Construction

The construction phase allows the effective achievement of the proposed system. The objective is to iteratively develop a complete product ready to be transferred to the client.
Figure 16 below shows the proposed tasks of the construction phase of SDI Process.

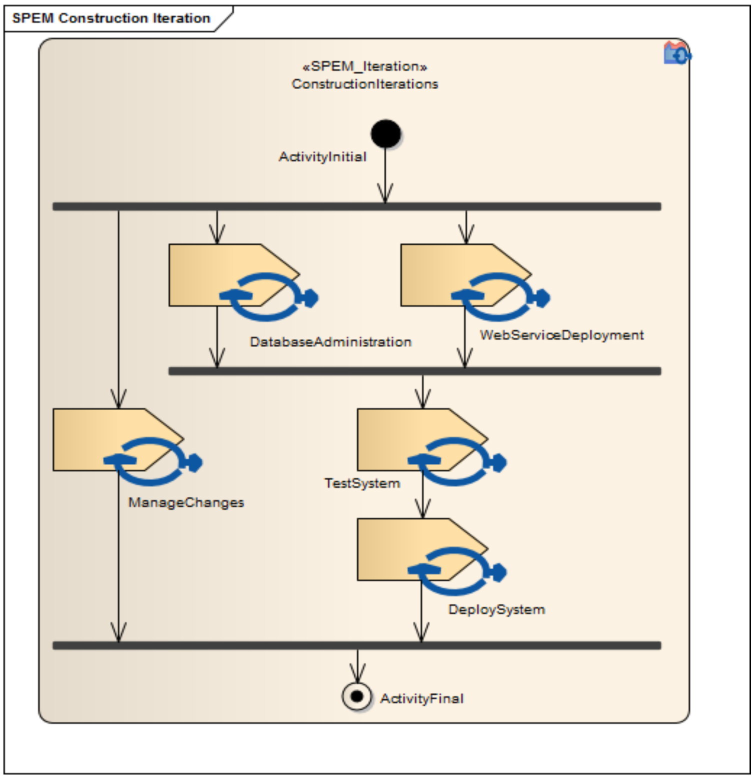

Figure 16. Construction iteration - SPEM diagram

The figure below illustrates the process proposed to test the various system components.

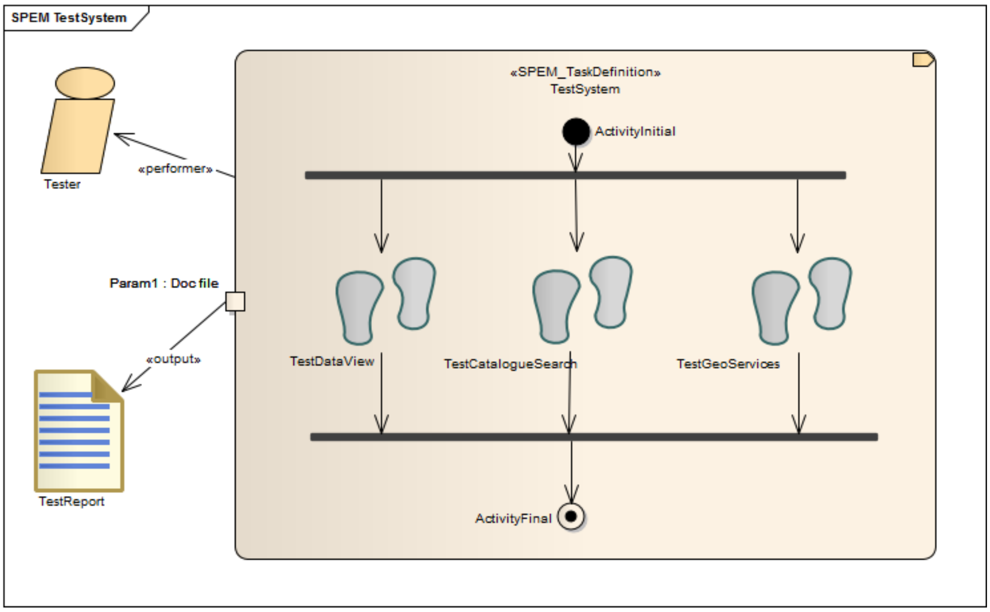

Figure 17. Construction Iteration “Test system” - SPEM Diagram

The figure below illustrates the process proposed to deploy the various components of the system.

