TOWARDS A NATIONAL ATLAS - GEO WEB SERVICE

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February, 2011

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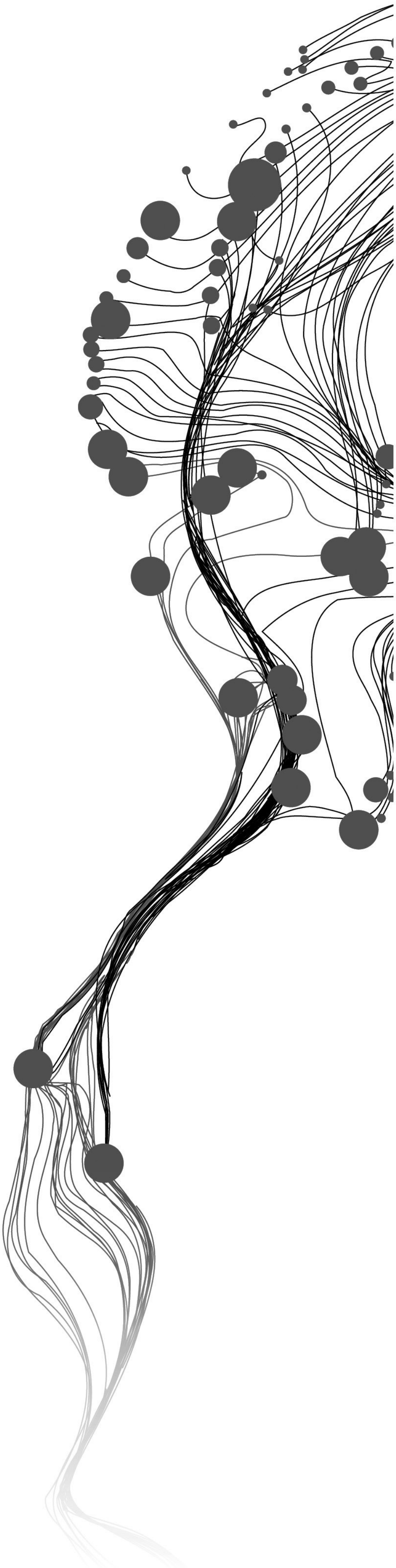

TOWARDS A NATIONAL ATLAS - GEO WEB SERVICE

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Enschede, The Netherlands, February, 2011

Thesis submitted to the Faculty of Geo-information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.

Specialization: Geoinformatics

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ABSTRACT

A National atlas is a collection of maps with a narrative function. Maps of a National Atlas represent spatial datasets which characterize a country. An important aspect of a National Atlas is the ability to compare maps. A National Atlas can provide an alternative access to the National Spatial Data Infrastructure (NSDI), this means that National Atlas maps can use spatial datasets from various sources available within the NSDI. The main objective of this research is to formulate and design a conceptual model of the National Atlas - Geo Web service. The National Atlas - Geo Web service is designed as a loosely coupled system. As an interoperable node, the National Atlas will then be integrated as a node of the NSDI.

Keywords

The National Atlas, The National Spatial Data Infrastructure (NSDI), Geo Web service

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ACKNOWLEDGEMENTS

I would like to thank my parents, family, and my friends for their moral support and help.

My gratitude to my supervisors Drs. B.J. (Barend) Köbben and Prof. Dr. M.J. (Menno-Jan) Kraak; Mr. Köbben, for his effort, for all times he dedicated to me and for all his advices; Professor Kraak, for his supervision and his guidance.

My grateful to the European Commissioners who initiatively provide scholarship (EMMA) to the students of the Southeast Asia region.

Chapter 1
Introduction

1.1 MOTIVATION AND PROBLEM STATEMENT

Maps have been utilised as sources of geographical knowledge such as location, attributes of objects, or phenomena located on Earth. Since the 1980s, maps have been developed as digital products. The innovation of technology and the availability of the software packages stimulate the rapid growing of digital maps [15]. With the numerous map productions, maps have been collected as collection of maps called "Atlas." The publication of atlases can be found in two different forms, World Atlas and National Atlas. The difference between these two forms of atlas is that the National Atlas typically refers to a collection of maps which compose of maps at national scale. In this proposal we discuss mainly about the National Atlases. Concretely, we are going to study about the current development of the Dutch National Atlas; and propose a new conceptual design for the Dutch National Atlas's architecture and its components.

Generally, a National Atlas is a worthwhile publication of national Geo spatial resources such as geographical and statistical maps. Since it is a fundamental geographical knowledge, it is normally used by educational institutions as study material to help students understand geographical phenomena. In the past, National Atlases were printed on papers and published as series of books. Noticeably, National Atlases have been digitally published via CD or DVD at the early stage of digital age [16]. The innovation of technology has made it possible to publish a National Atlas over the Internet. As being the latest product of Atlas, the web-based Atlas software contains a variety of functions and up-to-date maps. The basic interaction functionalities, which can be found within the current prototype of the Dutch web-based National Atlas, are browsing (zooming, panning, layers filtering), and printing [27]. In addition, these basic functionalities can also be found within the other National Atlases such as the National Atlas of the United States of America [26]. Although the latest version of National Atlas seems to be more effective than the paper-based Atlases, further research need to be done in order to innovate the National Atlas application itself.

The latest research on the current prototype of the Dutch National Atlas suggested that the availability of the National Spatial Data Infrastructure (NSDI) can be utilised as a main data-source for the National Atlas [16]. Not only the new data-source has been suggested, but also some limitations of the current prototype have been pointed out. The main limitation of the current prototype is the lack of interoperability. Without concerning about technology and standardisation, the current prototype has been designed as tightly coupled system. As a result, the prototype is limited to specific data-sources and a specific client tool, which is designed to work exclusively with its own data-source; and its components are usually complex, difficult to maintain, and monolithic [20]. In addition, the current client tool is designed and implemented based on Adobe Flash platform which is a proprietary software and data format. Since this component is designed and developed based on proprietary product; a specific software package, which is normally commercial, is required for its enhancement and maintenance. This would discourage the potential developers and user community from getting involved in the development [6].

On the other hands, the current prototype is designed to be firmly tied with specific data-sources which are not interoperable. The main disadvantage of not being interoperable is the reusability of the collected data. The datasets which are collected especially for the National Atlas could not be used by the other software or systems. In addition, the National Atlas itself could not access to external datasets such as the datasets within the NSDI. Moreover, in order to have up-to-date maps, the datasets of the current National Atlas is required to be updated frequently. Data collection and integration are cost and time consuming. However, the National Atlas would be able to access to up-to-date datasets, which are available within the entire NSDI nodes. As stated [16] currently Central Bureau of Statistics and Geological Survey are providing such up-to-date dataset which can be used for the new National Atlas. To be a node of NSDI is not only having access to up-to-date datasets; but also making the National Atlas to be more interoperable. Hence, the adaptation of OGC standards and specifications will make the new National Atlas interoperable with the other NSDI nodes. Since OGC plays an important role in the innovation of Geo based Web Services, designing a new National Atlas with regardful to the OGC's standards and specifications is a prime.

In conclusion, this research is mainly focusing on the possibility of designing Geo Web service that could implement the components of the National Atlas; and the innovation of the Dutch National Atlas toward a state-of-the-art Atlas.

1.2 RESEARCH IDENTIFICATION

Based on the research papers related to the current prototype of the Dutch National Atlas, it is important to redesign it and its components in order to be interoperable. As suggested [16], the new Dutch National Atlas should be an integral part of the geo-data infrastructure. Therefore, the main objective of this proposal is to redesign the Dutch National Atlas. The new system should be OGC compatible so that it can be truly integrated into the NSDI.

1.2.1 Research objectives

There are two objectives which need to be achieved:

- The first objective is to design the software architecture of the new National Atlas.
- The second objective is to design Geo Web service based components for the National Atlas so that it could retrieve meta-data from the nodes of the NSDI.

The achievement of these two objectives will result in a new design for a new Dutch National Atlas being fully OGC compatible, interoperable, and scalable.

1.2.2 Research questions

The research questions posed for the research objectives are:

a) What are the existing designing approaches which can be used for web-based National Atlas within the context of NSDI?

b) What components are missing or improperly designed in the current prototype?

c) How can Geo Web service be used to tackle the problems stated in paragraph 3 and 4 of Motivation and problem statement?

d) How will Geo Web service be built as new components of the National Atlas?

e) How must the components be integrated into the NSDI?

f) How can the National Atlas system be designed to be interoperable and scalable?

g) How the new solution will be put into practice? Prototyping? Or setting up as theoretical recommendation?

1.3 INNOVATION AIMED AT

The innovation of this research aims at integrating the National Atlas as an integral part of NSDI. This would deliver a variety of maps with up-to-date information. With a well structured data, maps will be comparable based on their profiles and attributes. Technically, the new National Atlas will be designed based on a loosely coupled set up in which the new Atlas system will be interoperable and scalable. In addition, the new architecture of the National Atlas will support external features or components to be plugged into it as it adapt loosely coupled concept. As it is interoperable, the web-services components will support customised client tools and external data-sources.

1.4 RELATED WORK

There are five research papers, which are related to the late development of the National Atlas, have been selected for my research. In addition, the Geographic Information System (GIS) initiative organisation like INPIRE is also considered since it plays in an important role in the innovation of NSDI of the European nations. To deal with the rapid growing of the technology, the research papers are selected based on the years of publication which covers the period between 2007 and 2010.

The selected research papers which related to this work:

a) [35] - The main goal of this research was to perform an update process of the National Atlas maps in a NSDI (GDI) environment.

b) [3] - The main goal of this research was to conduct a research on envisioning and evaluating the potential of Atlas-based portal as an alternative to geo-portal for users when looking for and making sense of geospatial data and information.

c) [10] - The main goal of this research was to conduct an experiment on mashing up the spatial data of NSDI (GDI); and putting it onto the virtual globe so that it can be simulated as the National Atlas.

d) [13] - The main goal of this research was to identify the key features and functions of the Geo Web portal to be an effective gateway for users of the NSDI.

e) [2] - The main goal of this research was focusing on the development of the National Atlas as an alternative of the Geo Web portal, when the NSDI (GDI) is utilised as a data-source of the National Atlas.

f) The principles of INSPIRE [9] - They are considered as related works. Due to the fact that this organisation has been coordinating GIS related works among European nations in order to set up standards and specifications, the works which have been done by this organisation contributed tremendous value to the GIS community. By following the principles, the NSDI of the Netherlands is interoperable and scalable.

Apart from the research papers, the investigation on the current prototype of Dutch National Atlas shows that the designing and implementing of the current prototype is a good initiative for formulating the idea for this proposal. Although all these research works aim on the same goal as what being proposed here, it is just the stream of the development which is to make the National Atlas better. In addition, the problems, which are being stressed in this research, are different from the problems which have been addressed by the previous research. This research is focusing on two main problems, the lack of the interoperability and the meta-data structure. As it is being proposed, the Dutch National Atlas should be integrated as an integral part of the NSDI. Hence, being interoperable with the other nodes within the NSDI is a major concerning. Furthermore, the meta-data of the current prototype has its own templates which are not standardised. Due to the fact that the meta-data templates have no standard, it is not possible to compare the maps based on their attributes. By solving these two concerning problems, the next generation of the National Alas will be integrated as a node of the NSDI, and allow the users to perform side by side map comparison based on the attributes of the maps.

1.5 PROJECT SET-UP

This research will be strictly done based on a clearly defined planning. The knowledges acquired for this research will be based on the literature review. Technically, the National Atlas software and its components will be analysed, designed, and implemented based on the Business Process Modeling approach (BPM). As the matter of fact, the project would encounter some problems either during the research; so the risks and contingencies will be analysed and clearly defined.

1.5.1 Method adopted

The research will be carried out based on literature review, experiment, and designing and implementing the concepts:

Initially, the literature review will be used for analytical phase of the research in order to formulate the concepts. This will help in acquiring the knowledge concerning the National Atlas, NSDI, and the technology. In addition, a study on the current prototype will be conducted in order to identify the problems. By applying this method, missing components, functionalities, or improperly designed components will be identified.

After the concepts are formulated, the designing will begin. First, the National Atlas and its components will be conceptually designed. Second, the key components will be implemented, and evaluated in order to prove the concepts. In addition, the Model Driven Architecture (MDA) Approach will be used for this phase. However, the MDA approach is not the only one choice; there are other approaches which are potentially suitable for the innovation of the National Atlas.

On the other hands, the MDA will be initially used, since the concepts will be put into reality in which the architecture of the National Atlas software and its components will be designed based on Unified Modelling Language (UML). This software developments approach is selected as an initial approach because the architecture of the National Atlas software will be firstly designed as a conceptual model. As a conceptual model, it is a Platform Independent Model (PIM) and can be transformed to any Platform Specific Models (PSM) [8].

