# TOWARDS A NATIONAL ATLAS - GEO WEB SERVICE

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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.

**Key words:** The National Atlas, The National Spatial Data Infrastructure (NSDI), Geo Web service

## 1. Introduction

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 [(10)]. With the numerous map productions, maps have been collected as collection of maps called "Atlas."

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 [(11)]. 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 [(17)]. 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 [(16)]. 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.

## 2. 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.

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

b) [(2)] - 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) [(5)] - 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) [(8)] - 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) [1] - 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 [4] - 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.

## 4. The National Atlas

**4.1 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 [2].

**4.2 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 [1].

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) [14], 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 [11]. 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) [9] . Nevertheless, the digital National Atlas could be published through a so-called Information Technology, World Wide Web (WWW).

**4.3 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 [16] and the National Atlas of Canada [18]. 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 [6]. The online National Atlases of these two nations could illustrate how far the Internet based National Atlas have been.

**4.4 Functionality** Based on the paper of Farjan Ormeling [6], 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.

## 5. Spatial Data Infrastructure(SDI)

The fundamental of the SDI is about facilitation and coordination of the spatial data interchange and sharing among the stakeholders within the community [15]. In addtion, the basic components of SDI are: data sets, institutional framework, policies, technology, standards, and human resources [7]. 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 [12], the term National Spatial Data Infrastructure (NSDI) is introduced at the national level.

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) [11], "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 [13].

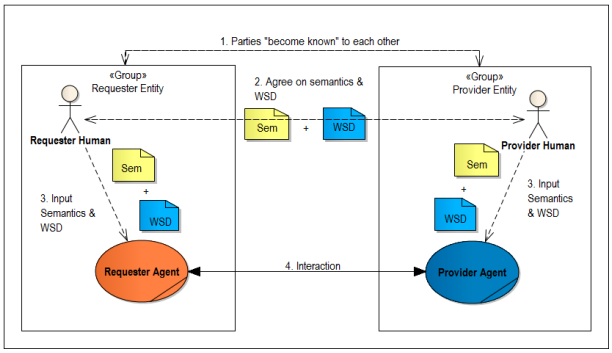
## 6. Web service and Geo Web service

"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 [20].

**6.1 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" [3].

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 1 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 [21].

Fig. 1. The General Process of Engaging a Web Service (modified [21])




**6.2 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) [19]. The description of the common OGC Web Service standards could be found in figure 2.

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.

## 7. Conceptual Model

This conceptual model defines the Geo Web service components, the relationship among the components, and the

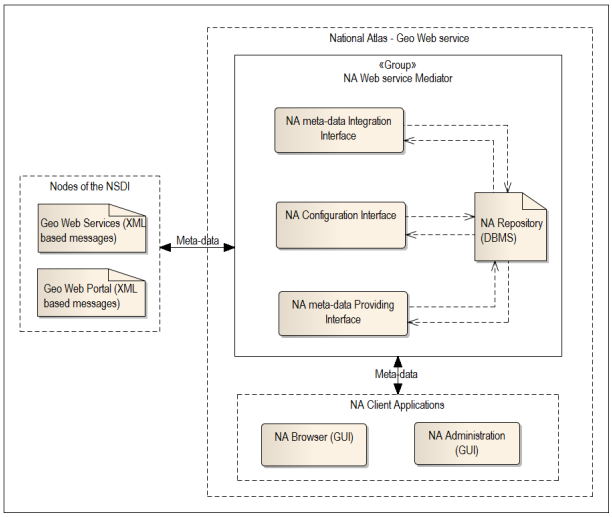
Fig. 2. OGC Geo Web Service Standards [23]

- 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.

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.

Fig. 3. Detail diagram of business processing model of the National Atlas - Geo Web service




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.

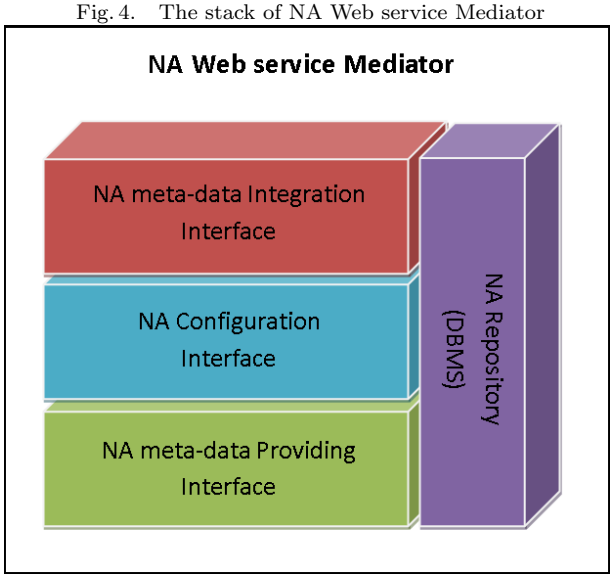
It is presented below a general description of the components:

- **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, 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.
- **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.