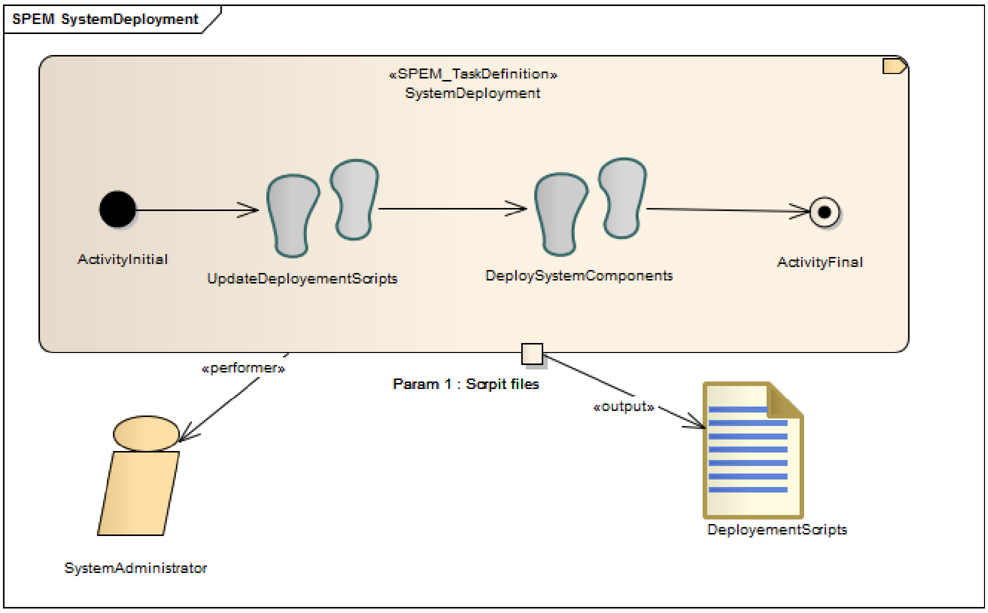

Figure 18. Construction Iteration “System deployment” - SPEM Diagram

The figure below illustrates the process adopted for managing the changes in the development of the system.

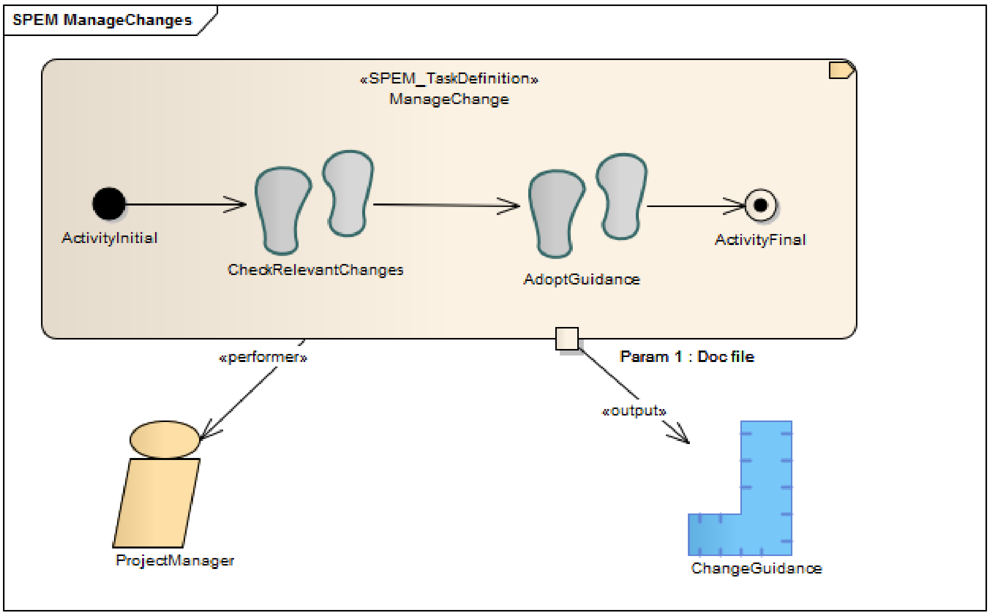

Figure 19. Construction Iteration "Mange Changes" - SPEM Diagram

2.4. Transition

In this phase, tests are performed to validate that the planned objectives have been achieved. At the end of these tests, the stakeholders agree on the completion of the deployment.
Figure 20 below shows the tasks proposed for the IDG Process Transition Phase.