1.6 THESIS STRUCTURE

The research will be started with phase I of thesis literature review. It is really important for further reviewing in order to broaden the knowledge of the current and future of the technology, NSDI, and the National Atlas. After phase I of literature review is completed, the analysis on the

current structures of the NSDI and its datasets will be started. Analysing is really a challenging task due to the complexity of the NSDI and its data structures. After analysing, the designing task will be started. However, the literature review phase II will be started earlier then designing in order to make sure that all the concepts are formulated. Here, the thesis writing is also started. Late after the designing is done, a prototype of selected components will be implemented, evaluated, and maintained in order to prove the concepts.
The list of tasks:

1. Literature review (proposal)
2. Proposal writing
3. Proposal defending preparation
4. Proposal defending
5. Thesis preparation
6. MSc Excursion
7. Christmas break
8. Literature review phase I (Thesis)
9. Data Structure Analysis
10. Design the Architecture
11. Implementation, evaluation, and maintenance
12. Literature review phase II (Thesis)
13. Thesis writing
14. Mid-term evaluation
15. MSc defending

Chapter 2
Literature review

2.1 INTRODUCTION

In this chapter, answers will be given to some questions posed within the first chapter. The questions will be answered based on the reviewing of the existing research papers and other material which are relevant to this research topic. The concept of National Atlas such as functions, structure, publisher, data infrastructure, NSDI, and (Geo)Web service will be discussed within the forthcoming sections.

2.2 THE NATIONAL ATLAS

2.2.1 The Concept of National Atlas

A National Atlas refers to a collection of maps in which the maps are composed of spatial information at national scale. The National Atlas has been used as a medium for disseminating the geographical information in order to provide an easy access to geospatial data and knowledge within a national context long before the SDI initiatives and geo-portal were established [3].

2.2.2 General concept

The first National Atlas was produced in 1899; and it was the National Atlas of Finland. Although the Finland National Atlas was the first publication of the National Atlas, the idea of gathering maps of different topics had been formulated since the seventeenth century [2].

The concepts of the National Atlas was provoked by the aims to deliver the contents of spatial information via collected maps of various topics and to assist the scientific community. The National Atlas was a concise media of synthesis of national information. As indicated in Ormeling (1979) [22], the requirement of a National Atlas's publication are: the availability of data, human resources, cartographic skills, financial support, and an editorial board. Since it is a synthesis of a national information, the task to produce a National Atlas usually requires people from different governmental bodies or institutes to work collaboratively.

On the other hand, the emerging of the technology brought the National Atlas publication to its state-of-the-art. Since the late twentieth century, the National Atlases have been digitally published via CD or DVD [16]. Although disseminating digital National Atlas through DVD is foremost better than paper, they are still a closed information system in which users are limited to access to non-updatable dataset(s) [14] . Nevertheless, the digital National Atlas could be published through a so-called Information Technology, World Wide Web (WWW).

2.2.3 Web-based concept

The innovation of the technology has been motivating the development of the National Atlas to the state-of-the-art of its kind. The principle of online National Atlas is to utilise the WWW technology so that the update-to-date spatial information could be easily disseminated and delivered to the users.

The two well-known nations, the United States and Canada, have been playing as an importance role in the innovation of the online National Atlas. Two examples of online National Atlas would be the National Atlas of the United States [26] and the National Atlas of Canada [28]. The online National Atlas of the United States was initially introduced to the users via the publication of the digital National Atlas which disseminated through CD-ROM. CD-ROM based National Atlas contained the base data along with the instruction on how to use Internet in order to access to more details and up-to-date information retrieved from National Information Infrastructure (NII) and NSDI [11]. The online National Atlases of these two nations could illustrate how far the Internet based National Atlas have been.

In conclusion, utilising WWW as a medium for disseminating the contents of the National Atlas, publishers have been able to provide more functionalities to the audiences. Meanwhile, the audiences has also been profiting from the accessibility to the up-to-date datasets and the interactivity of the software [2].

2.2.4 Functionality

The availability of the new technology, both hardware and software; and the availability of spatial datasets such as maps, remote sensing imagery enabled the advanced development of the National Atlas. As mentioned in earlier section that the online National Atlas was not built from scratch. It was the renovation. Therefore, the functionalities of the online National Atlas are the combination of all functionalities of online map and the electronic Atlas itself.

Based on the paper of Farjan Ormeling [11], the functionality of the Electronic Atlases are devided into nine groups as the following:

1. **General functions** - provide the possibility to the users in order to obtain a snapshot of the displaying map, or the possibility to save, export or import the map file.

2. **Navigation functions** - provide the possibility to the users in order to:

   a) Retrieve or marking the route followed through the Atlas

   b) Retrieve starting position in the Atlas

   c) Show an overview map, the position of the cursor in the area once zoomed in

   d) Show on a “map” or scheme where exactly the user is in

   e) Jump from one map with a specific theme to another map with the same them

   f) Jump form one map of an area to other maps of the same area with different theme

   g) Show the north arrow at the point of the cursor

3. **Map functions** - provide the possibility to turn on or off the legend, reference scale, and marginal information; and also provide the provisional of 4D information (longitute, latitude, altitude, and localtime); for example, perform query in order to retrieve the coordinates, hieght and the local time

4. **Database functions** - provide the possibility to the users in order to perform query

5. **Education functions** - allow users to access to the information of the Atlas itself

6. **Cartographic functions** - assist the learning process of the students so that they can remember the subject matter, or to allow teachers to follow the students’ advances, such as:

a) Explaining the map patterns via the explanatory texts behind the maps
b) Indicating preferential routes to be followed through the atlas
c) Subdivising the subject matter into parts
d) Monitoring the students' learning progresses and achievements
e) Providing animations of processes
f) Working with simple models
g) Game and competition fucntions

7. **Cartographic functions** - provide the possibility to change or modify the appearance of the maps on monitor; for example, change color and class boundaries or classification systems

8. **Map use functions** - provide the availability of the annotation functions, measuring functions, and simple GIS functions

9. **Other functions** - provide access to additional information such as texts, grphics, animations and sound

Although these functions are listed as the functionalities of the electronic Atlas, not all of them is required for such a National Atlas.

2.2.5 The publisher of National Atlas

Generally, the government of any nations own their National Atlas. The tasks such as collecting and publishing maps through World Wide Web are typically deligated to a specific governmental organisation body. Examples of current implementation of the web-based National Atlas, which I have collected for this section, are given in the figure 2.1

Title	Publisher	URL
The National Atlas of the United States and **The National Atlas of the United States of America**	the U.S. Geological Survey (USGS)	http://www.nationalatlas.gov/
Atlas of Canada	Natural Resources Canada	http://atlas.nrcan.gc.ca/site/english/index.html
The National Atlas of Korea (Internet Service)	National Geographic Information Institute	http://atlas.ngii.go.kr/english/index.jsp
The Botswana National Atlas	The Department of Surveys and Mapping	http://www.atlas.gov.bw/index.html

Figure 2.1: List of web-based National Atlases

2.3 SPATIAL DATA INFRASTRUCTURE(SDI)

The evolution of technologies triggers the innovation of the management of spatial data. Spatial Data Infrastructure (SDI) is a basic terminology which is used to describe a computer based system which provides access to the spatial data and metadata from a distributed data sources [5].

The fundamental of the SDI is about facilitation and coordination of the spatial data interchange and sharing among the stakeholders within the community [25]. In addtion, the basic components of SDI are: data sets, institutional framework, policies, technology, standards, and human resources [12]. Geospatial Data infrastructure (GDI) sometimes used as an alternative term to describe the same system. Since SDI or GDI is a broad term which can be used in different levels such as local, regional, or global [17], the term National Spatial Data Infrastructure (NSDI) is introduced at the national level. NSDI is a common term used by governmental bodies of many nations to describe their own spatial information system. However, the term SDI is somehow used interchangeably with the term NSDI. Nonetheless, the innovation of NSDI is not only focusing on local government; but also pursuing regional and global because co-operation could enrich the content of the spatial data which is every useful for decision making and planning.

Back to 1994 when President Bill Clinton issued an executive order (#12906) on the creation of the first generation of National Spatial Data Infrastructure (NSDI) for the United Stated [11]. Its goal was to minimise the costs related to geographic information which normally duplicated among organisations. In addition, the NSDI enables geospatial data to be more accessible to public sector as well as the government organisations. Moreover, the NSDI has not only been geospatial data and its infrastructure, but also has become technology, policies, criteria, and standards [29]. However, the term "National Spatial Data Infrastructure" had already used in a paper presented by Jonh McLaughlin at the Canadian Conference on Geographic Infromation System (GIS) in year 1991.

2.3.1 Concept of SDI

The innovations in Information and Telecommunication Technologies play a crucial role in the evolution of the SDI. The concepts of SDI have been formulated and implemented by many developed nations. The main concept of having SDI is "collect once, use many times." Regarding to Groot and McLaughlin (2009) [16], "A set of institutional, technical and economical arragements, to enhance the availability (access and use) for correct, up-to-date, fit-for-purpose and integrated geo-information, timely and at an affordable price, with the goals to support decision making processes related to countries' sustainable development." In addition, the basis of SDI is to provide spatial data discovery, evaluation, and application for users and providers; and it is applicable for the whole struture of goverment, non-profit and commercial sectors, and academia [21].

Additionally, there is a number of initiatives such as OGC and INSPIRE. These standardisation organisations have been pursuing to promote the standards of SDI architecture, data, and services. Since there are dozens of SDI initiatives, there is a variety of international standards have been implemented for data and service discovery, data access, visualisation, and analysis [21]. For example, OGC leads the innovation of SDI worldwide. Currently, there are 403 companies, government agencies and universities join this consortium. The OGC initiative has been coordinating the collaboration among its participants in order to define sets of standards and specifications [19]. OGC's standards and specifications enable SDI's stakeholders to share data and provide services seamlessly. Meanwhile, INSPIRE is an important stakeholder of the SDI development within Europe. The goal is to coordinating and directing the evolution of the SDI for european countries. Its principles enable SDI stakeholders to share spatial data and provide services seamlessly throughout europe [9]. The common principles of INSPIRE could be found in figure 2.2. Furthermore, the principles has been adapted by european counties for their SDI developments.

On the other hands, Geospatial standards are predominantly developed by the International Organisation for Standardisation (ISO) Technical Committtee 211 211 (TC211) and OGC; and they are often dependent on the industry standards such as WWW (W3C) and Organization for the Advancement of Structured Information Standards (OASIS), which develop e-bussiness standards [21].

- Data should be collected only once and kept where it can be maintained most effectively.
- It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.
- It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.
- Geographic information needed for good governance at all levels should be readily and transparently available.
- Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

Figure 2.2: The common principles which INSPIRE is based on [9].

2.4 DUTCH NATIONAL ATLAS AND NSDI

2.4.1 The NSDI of the Netherlands

In Spring 2007, a new organisation, GEONOVUM, is founded. It is an NSDI executive committee in the Netherlands. The Goals of this organisation is to develop and standardise the Dutch NSDI [30]. The details of goals and tasks of GEONOVUM could be found in figure 2.3. In addition, GEONOVUM was formed as a new foundation of public sector parties for buiding approach and implementation, with the support from the Ministry of Housing, Spatial Planning, and Environment (VROM) and other organisations. The Dutch SDI is the implementation of INSPIRE concepts which is guided by the GIDEON report. GIDEON is known as the result of the devision of implementation, approach and strategy which is advised by the GI counsil, the GEONOVUM, and RGI foundations. The core principle of GIDEON is “record once, use many times.” This principle would help improve the public administrative works by reducing administration burden [1].

Regarding to the approach and implementation plan (2008-2011); by 2011, the Netherlands will have an advanced and up-to-date key geo-information facility to deal with the spatial issues in the society with effectiveness and efficiency. As illustrated in figure 2.4, GIDEON is pursuing to facilitate the resuse geo-information. In order to do so, the information is delivered to the users through two information exchange settings, Extranet and Internet. The support information which is shared with the public authorities should be accessible through an Extranet. Meanwhile, the third parties could access to the geo-information via the Internet. In addition, GIDEON is constructed by three main components (Services, Data and Technology) [1]. Figure 2.5 illustrates the GIDEON comceptual model with the three visible components.

Practically, with a well designed approach and implementation guideline, the NSDI of the Netherlands currently provides possibility to its stakeholders to access and share geo-information. As a result, the National Atlas is potientially integrated as a node of NSDI [16].

Goals and tasks
Geonovum is recognisable and professional, result-driven and independent. Its main goals are:

- to develop and standardise the geo-information infrastructure while also being innovative.
- to build up and disseminate knowledge in the area of geo-information infrastructure.
- to make the geo-information infrastructure more accessible to administrative bodies, institutions and departments in the Netherlands and the European Union.