## 8. 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 4.

Fig. 4. The stack of NA Web service Mediator




**8.1 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 and Meta-data.

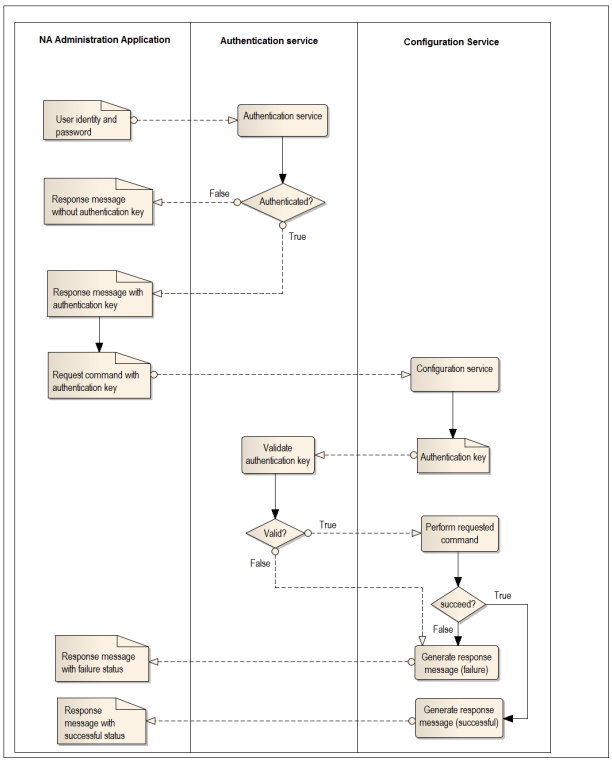
The NA Repository should be implemented in a Database Management System (DBMS) because it has full functionality on managing and storing information (meta-data).

**8.2 NA Configuration Interface** This component is designed to allow the NA Administration application ac-

cess 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.

Fig. 5. The interaction between the NA Administration application and the NA Configuration interface



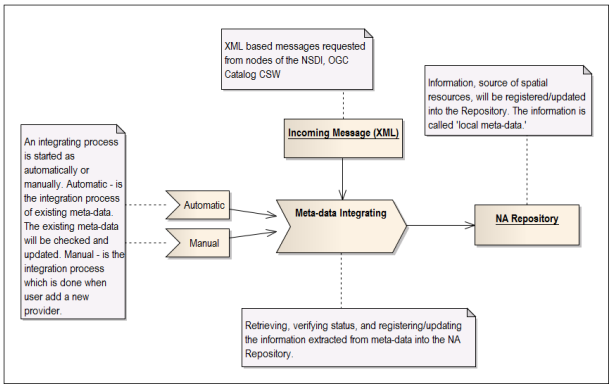

The figure 5 shows the process of exchange of information between both applications. Upon the execution of the received request, the NA Configuration Interface sends back a response message back to the requester (in this case the NA Administration application).

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.

**8.3 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).

Fig. 6. The business processing model of NA meta-data Integration Interface




As can be seen in figure 6, the NA meta-data Integration's process can be invoked via two methods: Automatic and Manual.

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.

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:

(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).

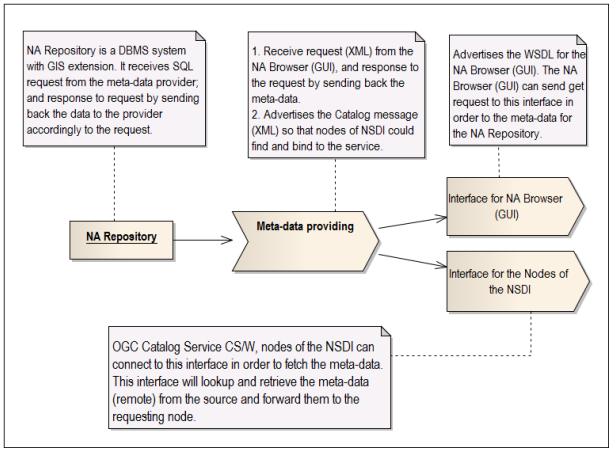
(4) Based on the status of the meta-data verified in task 2, the extracted information of the meta-data would be inserted or updated into the NA Repository.

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.

**8.4 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) [22]. It provides the possibility to the NA Browser and the nodes of the NSDI to access the meta-data within the NA Repository.

Fig. 7. The business processing model of NA meta-data Provider




As shown in figure 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 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 [22]. 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 [1].

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.

## 9. Conclusion

This research presents a conceptual model of the National Atlas - Geo Web service. The new conceptual model is proposed, designed, and evaluated based on the research objectives. The two main objects are:

- 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.

This research is successfully achieved; and result in a new design for the National Atlas to be fully OGC compatible, interoperable, and scalable. The research proved that the next generation of the National Atlas can be integrated as a node of NSDI.