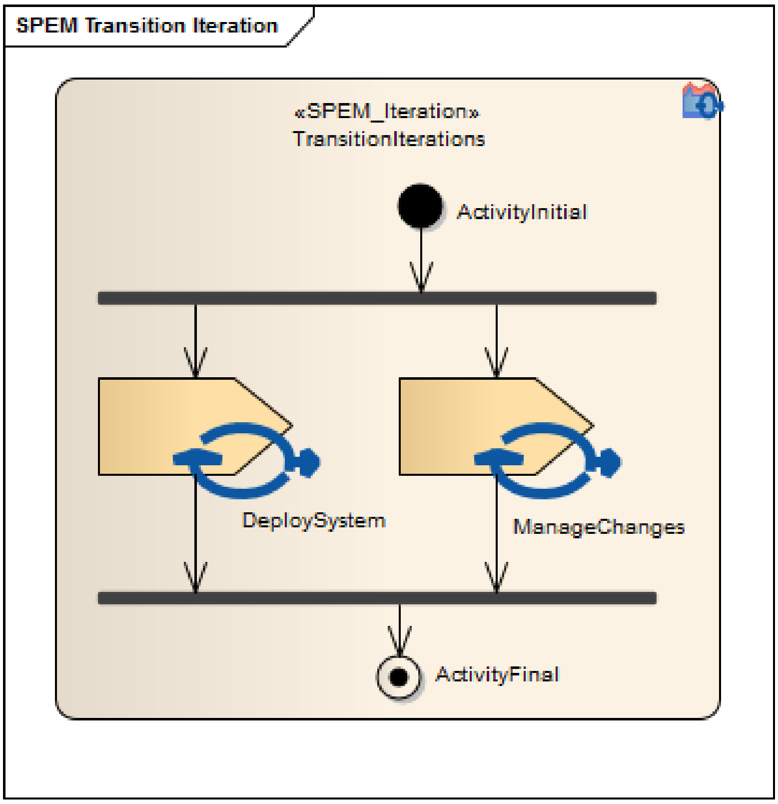

Figure 20. Transition iteration - SPEM diagram

3. Validation

To preliminarily validate the proposed process, a prototype of an Algerian NSDI was developed at the National Institute of Cartography and Remote Sensing (INCT).

This prototype takes the form of a geoportal based on the open community source project EasySDI [EasySDI.org]. It guarantees, among other things, the use of OGC Web Services like WMS and WFS previously published in the structures concerned.

The deployment diagram, component diagram and the use case diagram of the system developed in the pilot project are detailed below.

3.1. Presentation of the urban database

Urban Database contains the main elements providing basic information of the geographical data including: frames, road network, road Node, administrative boundaries and geonames that are characterized by a number of properties.

The Building and the Road Network layers contains attributes of the address and geoname themes. The Structure, the design and the integration of this database is inspired by several urban databases produced by different international organizations such as ISOTC211, INSPIRE, OGC and IGN, taking into account different local needs.

Figure 21 illustrates the package diagram of the Urban Database designed as part of this work.