In order to attain its goals Geonovum has set itself the following tasks:

- to share and make accessible all the geo-information available in the Netherlands.
- to be a think tank in the domain of geo-information.
- to be the 'voice of geo-information' that provides the minister of VROM and the Council for Geo-information with professional advice and relevant knowledge.
- to develop high-quality and widely applicable standards and to monitor their use.

Figure 2.3: The Goals and Tasks of Geonovum, the National Spatial Data Infrastructure (NSDI) executive committee in the Netherlands [30].

2.4.2 The National Atlas of the Netherlands

Not too much different from her neighboring countries, within the european region, the Dutch governments have been putting their efforts on bringing their National Atlas to state-of-the-art of its kinds. Not only the government institutions which get involved in this hardship, but also public and private sector parties. The idea of creating the National Atlas was made in between year 1963 and 1978. However, the first National Atlas was set up in 1958 in which the project was backed by the Ministry of Education, the Royal Netherlands Geographic Society, Topographic Survey, and universities. The publication of the second edition during 1989 and 1995 was clearly focusing on the inhabitants of the country. It covered the information such as climate, geology, soil, and so on. The production of the second edition was still going on up until the outlook of the Ministry had been changed. The Atlas bureau was closed followed the Ministry's decision as it claimed that the National Atlas should be self-supporting. Although the Atlas bureau was closed, the concept of the National Atlas was still preserved and a final decision was made as to make all maps from both editions available on a website, http://www.nationaleatlas.nl [16].

In addition, the current prototype has been developed and made available as shown in figure 2.6. This prototype tends to be the latest edition although the formal productions are still published in paper and CD-ROM formats [10]. Since the current prototype has been developed with regardful to online Atlas concepts, it has become an experimental tool for researchers who are interested in the study of Atlas application. This has also become a good initiative for further development of the online Dutch National Atlas. As suggested [16], the new Dutch National Atlas should be an integral part of the geo-data infrastructure. Based on this suggestion and other research papers, a new conceptual of the Dutch National Atlas should be designed and implemented

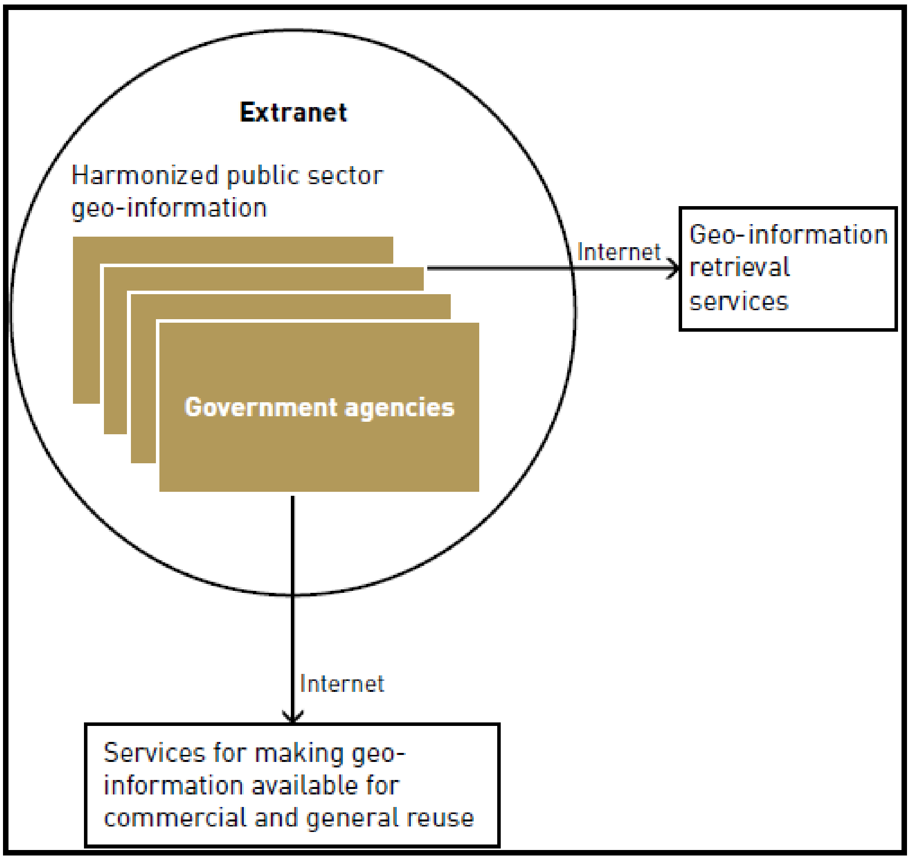

Figure 2.4: GIDEON Architecture [1].

following standards and specifications of standisation organisation such as OGC or INSPIRE.

2.5 WEB SERVICE AND GEO WEB SERVICE

“Web of Service,” as it is named by W3C, is typically well-known as “Web service” by many people over the world. As given its definition by W3C, “a Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards.” Once you read through the above definition, you might notice two different terms, “Web of Service” and “Web service”. In fact, there is no different meaning. These two terminologies are used for describing the same software technology [32].

2.5.1 Web service

Software is meant to be used for solving problems, but the complexity of the problems has been driving software development to its own complexity. In addition, software development community has been dealing with the issues of how to make software be interoperable and reusable. Meanwhile, the ingenuity of human has made another evolutionary work of software engineering which is “Web service” [4].

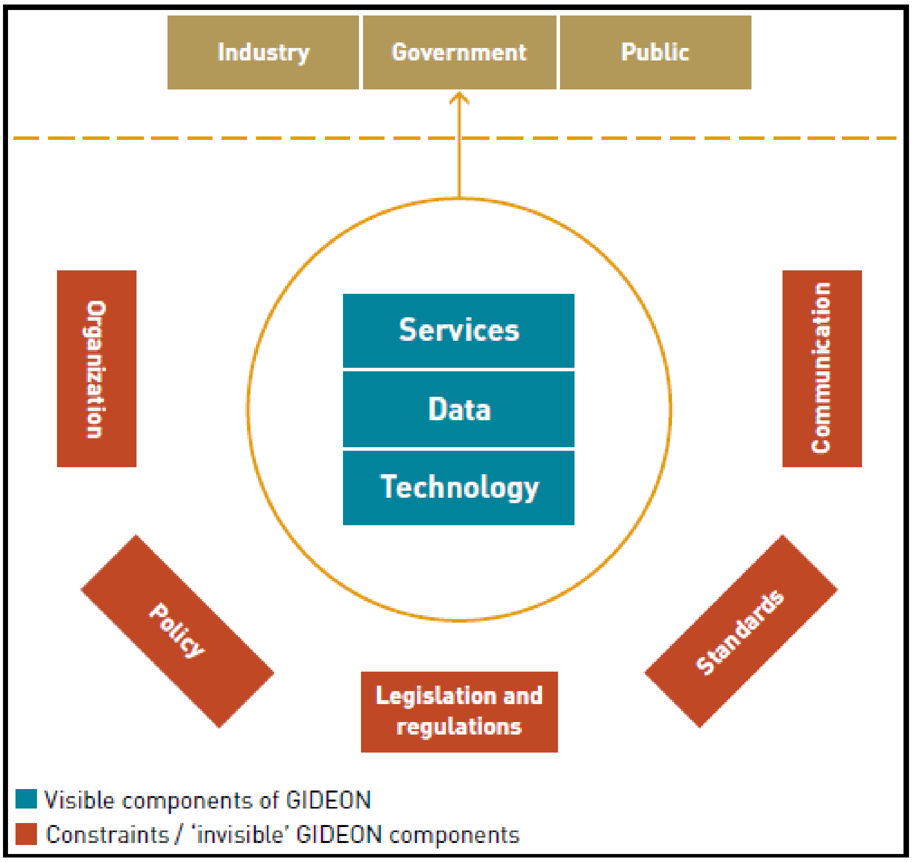

Figure 2.5: GIDEON Conceptual model [1].

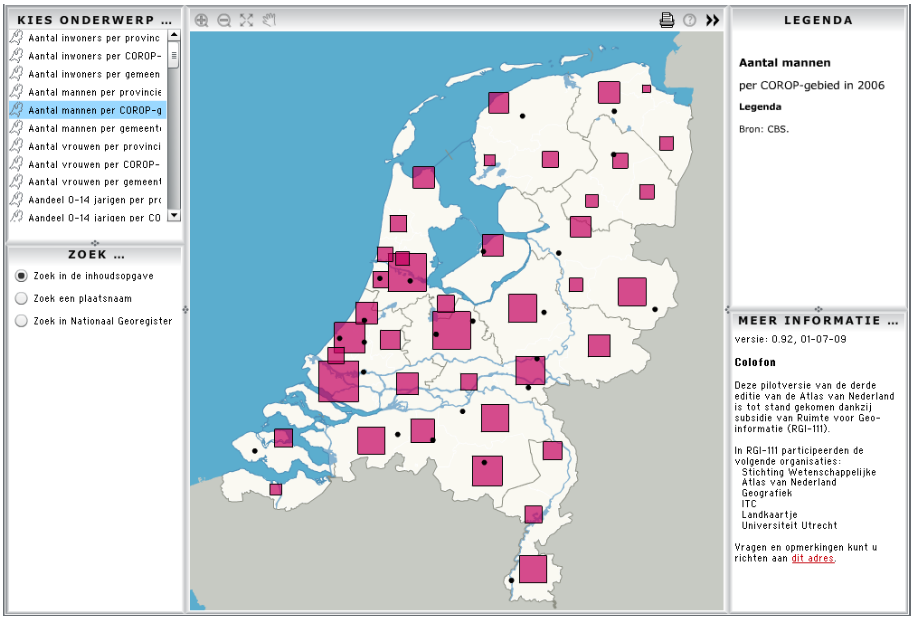

Figure 2.6: The screen-shot of the current prototype of Dutch National Atlas [27].

Unlilke tightly coupled system, a functionality of a system could be provided as Web service; and it is interoperable and reusable. A service is typically provided by a provider, whilst requester requests for a wanted service. Figure 2.7 illustrates how the message is being exchanged between the requester and provider. In most cases, the requester is the one who establish the message exchange session [33].

Service Oriented Architecture (SOA) is the conceptual model of software development. Besides delivering the whole package of software to the end user, service based software allows software provider to deliver components or functionalities of the software as services. SOA is rooted in the traditional software development best practices and standards in which this software modeling tends to have more advantages. In addition, SOA has been designed to support all phases of software development life cycle, and whole range of applications. The principle of SOA could be adapted for any loosely coupled software development projects or even transform such a tightly coupling component to be a loosely one. [4].

SOA priciple are mostly adapted by enterprise software systems such as financing system, GIS, and web 2.0.

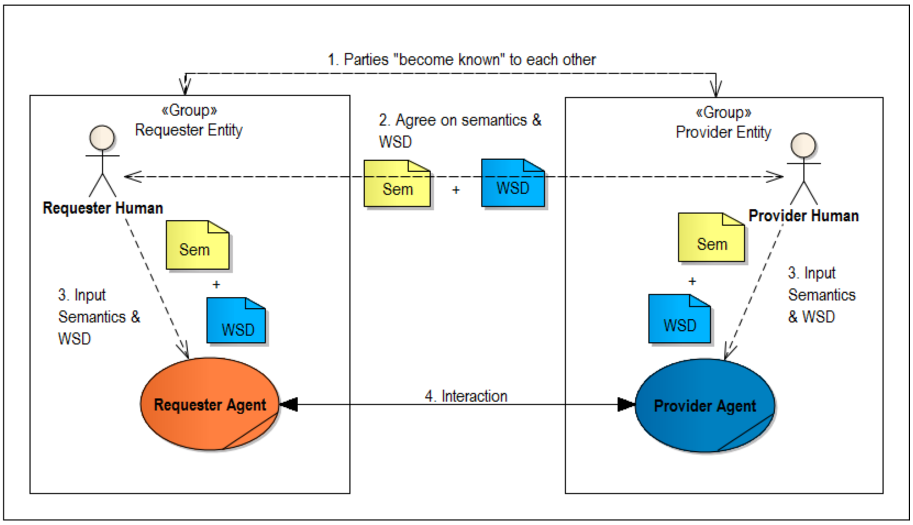

Figure 2.7: The General Process of Engaging a Web Service (modified [33])

2.5.2 Geo Web service

Geo Web service is another utilisation of Web service technology for GIS application. Web service is the main feature of OGC specifications and standards. Besides using standard XML message, OGC has implemented another XML standard called “Geography Markup Language (GML)”. GML is a standard message used for handling geography data; and it is an extended version of XML standard. In addition, there are some common Geo Web service standards such as Web Map Service (WMS), Web Feature Service (WFS), Web Coverage Service (WCS) and Web Integrator Service (WIS) [31]. The description of the common OGC Web Service standards could be found in figure 2.8.

Geo Web service standards, which are published by OGC, have been widely adapted by GIS community. Since they are open standards, Geo Web service based products could be found in both software domains, open source and proprietary.