## References

(1) T. Aditya, M.J. Kraak, and F.J. Ormeling. *National Atlas as a Metaphor for Improved Use of a National Geospatial Data Infrastructure*. PhD thesis, 2007.

(2) T. Aditya, F.J. Ormeling, and M.J. Kraak. Advancing a national atlas - based portal for improved use of a gospatial data infrastructure : Applying scenario - based development. *In: Proceedings of Map Asia 2009 : 8th annual Asian conference and exhibition on geospatial information, technology and applications, 18-20 August*

*2009, Singapore. 19 p.*, 2009.

( 3 ) M. Bell. *Service-oriented modeling: service analysis, design, and architecture*. John Wiley & Sons, 2008.

( 4 ) INSPIRE. About INSPIRE. `http://inspire.jrc.ec.europa.eu/index.cfm/pageid/48`, 17-08-2010 2010.

( 5 ) B.J. Köbben and M. Graham. Maps and mash - ups : the national atlas and google earth in a geodata infrastructure. *In: AGILE 2009 : Proceedings of the 12th Agile internationational conference : 2-5 June, Hanover, Germany. AGILE, 2009. 11 p.*, 2009.

( 6 ) B.J. Köbben, F.J. Ormeling, and T. Trainor. *Proceedings of the seminar on electronic atlases II : Charles University, Prague, July 31 - August 2, 1996, and 28th IGU conference, The Hague, August 8, 1996*. International Cartographic Association (ICA), S.l., 1997.

( 7 ) Bas Kok and Loenen Bastiaan van. How to assess the success of national spatial data infrastructures? *Computers, Environment and Urban Systems*, 29(6):699–717, 2005.

( 8 ) A. V. Koshkarev, A. N. Antipov, A. R. Batuyev, V. V. Yermoshin, and V. P. Karakin. Geo-portals as part of spatial data infrastructures: Russian academy-supported resources and geoservices. *Geography and Natural Resources*, 29(1):18–27, 2008.

( 9 ) M.J. Kraak. Dutch national atlas in a GII environment : the application of design templates. *In: Proceedings of the 23nd international cartographic conference ICC: Cartography for everyone and for you, 4-10 August Moscow, Russia. Moscow: International Cartographic Association (ICA). ISBN: 0-958-46093-0. 13 p.*, 2007. [et al.].

(10) M.J. Kraak and F.J. Ormeling. *Cartography : visualization of geospatial data : also as e-book*. Pearson Education, Harlow, third edition edition, 2010.

(11) M.J. Kraak, F.J. Ormeling, B.J. Köbben, and T. Aditya. The potential of a national atlas as integral part of the spatial data infrastructure exemplified by the new dutch national. *In: SDI convergence, research emerging trends and critical assessment / ed by. B. van Loenen, J.W.J. Besemer, and J. Zevenbergen. Delft : Netherlands Geodetic Commission, ISBN 978-90-6132-310-5. (Netherland Geodetic Commission : green series, 48) pp. 9-20*, 2009.

(12) J. Nogueras-Iso, F. J. Zarazaga-Soria, R. Béjar, P. J. Álvarez, and P. R. Muro-Medrano. OGC Catalog Services: a key element for the development of spatial data infrastructures. *Computers and Geosciences*, 31(2):199–209, 2005.

(13) Harlan Joseph Onsrud. *Research and theory in advancing spatial data infrastructure concepts*. ESRI Press, Redlands, Calif., 2007.

(14) F. J. Ormeling Sr. The purpose and use of national atlases. *Cartographica: The International Journal for Geographic Information and Geovisualization*, 16(1):11–23, 1979.

(15) Abbas Rajabifard, Mary-Ellen F. Feeney, and Ian P. Williamson. Future directions for SDI development. *International Journal of Applied Earth Observation and Geoinformation*, 4(1):11–22, 2002.

(16) URL1. United States National Atlas. `http://www.nationalatlas.com/`, 14-07-2010 2010.

(17) URL2. Dutch National Atlas. `http://www.geografiek.nl/anderen/nationaleAtlas/interactief/`, 01-07-2009 2010.

(18) URL4. National Atlas of Canada. `http://atlas.nrcan.gc.ca/site/english/index.html`, 25-10-2010 2010.

(19) B. Van Loenen, J.W.J. Besemer, and J.A. Zevenbergen. *SDI convergence : research, emerging trends, and critical assessment*. Nederlandse Commissie voor Geodesie : groene serie : publikatie;48. Nederlandse Commissie voor Geodesie (NCG), Delft, 2009.

(20) W3C. Web Of Services. `http://www.w3.org/standards/webofservices/`, 16-11-2010 2010.

(21) W3C. Web Services Architecture. `http://www.w3.org/TR/ws-arch/`, 10-11-2010 2010.

(22) W3C. Web Services Description Language. `http://www.w3.org/TR/wsdl`, 24-01-2011 2011.

(23) M. Zumbulidze. Updating process of a national atlas in a GDI environment : the role of atlas editors, 2010.