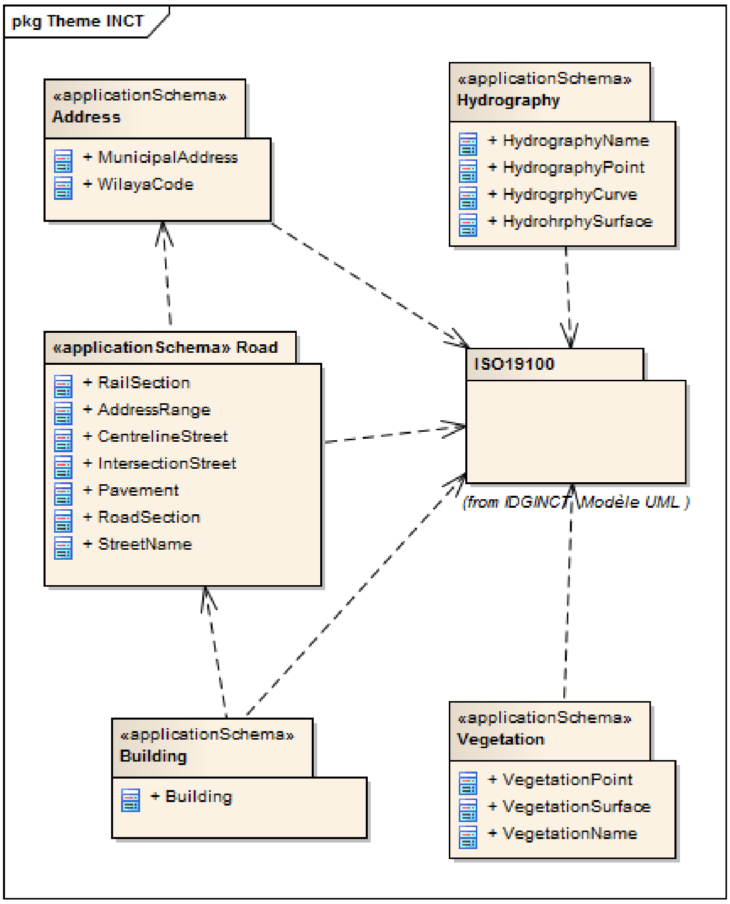

Figure 21. Urban database package diagram

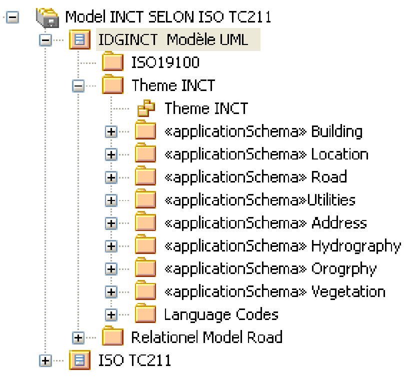

Figure 22. Arborescence model of the application schema

3.2. Building Class - Example

Figure 23 illustrates the class diagram of the Building class designed in the context of this work.

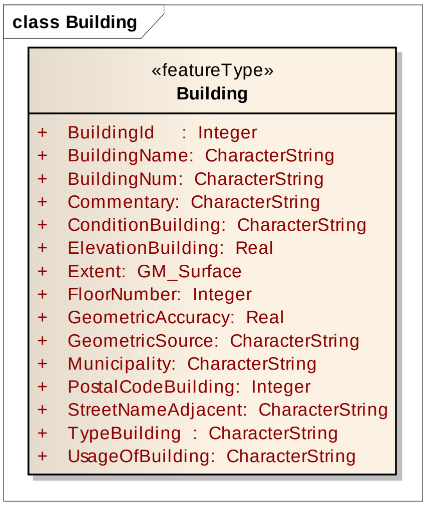

Figure 23. Building class diagram

Stereotype: featureType

Model Element: class

Attributes. (BuildingId, BuildingName, BuildingNum, TypeBuilding, PostalCodeBuilding, ElevationBuilding, ConditionBuilding, StreetNameAdjacent, Municipality, UsageofBuilding, GeometricSource, GeometricAccuracy, FloorNumber, Commentary, Extent).