- Web Coverage Service (WCS) allows interoperable access to geospatial data that has values at each measurement point (e.g. satellite images, digital aerial photos, and digital elevation data).
- Web Feature Service (WFS) enables to retrieve geospatial data (vector data) using Geography Markup Language (GML).
- Web Processing Service (WPS) allows standardizing input and output for geospatial processing services. It characterizes an interface, which helps to publish geospatial processes. The data used by WPS can be available at the server.
- Web Map Service (WMS) allows displaying map images from distributed geospatial databases using HTTP interface. WMS request defines the geographic layers to be processed, and response is one or several map images (JPEG, PNG, etc) to be displayed using a browser application.

Figure 2.8: OGC Geo Web Service Standards [35]

2.6 SUMMARY

As per discussion throughout this chapter, the evolution of technologies together with the inventiveness of human could foster a new concept of the National Atlas. Web service technology, standards and specifications play an important role in advanced development of the NSDI. An interoperable NSDI gives a foresight to reuse the available resources within the NSDI for other applications. With the potiential of utilising the available resources within the Dutch NSDI, there have been research papers suggested that the National Atlas should be integrated as a node of the NSDI. The new concept of National Atlas as an integral part of National Atlas will be discussed in the next chapter.

Chapter 3

National Atlas - Geo Web service: conceptual design

3.1 INTRODUCTION

As mentioned in the introductory chapter, the main objective of this research is to formalise the concept of the National Atlas - Geo Web service. Therefore, the primary goal of this chapter is to present the concept of the National Atlas - Geo Web service, and its components.

In this research, I mainly focus on the Web service components which will transform the concept of current edition of the Dutch National Atlas from a tightly coupled system to a loosely coupled system.

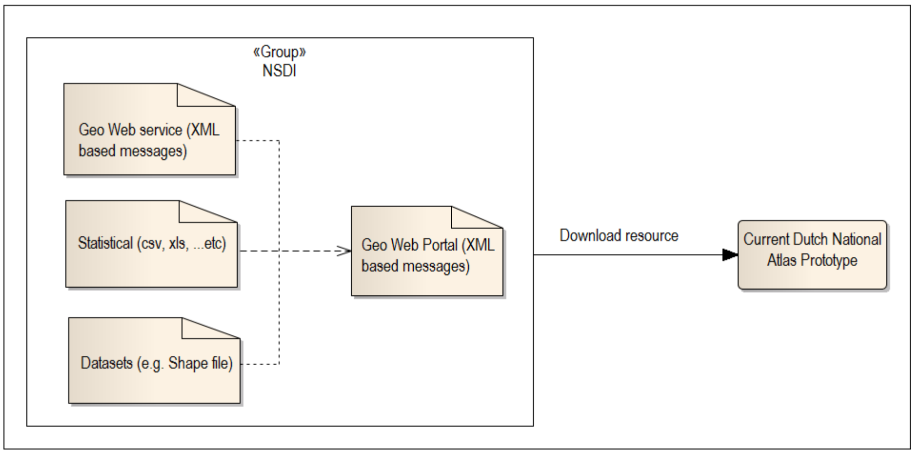

Figure 3.1: A conceptual model of the current Dutch National Atlas

The current edition of the Dutch National Atlas was designed and implemented as a tightly coupled system. For example, the graphical user interface (GUI) was designed to work with its own datasets, which are potentially out-of-date. These datasets are typically obtained from nodes of the NSDI and disseminated especially for the National Atlas (GUI) itself. With the growing number of nodes within the NSDI, the availability of up-to-date datasets is also increasing. In order to allow the users of the National Atlas to access up-to-date information, the datasets need to be integrated frequencely. However, integrating datasets is time and resource consuming. In addition, it is not possible for the current edition of the Dutch National Atlas to connect and retrieve the up-to-date datasets directly from providers. According to the issues mentioned above, having datasets integrated directly and automatically from the nodes of the NSDI could be a solution; and this solution would enable the National Atlas's users to access the up-to-date information.

A new conceptual model of the National Atlas is illustrated in figure 3.2. The purpose of this conceptual model is to make the National Atlas as an interoparable node so that it can be integrated as a node the NSDI. The National Atlas would be able to obtain spatial datasets and also allow the nodes of the NSDI to access those datasets seamlessly. Based on the conceptual model shown in figure 3.2, the National Atlas is designed to obtain meta-data from the Geo Web catalog, a node of the NSDI. The meta-data contains the information that could be used by the National Atlas to locate the spatial datasets provided by other nodes of the NSDI. In addition, the National Atlas is also designed to provide access to the meta-data stored in the Geo Web Catalog. In another word, the National Atlas provides a chaining service between the Geo Web Catalog and the other nodes of the NSDI (more details will be given in section 3.3.4).

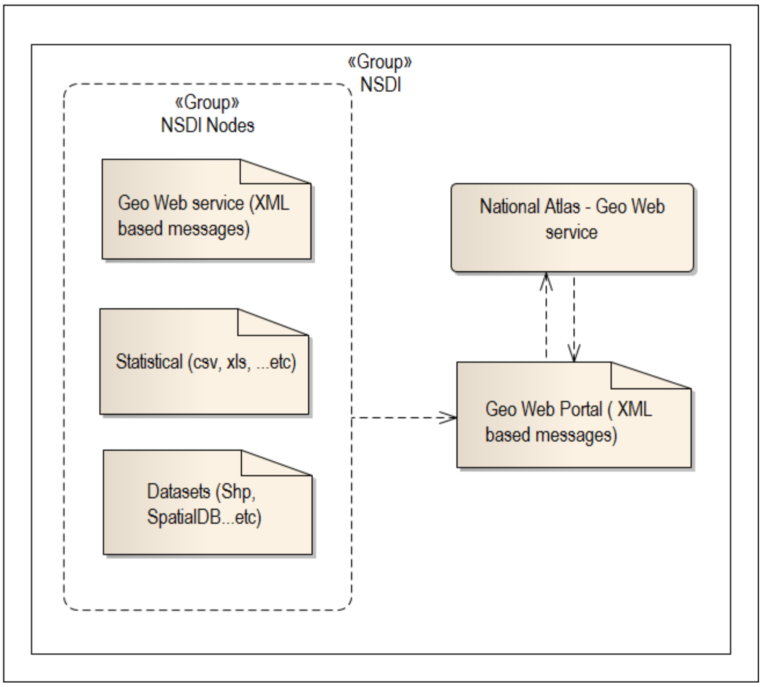

Figure 3.2: The conceptual model of the National Atlas - Geo Web service, as a node of the NSDI

The National Atlas and the nodes of the NSDI exchange meta-data and spatial datasets seamlessly based on standard Web service protocols such as WMS, WFS, WCS, OGC-CS/W (OGC Catalog Service for the Web [18]), ...etc.

3.2 CONCEPTUAL MODEL

In this section a conceptual model of the National Atlas - Geo web service is presented. This conceptual model defines the Geo Web service components, the relationship among the components, and the relationship between these components and the nodes of the NSDI.

The National Atlas - Geo Web service is composed of two main components: NA Web service Mediator and the NA Client Applications. Based on separation of concerns, these components need to be designed to work independently because they have different functionalities. The NA Client Applications provide Graphical User Interface (GUI) to the end users; and the NA Web service Mediator handles and provides the meta-data. Both components will be explained further in the next section.

As illustrated in figure 3.3, the components of the National Atlas - Geo Web service are connected in order to exchange meta-data (XML based message). In addition, the NA Web service Mediator acts as a middleware between the nodes of the NSDI and the National Atlas itself.

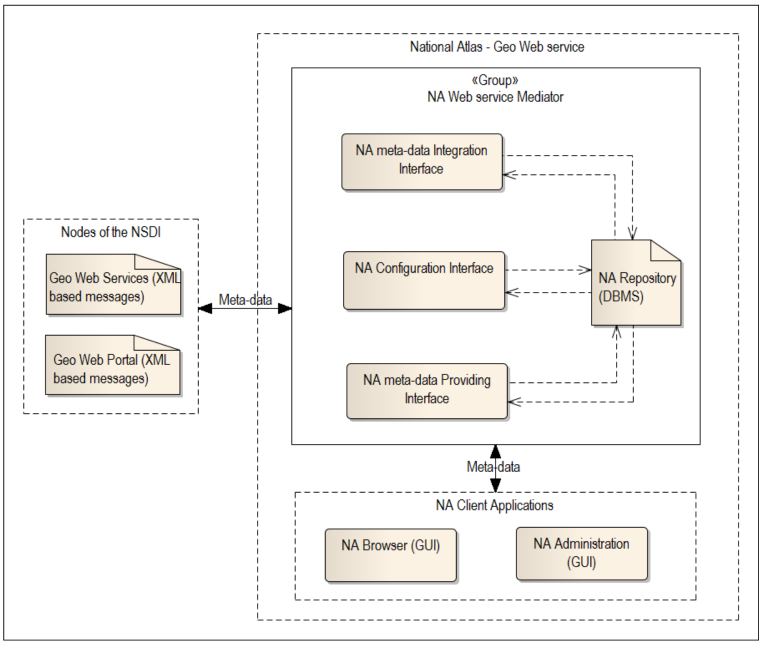

Figure 3.3: Detail diagram of business processing model of the National Atlas - Geo Web service

It is presented below a general description of the components:

- **NA Client Applications:** they are the Graphical User Interface (GUI) applications. They are designed to be compatible with the NA Web service Mediator. As we can see in the figure 3.3, the NA Web service Mediator provides two interfaces to NA Client applications: the NA Browser and the NA administration. The NA Browser is a GUI application designed for user(s) to navigate and explore the geographical information within the National Atlas system. The NA Administration application is designed for administrative user(s) to define the configuration parameters of the National Atlas system. With this GUI, an administrative user can set up the configuration parameters without requiring the knowledge of how the NA Configuration Interface works (See section 3.3.2).

- **NA Web service Mediator:** this is the core component of the National Atlas - Geo Web service designed to be a middleware between NA Client Application and the nodes of the NSDI. The NA Web service Mediator will be explained in detail in section 3.3.

In addition, the nodes of the NSDI are organisations which provide geo-information within the interconnected infrastructure. Each organisation owns and shares their spatial datasets based on standard Web service interfaces such as WMS, WFS, WCS, ...etc. Furthermore, the spatial datasets are typically published on the Geo Web portal. Basically, Geo Web portals use standard Web Catalog service such as OGC-CS/W to advertise the meta-data of the available spatial datasets.

Assuming that we are allowed to connect and retrieve meta-data from the Web Catalog service of the Geo Web portal, the meta-data will be fetched by the NA Web service Mediator. Since the NA Client Application need to access the actual datasets in order to visualised them as maps, the information which is necessary for locating those spatial datasets will be extracted from the meta-data fetched from the Web Catalog service.

3.3 COMPONENTS OF NA WEB SERVICE MEDIATOR

The NA Web service Mediator is designed to serve as a middleware between the National Atlas's client application and the NSDI's nodes. Its main purpose is to retrieve, process, and provide meta-data to both ends. The NA Web service Mediator is composed of four sub-components: NA Repository (DBMS), NA Configuration Interface, NA meta-data Integration Interface, and NA meta-data Providing Interface. These components perform tasks such as storing, manipulating, and providing meta-data. The details of these component will be described within the next sections. The architecture of the NA Web service Mediator is illustrated in figure 3.4.

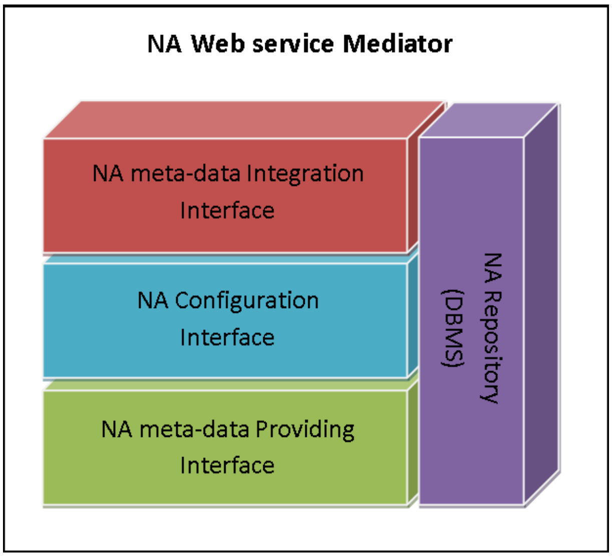

Figure 3.4: The stack of NA Web service Mediator

3.3.1 NA Repository (DBMS)

The NA Repository is a fundamental component of the NA Web service Mediator because it stores the configuration parameters and meta-data from the nodes of the NSDI. This means that this component is required to handle meta-data from two sources: the NA Configuration Interface and the NA meta-data Integration Interface.