Building spatial dictionary (in French)

Attribut	Description	Type	With	Domain
BuildingId	Identifiant	Integer	6	
BuildingNum	Numéro de bâtiment lié à l'adresse communal	Integer	6	
PostalCodeBuilding	Numéro postal d'acheminement selon la liste officielle	Integer	8	
BuildingName	renseignent sur les noms des bâtiments.	CharacterString		*
ElevationBuilding	renseignent sur la hauteur, la position altimétrique du bâtiment.	Real	10	
ConditionBuilding	Etat de bâti	CharacterString	30	
TypeBuilding	assure la différenciation sémantique des bâtiments. peut prendre les valeurs : Administratif, Industriel, agricole ou commercial, Religieux, Sportif,...etc	CharacterString	50	**
Extent	Géométrie des objets	GM_Surface	(4,2)	
StreetNameAdjacent	Nom de la rue adjacente	CharacterString	50	
Municipality	Nom de la commune selon le découpage administratif	CharacterString	50	
UsageofBuilding	usage pour lequel le bâtiment est prévu : industriel,militaire, par des étrangers	CharacterString		
GeometricSource	Source géométrique précise comment on a récupéré le bâtiment PDV , image satellitaire, levé GPS…..	CharacterString	20	***
GeometricAccuracy	Précision géométrique planimétrique en mètre	Real	(4,2)	****
FloorNumber	Nombre d'étage (-1,-2,R, 1, 2, 3,4…)	Integer		
Commentary	Commentaire portant des informations peuvent être utiles	CharacterString	150	

Table 2. Building spatial dictionary (in French)

Geometry : surface.

3.3. Projected architecture of the Algerian NSDI

The deployment diagram in Figure 24 shows the overall architecture of the Algerian NSDI and precisely expresses the prototype developed. Other actors of the future national infrastructure will be integrated as soon as they set up their own infrastructure, the minimum being the establishment of their respective Geocatalog.

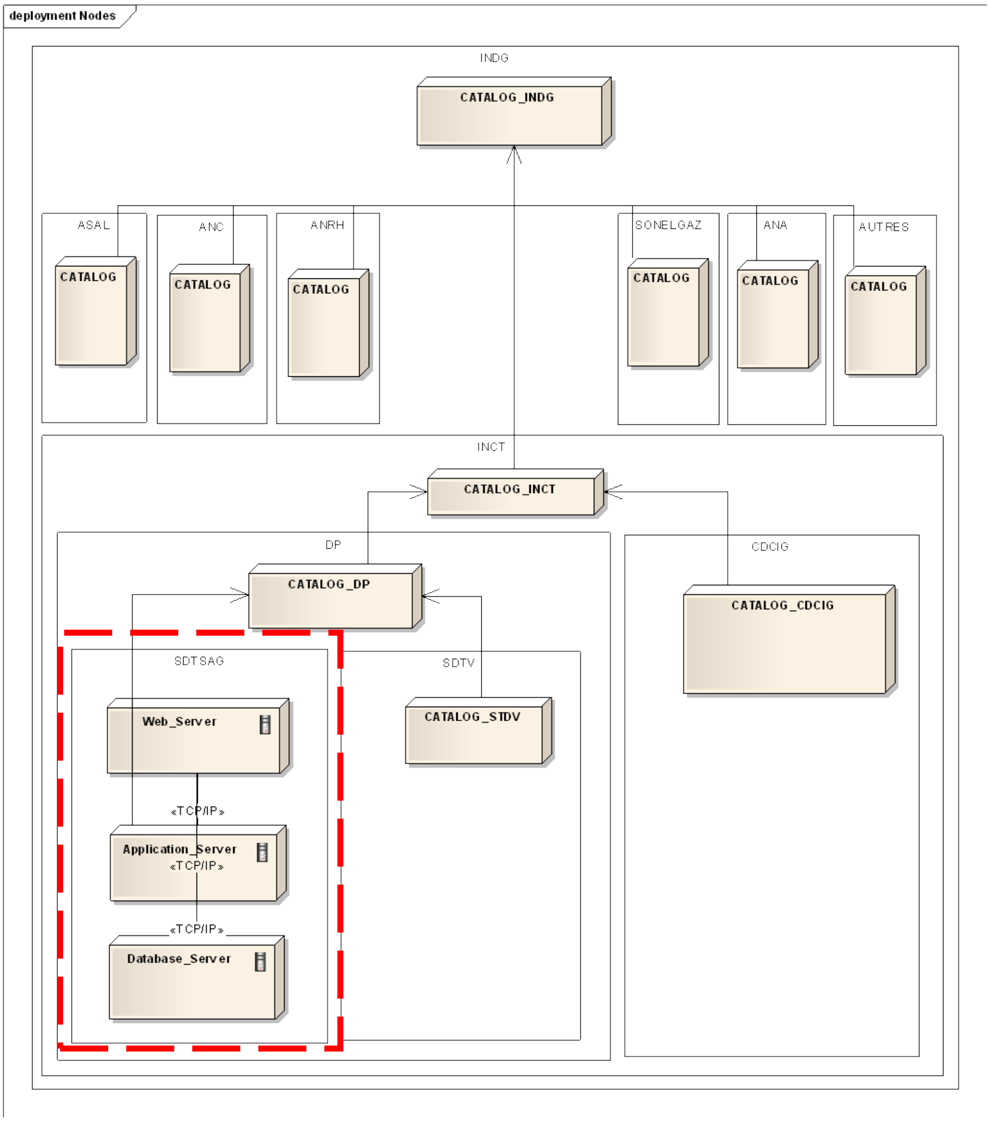

Figure 24. NSDI deployment diagram

Figure 25 illustrates the Primary use case diagram of the Algerian NSDI designed as part of this work.

Figure 25. Primary use case diagram

Figure 26 illustrates an example of a sequence diagram of the Algerian NSDI designed as part of this work.

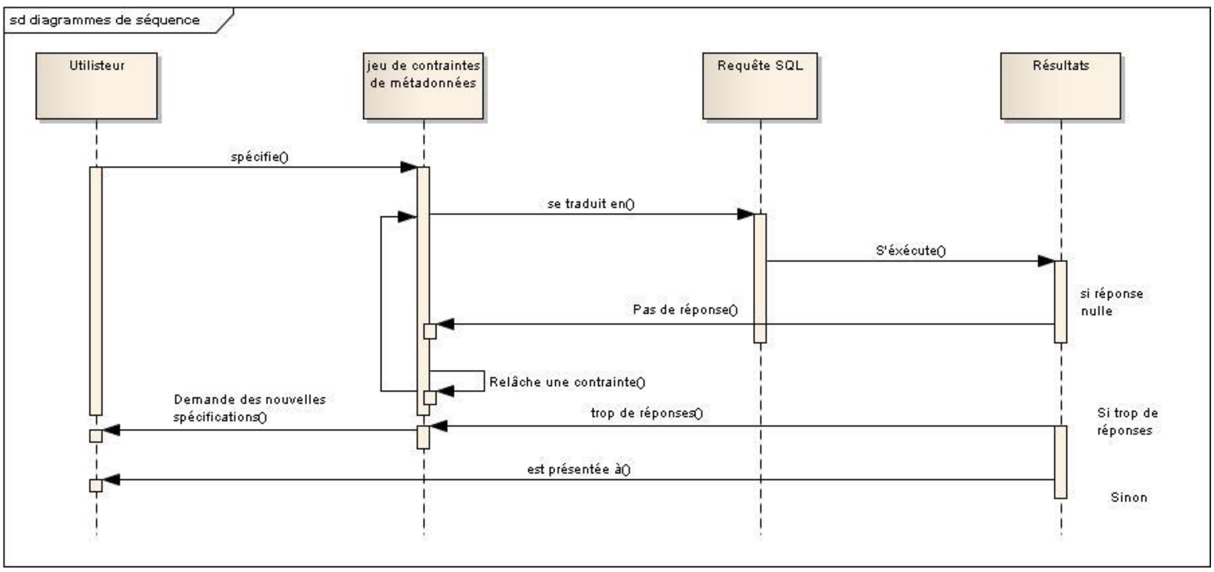

Figure 26. Sequence diagram of server interrogation

Figure 27 illustrates the components diagram of the developed application.

Figure 27. Components diagram of the developed application - interconnections

Figure 28 illustrates the Deployment diagram of the developed application.