The two groups of meta-data to be stored in the NA Repository are:

- **Configuration parameters:** they are the parameters required for the National Atlas - Geo Web service itself.

  The required parameters are:

  1. **User account:** it is a collection of information that allows the system to identifies user. Each user has different permission to access to certain resources and functionalities.
  2. **Group:** it is an aggregation of user accounts that defines sets of users with the same type of permissions. For example, a group of user may be limited to a certain resources or functionalities.
  3. **Map Category:** it is a list of map categories or subjects required for classifying the meta-data so that it helps optimising the meta-data searching process. This list can be

any kinds of map classification such as category, subject, type, ...etc. For example, subjects of map would be Biology, Geology, Agriculture, ...etc; or types of map would be Choropleth, Thematic, Topographic, ...etc.

4. **Pre-defined filter:** it is a set of selecting queries defined for filtering meta-data. A user or a group has a default pre-define filter as a preference so that the meta-data of interest would be loaded.

5. **Meta-data schema:** it is definition and structure of meta-data required for the NA meta-data Integration process in order to validate the incoming meta-data.

6. **Spatial index:** it is a function of a DBMS that allows certain operations on spatial information. It is required for indexing the spatial property of the meta-data. The information (four coordinates) of the bounding box is included in the meta-data retrieved from the Geo Web Catalog. This information could be extracted and stored as a spatial property. Basically, there are many ways of managing these four coordinates for spatial indexing. For example, they can be stored as a polygon or as a point by computing the centroid. This spatial index would help optimising the searching process.

- **Meta-data:** it is the information concerning the spatial datasets provided by the nodes of the NSDI. This information is necessary for the NA Browser (GUI) to locate and access the spatial datasets. For example, information related to the provider such as UUID, URL, type, Web service protocol, ...etc. However, there is no such a clear determination of which information are really necessary because this research does not focus on the NA Browser (GUI), which is the component that uses this information. In addition, there is no such a standard schema adapted for this meta-data because only specific information would be extracted and stored in the NA Repository. By storing only necessary information helps to avoid storing duplicated information (meta-data retrieved from the Geo Web Catalog).

The NA Repository should be implemented in a Database Management System (DBMS) because it has full functionality on managing and storing information (meta-data).

3.3.2 NA Configuration Interface

This component is designed to allow the NA Administration application access to the configuration parameters stored in the NA Respository (DBMS).

Both, request command and response message are XML based messages that can be sent over the Internet via protocols such as SOAP (Simple Object Access Protocol) or JMS (Java Message Service). The NA configuration interface has two services: the configuration service and the authentication service.

1. **Authentication service:**

   This service is built on top of the configuration service, here users need to provide their credential information (user identity, and password) in order to access the configuration parameters. This functionality will avoid the configuration parameters from being modified anonymously.

   If a user send a request command without authorisation, this service will response back a response message with status _UA (unauthorised access). However, if the credential information is validated and correctly represented to the service, a response message will be sent back to the requester with a authentication key. This authentication key is required for submitting an operational request to configuration service.

2. **Configuration service:**

   As illustrated in figure 3.3, the NA Administration (GUI) would be used for defining the configuration parameters of the system. Therefore, this service is designed to allow the authorised users to set up or modify the configuration parameters seamlessly, without the need to access the NA Repository. This service will be designed based on a standard Web service so that the NA Administration (GUI) could be implemented in any platforms, thick or thin.

   This service interface would allow the authorised user to access the configuration parameters of the system such as the user account, group, map category, ...etc. As described in section3.3.1, these basic configuration paramenters are neccessary for the National Atlas - Geo Web service. Besides providing access to the basic parameters, this service would also allow the authorised users to define and configure the maps as described in a research paper of M. Zumbulidze [35].

   In addition, this service provides operational request such as Add, Remove, Update, and Search. These commands are used for manipulating all the configuration parameters within the NA repository.

   - **Add:** it is a request which is used for inserting a new configuration item.
   - **Remove:** it is a request which is used for deleting a confirguration item.
   - **Update:** it is a request which is used for modifying a configuration item.
   - **Search:** it is a request which is used for searching and retrieving one or more configuration items.

   The configuration item refers to a set of configuration values. For example, user account is a set of values, it consists of name, address, and so on.

The figure 3.5 shows the process of exchange of information between both applications. Upon the execution of the received request, the NA Configuration Interface sends back a response message back to the requester (in this case the NA Administration application).

The response message is designed to carry two types of message: acknowledgment status, and configuration item(s). The acknowledgment status message is sent back to the NA Administration application as a response to the following commands: Add, Update, and Remove. Meanwhile, the message with configuration item(s) is sent back to the NA Administration application in response to Search command.

3.3.3 NA meta-data Integration Interface

This component is designed to handle meta-data retrieved from the nodes of the NSDI such as OGC-CS/W. In addition, The NA meta-data Integration Interface is capable of extracting information, concerning the reference to the spatial datasets, from the meta-data. The extracted information is stored in the NA Repository; and later used by the NA Browser (GUI) to locate the spatial datasets (e.g. WMS, WFS, WCS, ...ect).

Within this section the term 'local meta-data' is used, and refers to the extracted information stored in the NA Repository. Whilst, the term 'remote meta-data' refers to the meta-data within the Web Catalog servers (OGC-CS/W).

As can be seen in figure 3.6, the NA meta-data Integration's process can be invoked via two methods: Automatic and Manual.

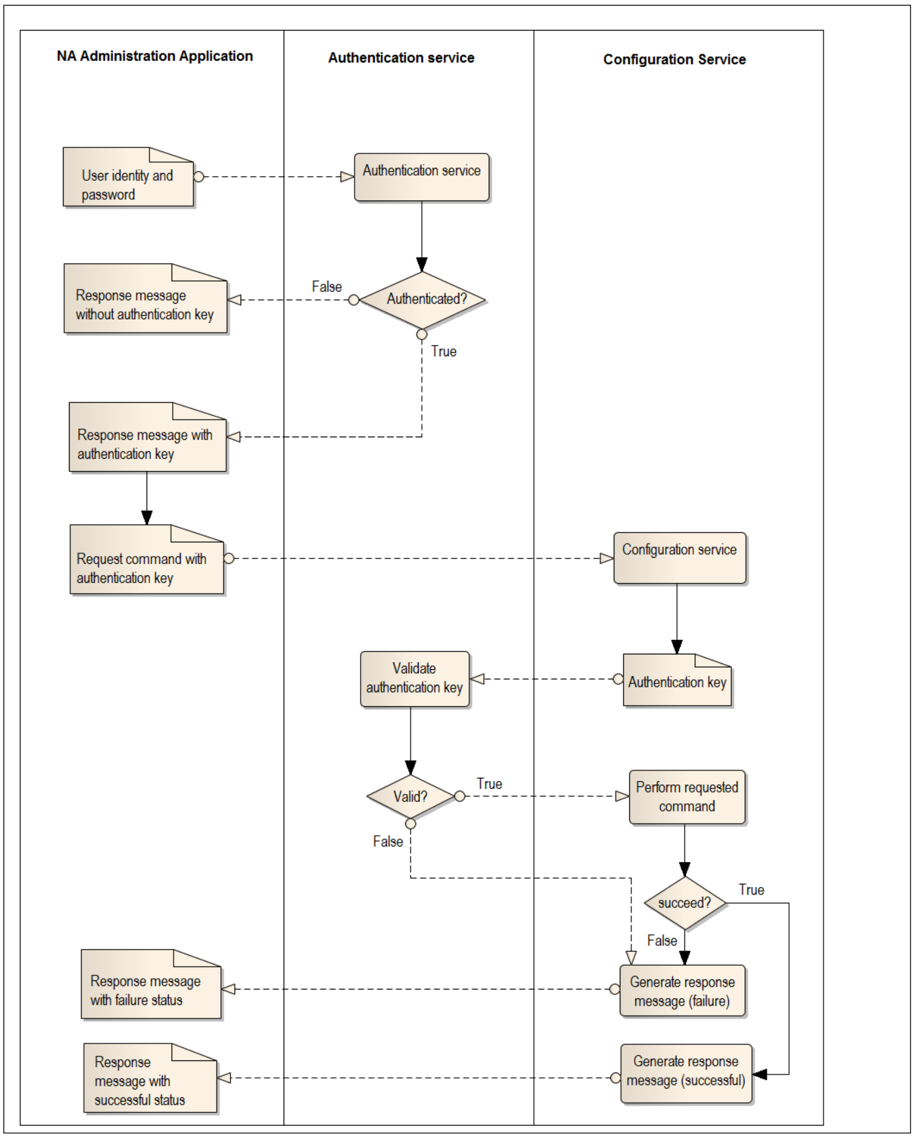

Figure 3.5: The interaction between the NA Administration application and the NA Configuration interface

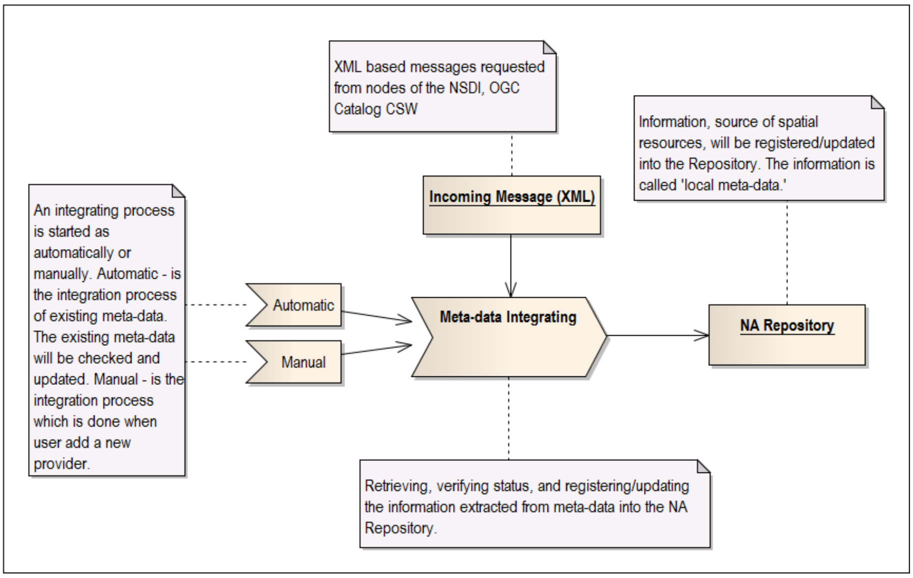

Figure 3.6: The business processing model of NA meta-data Integration Interface

The automatic process is used for synchronisation process. This process is automatically started based on the synchronisation schedule. It synchronises the local meta-data with the remote meta-data. The modified date of the remote meta-data will be compared with the modified of the local meta-data in order to determine whether the local meta-data need to be synchronised or not. A meta-data could be daily, weekly or monthly synchronised with the remote meta-data. Initially, the synchronisation plan (daily, weekly, or monthly) of a newly inserted meta-data will be set to daily; and the next synchronisation date will be set after it is successfully synchronised.

The synchronisation process will change the synchronisation plan after the synchronisation process is done based on the following pattern:

1. If the [current date] - [modified date] >= 7 days, the synchronisation plan will be change to weekly.

2. If the [current date] - [modified date] >= 4 weeks, the synchronisation plan will be change to monthly.

   The flowchart of the synchronistation plan updating process is illustrated in figure 3.7.

Once the meta-data is modified, the synchronisation plan is set back to daily and the plan will be changed accordingly to the above pattern upon the synchronisation process is successfully done. In case remote meta-data is unreachable, the inactive date will be set. This inactive date will be used by the NA Browser (GUI) in order to exclude the inactive meta-data from being loaded. All inactive meta-data will be removed from the NA Repository after the next synchronisation. This synchronisation process will keep the local meta-data being up-to-date.

On the other hand, the manual process is used for adding new node (provider) and retrieving meta-data from the nodes of the NSDI. A new provider would be manually added by authorised user(s) via the NA Administration (GUI). The NA Administration (GUI) also provide the functionality for the authorised user(s) to invoke the meta-data fetching process.

In addition, this component performs the following tasks in order to handle the incoming meta-data and store them in the NA Repository:

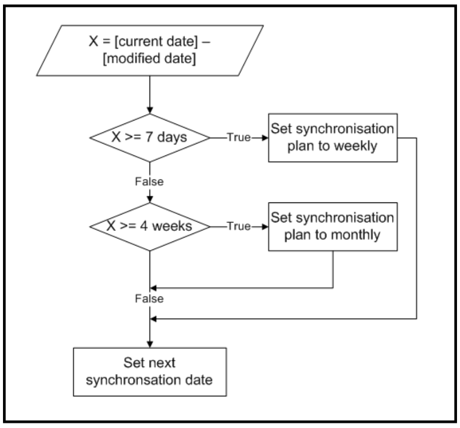

Figure 3.7: Flowchart of the synchronisation plan

1. Verify and identify the schema of the incoming meta-data. Integration process will be aborted if meta-data has un-supported schema.
2. Verify the status of the meta-data. Initially, the UUID of the provider and the UUID of the meta-data will be used for determining whether the meta-data is already existing or not. In case the meta-data already exists, the status will be determined based on the modified dates of the local meta-data and the remote meta-data.
3. Extract information from the meta-data (See section 3.3.1 for what is the information).
4. Based on the status of the meta-data verified in task 2, the extracted information of the meta-data would be inserted or updated into the NA Repository.