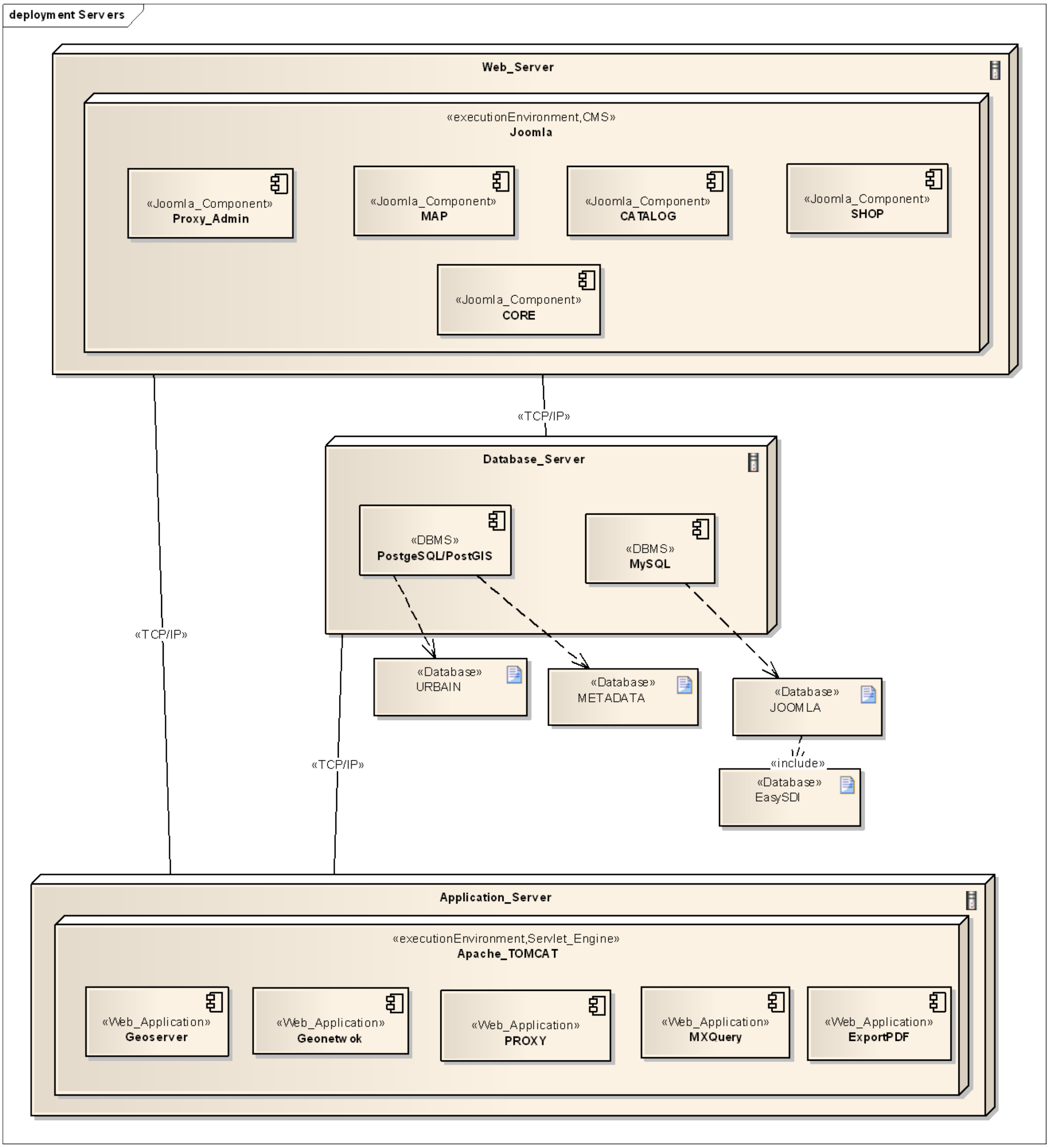

Figure 28. Deployment diagram of the developed application

3.4. User interface

Figure 29 shows the homepage of the geoportal solution implemented with Joomla and EasySDI. This webpage contains a menu allowing access to the webmapping module (Figure 30), geocatalog module (Figure 31) and the shop module (Figure 32).

Figure 29. Homepage of the geoportal

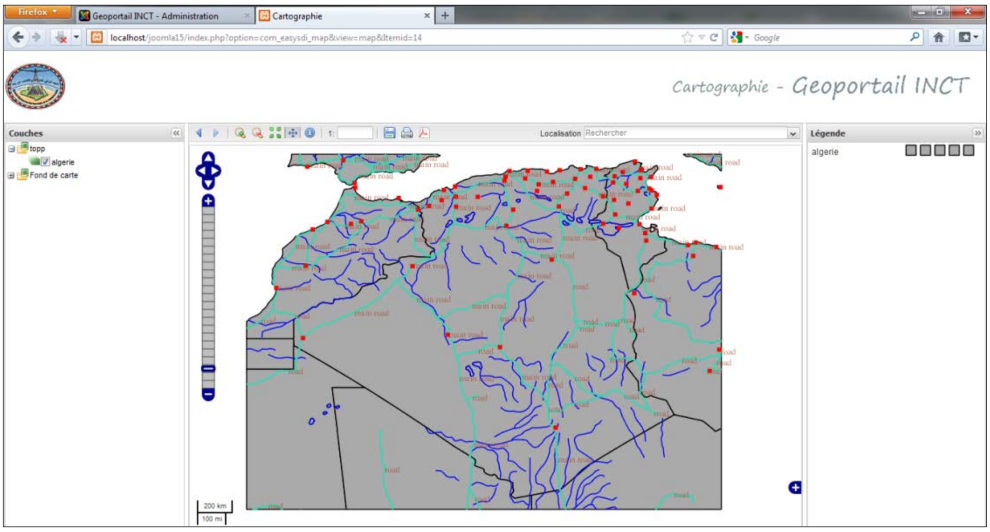

Figure 30. Web mapping module

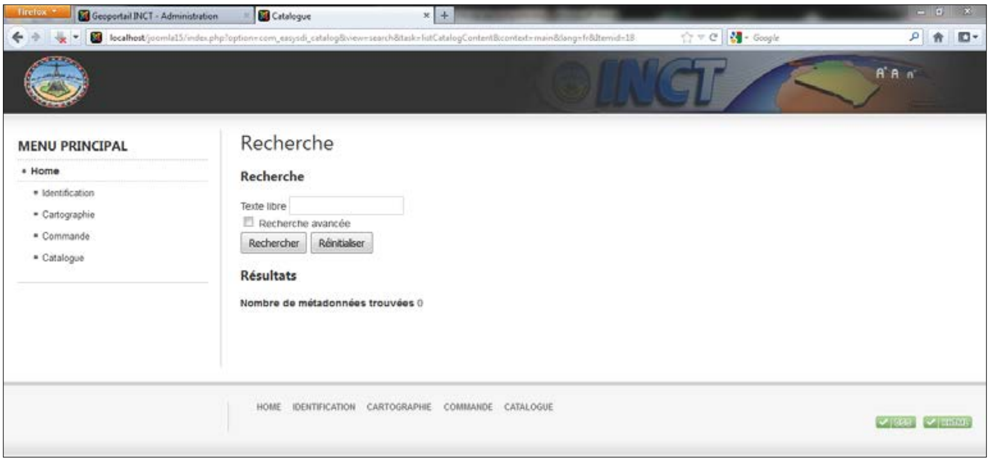

Figure 31. Catalog module

Figure 32. Shop module

4. Conclusion and outlook

The realization of this project has raised a number of questions and opened new fields of research and investigation in the field of geomatics. Indeed, we necking our methodology to the core functionality of an SDI. The same applies to the development of the database schema; we have realized a small part for the first validation of our method.
In addition, it should be noted that the use of open source tools, such as EasySDI, allows a rapid and efficient development of complex systems with very low costs. However, their implementations require highly specialized skills in programming, a lot of patience and quite significant research efforts.
For years, multiple perspectives must be considered, such as:

- Refining the proposed process by its use in other specific projects;
- The integration of the developed process in the project "EPF" of the Eclipse Foundation;
- The study of the legal aspects related to the implementation of spatial data infrastructures;
- Experimenting XML databases for the storage of GML files and metadata;
- The integration of the GeoDRM standard (digital rights management) on the services cycle.

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