   The record will be flaged as "alert" in case there is any conficts; and it would be flaged as "active" if the meta-data can be inserted or updated successfully.

The NA Administration (GUI) will be used for adding, editing, or removing provider(s). Moreover, the synchronisation plan can be also configured via this application.

3.3.4 NA meta-data Providing Interface

This component is designed based on Web service standards such as OGC-CS/W, and WSDL (Web Services Description Language) [34]. It provides the possibility to the NA Browser and the nodes of the NSDI to access the meta-data within the NA Repository.

As shown in figure 3.8, this component has two interfaces: interface for the NA Browser (GUI) and interface for the nodes of the NSDI. These two interfaces provide the following functionalities:

- **Interface for the NA Browser (GUI):** it is especially designed as an interface for the NA Browser (GUI) in order to retrieve the meta-data from the NA Repository. The meta-data contains the necessary information that the NA Browser (GUI) could use for locating and accessing the spatial datasets located in the remote servers (nodes of the NSDI). This interface provides a list of request commands and parameters. For example, the command "getrecords" allows the NA Browser (GUI) to get all meta-data from the NA Repository. Whilst, the parameter "metadataid" would be required for the command "getrecord". As it provides a list of request commands and parameters, it is a good idea to adapt the WSDL

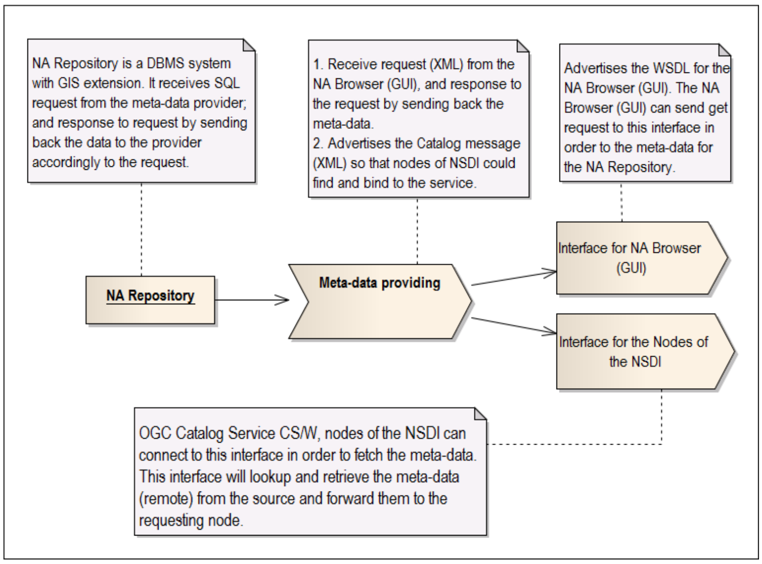

Figure 3.8: The business processing model of NA meta-data Provider

Web service standard so that the request commands and parameters could be advertised as a WSDL based document. This doucment is an XML based message that helps to describe the service [34]. With this document, the application client such as the NA Browser (GUI) could discover the services provided by this interface.

- **Interface for the nodes of the NSDI:** it is required for this interface to be designed based on OGC-CS/W standard so that the National Atlas - Geo Web service could provide a chaining service for the nodes of the NSDI. This interface allows the nodes of the NSDI to discover, bind to the service, and retrieve the meta-data from the Geo Web Catalog. Since the NA Repository stores only the reference information of the available meta-data, this interface will use the functionality of the NA meta-data Integration Interface to retrieve the meta-data from the providers and forward those meta-data to the requester. However, this interface is not necessary for the National Atlas - Geo Web service. It is designed as an additional feature in which the National Atlas - Geo Web service could be an alternative access to spatial information with the NSDI [2].

These two standard Web service interfaces allow the NA Browser (GUI) and the nodes of the NSDI to discover and bind to these services in order to fetch meta-data and locate the spatial datasets.

3.4 SUMMARY

In conclusion, the purpose of this conceptual model is to design the National Atlas as a loosely coupled system. As illustrated in figure 3.3, the National Atlas - Geo Web service is designed to have two main componenets: the NA Web service Mediator and the NA Client applications. The NA Web service Mediator is designed to be an interoperable interface so that it can serve as a middleware between the NA Client applications and the nodes of the NSDI. In addition, this conceptual model allows us to implement and upgrade the two components independently which makes the National Atlas - Geo Web service more scalable. As a result of this design, the conceptual model makes the National Atlas - Geo Web service more interoperable and scalable, and it can be integrated as a node of the NSDI.

Chapter 4

National Atlas - Geo Web service: prototype - design & implementation

4.1 INTRODUCTION

A prototype of the National Atlas - Geo Web service is presented in this chapter in order to evaluate the conceptual model provided in the previous chapter. As mentioned earlier, the NA Web service Mediator is the main component; and parts of its sub-components will be implemented as a prototype. In addition, a small part of NA Admistration (GUI) will be built as client tool in order to invoke the services of the NA Web service Mediator.

The sub-components of NA Web service Mediator included in this prototype are:

- NA Repository
- NA Configuration interface
- NA meta-data Integration Interface
- NA meta-data Providing Interface

4.2 DESIGN AND IMPLEMENTATION ENVIRONMENT

This prototype is designed and built by using software from both domains, proprietary and open source. The software selected for the development of this prototype are:

1. **Proprietary software:**
   - Enterprise Architect (Sparx System): this software is used for modeling the structure of the database of the NA Repository. It is chosen for this prototype because this software is available for ITC student, and it supports MDA approach (refer to section 1.5.1 for more details) which is adapted for modeling the database of the NA Repository.
2. **Open source software:**
   - Eclipse IDE: this software is used for implementing the NA Web service Mediator and the NA Administration (GUI). I chose this development environment because I am familiar with this software and it has variety of plug-in which facilitates the software development by reducing the development's time and tasks. For example, the Web plug-in provides a wizard for creating Dynamic Web application (Java 2 Enterprise Edition - Servlet & JSP).
   - Tomcat (Apache): this is a free Web server application which supports server programming language such as Java. I chose this Web application because it is widely use by Web development community in which trouble shooting is usually available in online forum.

- PostgreSQL and PostGIS extension: this DBMS package is free and well-known by software development community. It support SQL query language; and its GIS extension is OGC compliant which is reliable for handling spatial information.
- JEE (Java Enterprise Edition): this is a Java programming language designed for Web platform. It provides web library API for a fast development in Web based application. I chose this programming platform because I am familiar with Java programming language.
- HTML and Javascript: they are used for implementing the NA Administration (GUI). HTML is used for visualisation (GUI), while Javascript is used as a communication interface between client and server application (the NA Web service Mediator).

4.3 NA REPOSITORY

It is important for the prototype to have this component designed and implemented because this component is needed for storing and handling the configuration parameters and the information retrieved from the nodes of the NSDI. Based on the conceptual design, this component is a DBMS with GIS capability. So, PostgreSQL is used as a foundation for prototyping this component. This DBMS is free and its GIS extension is OGC compliant.

MDA approach is adapted for designing the structure of this component (database) because MDA based software such as Enterprise Architect (Sparx Systems) has transformation functionality. The transformation function allows us to transform a conceptual model to Data Definition Language (DDL). The result of the transformation is DDL script of the database structure. Since DMBS such as PostgreSQL supports DDL script, using MDA based software would reduce the development time.

In postgreSQL DBMS, a database can be created through two methods: running SQL creating script and wizard (the wizard is available in pgAdmin, a GUI application for managing postgreSQL database). For this prototype the database was created through database creation wizard as the following:

1. Creating a new user: this is an optional step in which the existing user such as "postgres" can be used. I create this user because I would like to manage the privileges of users within my database server.
2. Next steps are given in the screen-short as illlustrated in figure 4.1.

A screen-shot of the pgAdmin III is shown in figure 4.1. More details on the creation of the database and user in postgreSQL can be found in the online manual of the PostgreSQL's website [24].

After the database is created, the DDL script transformed from the database design model can be executed by using SQL console. However, the script need to be modified because the transformation done by Enterprise Architect software is not fully functioning. For example, the geometry column needs to be added by using function "AddGeometryColumn(...)". In addition, sequences are created in order to generate unique id for tables such as UserAccount, AuthKey, MetaDataProvider, and MetaData. Moreover, functions also need to be created in order to handle the information within the database. The list of sequence's name, function's name, and table's name are given as the following:

1. **Tables:**

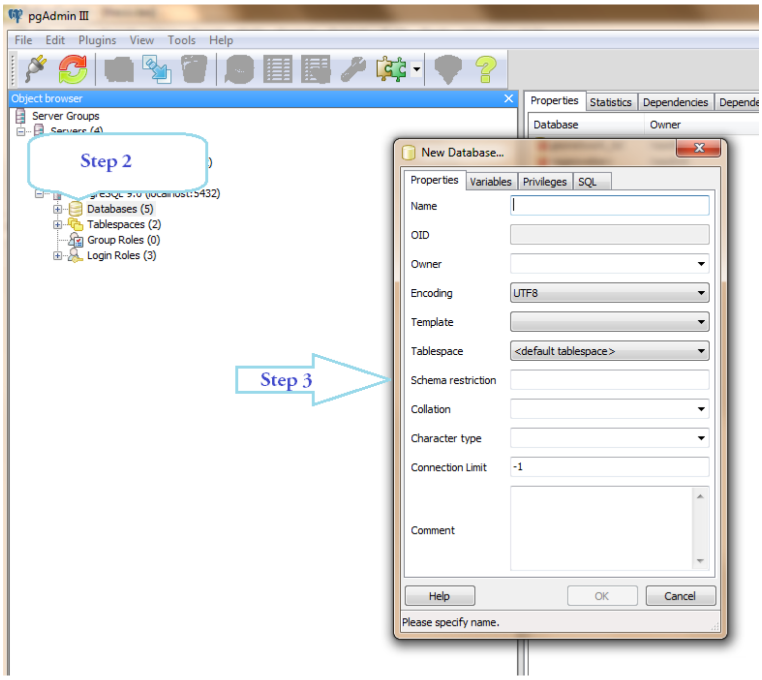

Figure 4.1: Screen-shot of pgAdmin III (database creation).

- NaGroup (notice that I was trying to create this table with name “Group” but it conflicts with the keyword used by PostgreSQL software itself.)
- UserAccount
- UserGroup
- AuthKey
- MetaDataProvider
- Category
- MetaData

2. **Sequences:**

   - nagroup_seq
   - useraccount_seq
   - category_seq
   - provider_seq
   - metadata_seq

3. **Functions:** these functions were written in PL/pgSQL (Procedural Language/PostgreSQL Structured Query Language) procedural language supported by PostgreSQL DBMS. The PL/pgSQL language allows us to create SQL based procedure that can be loaded by using standard SQL [23]. On the other hand, I prefer to create these functions because they will be processed in the database server so that the processing at the Web server side could be reduced. This would help optimising the performance of National Atlas system.

   - na_getauthkey

- na_delAuthKey
- na_insert_provider
- na_del_provider
- na_insert_metadata

The database model is shown in figure 4.2. The database, tables, sequences, and functions creation scripts will be available in digital format which could be found in the Dutch National Atalas's website (http://www.nationaleatlas.nl/).

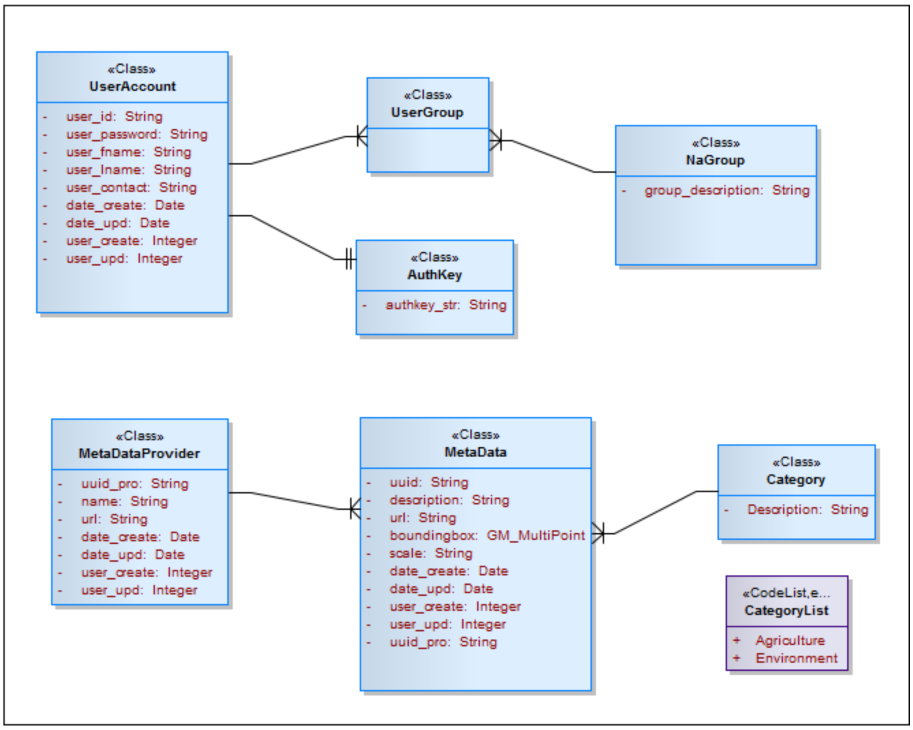

Figure 4.2: The model of the NA Repository's database (prototype).

In addition to the figure 4.2, there are relationships between tables (UserAccount and MetaData, UserAccount and MetaDataProvider) which is added to the creation script manually. The fields, user_create and user_upd of tables MetaData and MetaDataProvider, are foreign keys of the primary key userAccountID of table UserAccount. These fields are used for keeping track of who creates and updates the record(s).

4.4 NA CONFIGURATION INTERFACE

As mentioned in the conceptual model, this component has two main services: the authentication service and the system configuration service. However, only the authentication service was designed and implemented in this prototype. This component was implemented by using Java Servlet technology, and deployed in Apache Tomcat server application. It was developed as a Web service interface in which the client application can send the request command to the service through http (request and response) protocol. Moreover, the request commands which are designed and implemented for this prototype are: login and logout.

1. **Login request (REQUESTS=login):** this request command has two parameters as the following:

    - usrid: this parameter handles user identifier from the client application.
    - usrpwd: this parameter handles password from the client application. Notice that as a prototype the password is not encrypted, but for production environment this is strongly recommended.

    Both parameters are mandatory. Once the user identifier and password are given, service will validate the given credential information with the credential information within the database. Once the validation is completed, a response message will be sent back to the client. The response message contains the status of the validation and the authentication key. However, the authentication key is sent back to the client only if the given credential inforamtion are matched with the credential information within database. In addition, the authentication key is generated and stored in the database in order to manage the session of the user. Since the authentication key generating process could be done either at database system level or at Web service component level, I chose to implement it at the database system level for this prototype. Furthermore, this authentication key is required by the other services of the NA Web service Mediator in order to identify the user and operate the requested command. This authentication service allows the National Atlas - Geo Web service to prevent the system from being anonymously accessed.

2. **Logout request (REQUESTS=logout):** this request command has one parameter as the following:

    - authkeystr: this parameter handles the authentication key from the client application. It is a mandatory parameter needed for removing the session of the user from the database.

    The authentication service remove the authentication key from the database once it recieve this request command. The response message with operation status will be sent back to the client appliation.

Sample structure of the request command

```
http://localhost:8080/nageowebsrv/na.config?REQUESTS=login&usrid=<userid>&usrpwd=<password>
```

Response message when the authentication is failed

```
<?xml version="1.0" ?>
<response status="_FL" requestparam="login">null</response>
```

Response message when the authentication is successful

```
<?xml version="1.0" ?>
<response status="_OK" requestparam="login">1-CHA-0000 0-RM</response>
```

Figure 4.3: A sample structure of request (URL) and response messages.

A sample structure of the request (URL) and response messages is shown in figure 4.3; and the programming code will be be available in digital format which could be found in the Dutch National Atalas's website (http://www.nationaleatlas.nl/).

4.5 NA META-DATA INTEGRATION INTERFACE

As a sub-component of the NA Web service Mediator, only parts of this component was designed and implemented in this prototype. It was implemented by using Java Servlet technology. In this prototype, the implemented functionalities are: adding new provider, removing a provider, fetching meta-data from the provider, and retrieving providers. The characteristics of these functionalities are described as the following:

1. **Adding new provider (REQUESTS=addpvd):** this service has three mandatory pararamters: authkeystr, pvdname, and pvdurl.

    - authkeystr: this parameter handles authentication key.
    - pvdname: this parameter handles name of meta-data provider. The value of this parameter must be unique.
    - pvdurl: this parameter handles URL of meta-data provider. The value of this parameter must also be unique.

    As shown in figure 4.4, this function validates the authentication key, check name and URL whether they are unique or not. Before inserting the provider into the NA Repository's database, the availability of the URL will be check. In addition, this function would send a response message back to the requester. The message contains the status of the operation whether it is successfully performed or failed.

2. **Removing a provider (REQUESTS=delpvd):** this service has two mandatory parameters: authkeystr and pvdid.

    - authkeystr: this parameter handles authentication key.
    - pvdid: this parameter handles identifier of a provider.

    Like the above function, this function validates the authentication key and performs the removing operation. Before removing a provider from the NA Repository's database, it checks the meta-data associated with the provider. The associated meta-data would be removed before removing the provider. A response message with the status of the operation would also be sent back to the requester.

3. **Fetching meta-data from provider (REQUESTS=fetchme):** this service has two mandatory pararamters: authkeystr and pvdid.

    - authkeystr: this parameter handles authentication key.
    - pvdid: this parameter handles identifier of a provider.

    This function also validates the authentication key and performs the fetching operation. Before fetching meta-data from the provider, it checks the meta-data associated with the provider. The associated meta-data would be removed before inserting new meta-data retrieved from the provider. A response message with the status of the operation is also sent back to the requester.

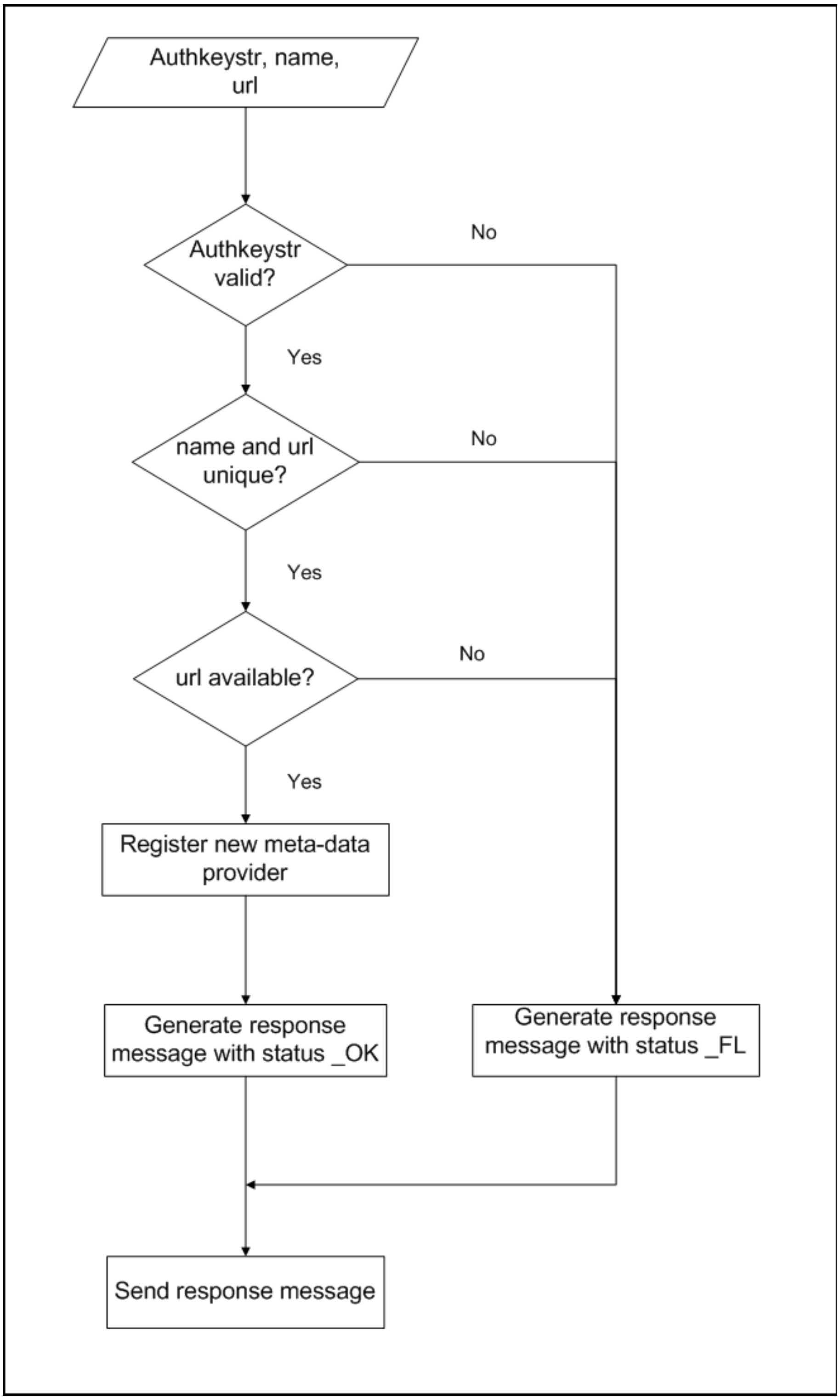

Figure 4.4: Flowchart of Adding new provider.

4. **Selecting provider from the NA Repository's database (REQUESTS=getrecords):** this service has two mandatory pararamters which are authkeystr and pvdid.

   - authkeystr: this parameter handles authentication key.
   - pvdid: this parameter handles identifier of a provider.

   This function also validates the authentication key and performs the selecting operation. It retrieve the information of all providers from the NA Repository's database and send them back to the requester. Unlike response message of the above functions, the response message of this would contain the information of selected providers in case the operation is successfully done. Otherwise, a normal response message would be sent back to the requester. A sample of response message is shown in figure 4.5.


```
  <?xml version="1.0" ?>
- <response status="_OK" requestparam="getrecords">
    <pvd id="21">Dutch Cat.</pvd>
    <pvd id="23">Inspire Cat.</pvd>
  </response>
```


Figure 4.5: Response message with the information of provider(s).

4.6 NA META-DATA PROVIDING INTERFACE

In this component, there is only one function is implemented. The task of this function is to select all meta-data from the NA Repository's database. Like the other sub-component, Java Servlet technology is used for implementing this component. In addition, this function (REQUESTS=getrecords) has one mandatory parameter which is **authkeystr**. This function would return a response message with the information of meta-data or a response message with the status of the operation. A sample of the response message is shown in figure 4.6. Moreover, there is no standard schema adapted for the response message in this prototype. However, it is recommended for the production environment to adapt a standard schema for the response message in order to standarise the interface so that it could be an interoperable interface.

4.7 NA ADMINISTRATION GUI (CLIENT)

Besides implementing parts of the NA Web service Mediator, a client tool (GUI) is also implemented. This client tool is a thin client application implemented based on HTML and Javascript technologies. This client tool is used for invoking the services provided by the NA Web service Mediator. The functionalities of this client tool are listed as the following:

1. **Login:** the login form consists of two text boxes and two buttons. The text boxes allow the user(s) to input user id and password. The user can click on the button <Login> in order to start the authentication process. While, the button <Clear> is for clearing the user id and password. Once the button <Login> is clicked, the user id and password are submitted to

```xml
<?xml version="1.0" ?>
- <response status="_OK" requestparam="getrecords">
    <met id="277">Image2000 Product 1 (fr13) Multispectral</met>
    <met id="278">Image2000 Product 1 (pt8) Multispectral</met>
    <met id="279">Image2000 Product 1 (uk13) Panchromatic</met>
    <met id="280">Image2000 Product 1 (es30) Panchromatic</met>
    <met id="281">Image2000 Product 1 (se34) Panchromatic</met>
    <met id="282">Image2000 Product 1 (ie6) Panchromatic</met>
    <met id="283">Image2000 Product 1 (es23) Multispectral</met>
    <met id="284">Image2000 Product 1 (fr19) Multispectral</met>
    <met id="285">Image2000 Product 1 (gr1) Multispectral</met>
    <met id="286">Image2000 Product 1 (nl5) Multispectral</met>
    <met id="257">RiverBasin</met>
    <met id="258">Watercourse</met>
    <met id="259">DamOrWeir</met>
    <met id="260">DrainageBasin</met>
    <met id="261">Crossing</met>
    <met id="262">PKB Derde Nota Waddenzee - Onveilige zone</met>
    <met id="263">PKB Derde Nota Waddenzee - Bestaande gaswinning</met>
    <met id="264">Aster_5aug2007_Ede_false colour</met>
    <met id="265">Schiphol Lden geluidscontouren 1999</met>
    <met id="266">Schiphol Lden geluidscontouren 1994</met>
  </response>
```


Figure 4.6: Response message with the information of meta-data.

the NA Configuration Interface as it provides the authentication service. Javascript techology is used for submitting the request command and handling the response message. If the user is authenticated, an authentication key is given and the user is navigated to another form. In case the authentication is failed, a notification message is displayed. The figure 4.7 shows the login form and warning message.

2. **Meta-data Provider Management:** this page consists of text boxes, buttons, and tables. This page could be devided into three main modules as the following:

    - Logout: this is a common module which would be included in all pages of the NA Administration (GUI). This module conists of a message box and a button. The message box is used for displaying the authentication key, while the <Logout> button is used for logging out of the NA Administration (GUI) application. Once the button is clicked, a request is sent to the NA Configuration interface. The user would be navigated back to the homepage (Login) if the logout process is successfully performed.
    - Adding new meta-data provider: this module consists of text boxes which allows the user to fill the information of the meta-data provider. The text boxes such as name, host or ip address, and service name are mandatory. The button <Add> is used for submitting the information of provider to the NA meta-data Integration Interface.
    - Retrieving meta-data: this module consists of buttons and tables. These buttons perform three main tasks as the following:
        - Refreshing the lists: there are two buttons which is implemented for retrieving providers and meta-data from the NA Repository's database; and displaying them as tables.
        - Retrieving meta-data: these buttons send request command to the NA meta-data Intergation Interface in order to perform the meta-data retrieving task.

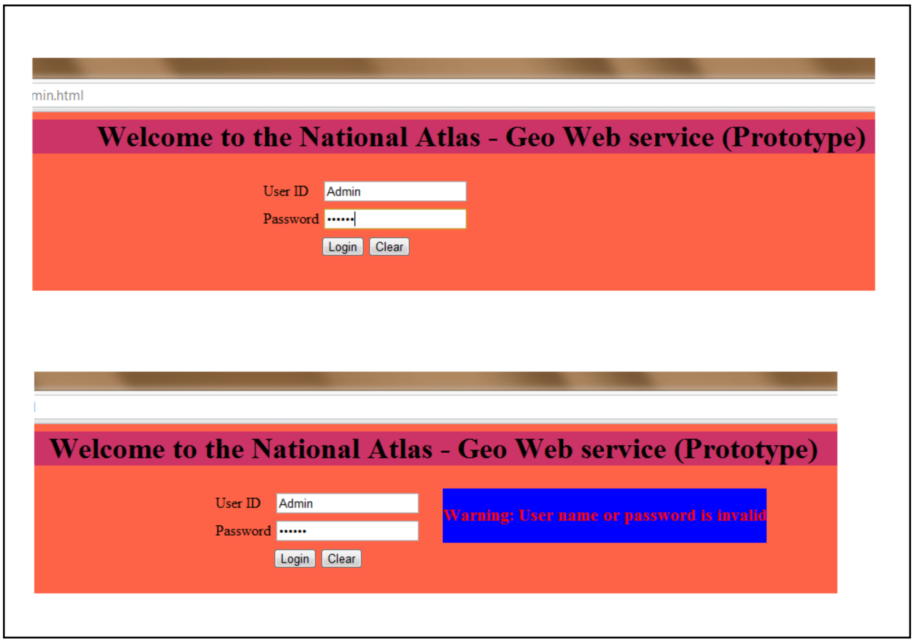

Figure 4.7: Login form, and warning message when the authentication has failed.

- Deleting provider: these buttons send request command to the NA meta-data Intergation Interface in order to perform the provider removing task.

A screen-shot of the Meta-data Provider Management is shown in figure 4.8.

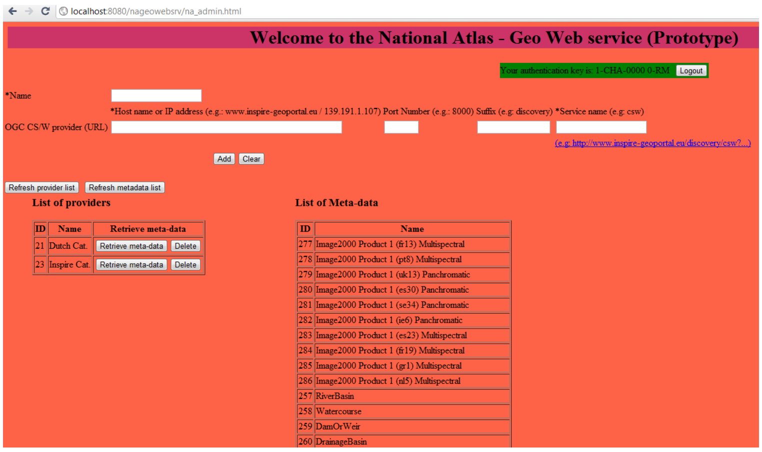

Figure 4.8: A screen-shot of the Meta-data Provider Management.

4.8 SUMMARY

In conclusion, as presented in the previous sections, a prototype of the NA Geo Web service is designed and implemented. The design and implementation of this prototype focuses on the NA Web service Mediator because this component is mainly focused in this research. A client application is also implemented in order to evaluate the services provided by the NA Web service Mediator.

This prototype is implemented in order to evaluate the conceptual model presented in chapter 3. As presented in this chapter, the next generation of the National Atlas can be fully integrated as a node of the NSDI.

Chapter 5

Conclusion and recommendation

In this chapter, the archievement of the research will be concluded and presented in section 5.1; and recommendations will also be provided in section 5.2.

5.1 CONCLUSION

This research has been conducted based on the research structure listed in section 1.6. By following this research structure, the research question posed in section 1.2.2 could be answered. The answers of these questions help to achieve the objectives of the research: designing the software architecture of the new National Atlas and Geo Web service based components for the National Atlas so that it could retrieve meta-data from the nodes of the NSDI. The archievement of this research are presented as the following:

- **The literature review:** the research papers and the documents related to the current edition of the Dutch National Atlas help to identify the improperly designed components; and they also help to realise on how these components would be designed as interoperable components so that the National Atlas could be integrated as a node of the National Spatial Data Infrastructure (NSDI). In addition, the documents and the recommendation of the research papers help in determining which techologies and design approaches could be used for the conceptualisation and the implementation of the National Atlas - Geo Web service. As a result of the literature review process, techologies and design approaches are chosen for designing the conceptual model of the National Atlas - Geo Web service. At this stage, the following questions are answered:

  a) **Question:** *What are the existing designing approaches which can be used for web-based National Atlas within the context of NSDI?*
  Answer: As stated in secion 1.5.1, the introductory chapter, Model Driven Architecture (MDA) approach would be initially used. However, the MDA is not used for modeling the National Atlas - Geo Web service because another approach, Business Process Modeling (BPM), is found to be more suitable. The BPM approach is suitable for modeling service oriented system. Since the National Atlas - Geo Web service is a service oriented system, BPM approach is adapted. Although MDA are not used for the conceptual model design, it is used for the design of the NA Repository, a component of the National Atlas - Geo Web service (see section 3.3.1). Therefore, there are two modeling approaches which have been used in this research.

  b) **Question:** *What components are missing or improperly designed in the current prototype?*
  Answer: As described in section 2.4.2, the National Atlas should be integrated as a node of the NSDI in order to make used of the available spatial datasets within the NSDI. Regarding to the current prototype of the Dutch National Atlas (third edition), the mediator component is required in order to mediate the data between the nodes of the NSDI and the National Atlas. The Mediator, as provide in section

3.3, provides the possibility to the National Atlas to make use of the available spatial datasets. Therefore, an interoperable component such as a Web service mediator is missing.

- **The conceptual design:** at this stage, we discovered how the components of the National Atlas could be designed based on the Geo Web service technology. The Geo Web service based components help transforming the National Atlas from a tightly coupled to a loosely coupled. As a result, the National Atlas is conceptually designed as an interoperable system which could be integrated as a node of the NSDI. At this stage the following questions are answered:

  c) **Question:** *How can Geo Web service be used to tackle the problems stated in paragraph 3 and 4 of Motivation and problem statement?*
  Answer: The Geo Web service technology provides the possibility to build such interoperable components for the National Atlas. The interoperable components allows the nodes of the NSDI and the National Atlas to connect and exchange data seamlessly. In addition, with such interoperable components; the National Atlas is a loosely coupled system. As a result, the National Atlas can be an interoperable and scalable system which can be integrated as a node of the NSDI.

  d) **Question:** *How will Geo Web service be built as new components of the National Atlas?*
  Answer: As described in section 3.3, the NA Web service Mediator is a Geo Web service component. It provides mediation services to the National Alas's client application (GUI) and the nodes of the NSDI as data exchange interfaces.

  e) **Question:** *How must the components be integrated into the NSDI?*
  Answer: To be a node of the NSDI, a system must be interoperable; and in order to be an interoperable system, a standard must be adapted. As Open Geospatial Consortium (OGC) plays an important role in the innovation of the Spatial Data Infrastructure (SDI), OGC's standards should be adapted for the design of this new component. Not only adapting standards would make the system interoperable, but also choosing the right technologies and design approach. Unfortunately, only design approach is being concerned in this research because the adaptation of standards is the concern at the production stage. However, the conceptual model presented in chapter 2 suggested that the National Atlas would be integrated into the NSDI as a node which could retrieve the meta-data and spatial datasets from the nodes of the NSDI and also could provide the chaining service to the nodes of the NSDI as well.

  f) **Question:** *How can the National Atlas system be designed to be interoperable and scalable?*
  Answer: In order to design the National Atlas as an interoperable and scalable system, first is to design it based on a proper design approach (such as BPM). Second, standards should be adapted according to the system environment. For example, OGC's standards would be adapted for the system that would be integrated as a node of the NSDI. Third, right technologies should be chosen for the implementation at the production stage. With the right technologies, a system will be scalable. For the design of the National Atlas, BPM approach is adapted for its conceptual model designing. The conceptual model is designed regarding to the OGC's standards such as OGC-CS/W. In addition, the technologies such as Web service, JEE (Java Enterprise Edition) are recommended for the implementation of the production.

g) **Question:** *How the new solution will be put into practice? Prototyping? Or setting up as theoretical recommendation?*
   Answer: Based on the availability of the time for this research, there is a space which can be spent on implementing parts of the conceptual model as a prototype. The prototype is built as an evaluation tool for testing the conceptual model. The result of the implementation proves that it is possible to integrate the National Atas as a node of the NSDI.

- **The prototype:** at this stage, the conceptual model is evaluated by implementing a prototype of the core component and a web based client. As a result of the evaluation, it could be concluded as the following:

  1. It is possible to integrate the National Atlas as a node of the NSDI.
  2. It is possible for the National Atlas - Geo Web service to provide a chaining service between the Geo Web Catalog (OGC-CS/W) and the other nodes of the NSDI.
  3. The core component of the National Atlas - GeoWeb service can be compatible with the client application (GUI) of any platform, thick or thin, because it is a Web service based component that was implemented in the prototype.

In summary, a conceptual model of the National Atlas - Geo Web service was designed, and evaluated. The evaluation proved that the National Atlas can be integrated as a node of the NSDI. Since this research only focuses on the main component, the research on the other components remains to be done.

5.2 RECOMMENDATIONS

As a result of this research, recommendations are given as the following:

1. **Design approach:** since BPM approach is adapted for the design of this conceptual model, the prototype is implemented manually. I would recommend to the future work to find any existing design approaches and software packages which allow transformation of the conceptual model to a specific platform. For example, MDA approach is used for designing the conceptual model of the NA Repository (DBMS) and this conceptual model could be transformed to a specific platform such as PostgreSQL.

2. **Necessary information to be extracted from meta-data:** as mentioned in section 3.3.1, the neccessary information to be extracted from the meta-data has not been determined yet because it depends on the requirement defined by the NA Browser (GUI). Therefore, I would recommend to the future work to focus on defining the necessary information.

3. **Client Applications (GUI):** since only the core component is focused in this research, other components such as the NA Browser (GUI) and the NA Administration (GUI) should be focused in the future work.

4. **Prototype:** due to the time constraint, the implementation of the prototype was done without adapting any software design patterns or frameworks. For example, the connection to the database (the NA Repository) is hard coded while the database abstraction layer could be used. The database abstraction layer framework such as Hiberate [7] could be used for the prototype because this framework supports Java based software. This database abstraction layer helps to reduce the programing workload by providing a consistent API. This

API allows developer to work on their application without concerning about how to handle database connection. In addition, the database abstraction layer is not only available in Java platform, but also in other platforms. Technically, it is reliable and scalable because the connection of the database is handled by the framework. Moreover, it provides the easiest way for switching database from one product to another without the requirement of modifying the business logic of the application. Therefore, I would recommend for the production environment of the National Atlas - Geo Web service to use a database abstraction layer framework.

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