TOWARD A GEOSPATIAL DATA INFRASTRUCTURE FOR NORTHRHINE-WESTPHALIA[1]

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Abstract

A better exploitation of existing geographic information through intelligent services for citizens, professionals, and decision-makers is urgently needed. The project for a Geospatial Data Infrastructure in Northrhine-Westphalia targets such an improvement by establishing the means for an expansion of markets for geographically related information products and services. This overall objective will be reached by an interdisciplinary approach of institutional, commercial, and research organizations in the GI-market. The Institute for Geoinformatics, University of Muenster, contributes the design of an overall service architecture and a systematic analysis of underlying research questions. A reference model provides the framework for design, communication, and a consensus process amongst the project partners. We present here a first overview of the chosen goals and strategies.

Keywords: geographic information infrastructures, GDI-NRW, information products, business networks, reference model, standards

1 Introduction

Geographic information (GI) remains too often deprived of the predicted market growth, because it is

- held in proprietary formats
- too complex to be easily browsed or combined with other information
- marketed through pricing schemes that reflect production costs rather than value.

Efforts to improve this situation through metadata, simplified viewer software, and alternative pricing policies have shown some promising results. However, a breakthrough to widely accessible intelligent services for citizens, professionals and decision-makers requires a more comprehensive approach. Rather than sectorial technology or policy measures, a treatment of the entire value chains connecting users to data sources is needed. Such an approach to market development for geographic information requires an integrated solution based on the needs of all stakeholders in a GI-market.

Within the scope of their legal mandates, the Survey and Cadastral Authorities of the *Länder* of the Federal Republic of Germany maintain the necessary geographic base data systems and make them available to a wide range of customers on request *(AdV 1995)*. Such base data are meant to be used for the most diverse tasks, ranging from real estate transactions and legal services to soil and nature conservation, regional and town planning, business geographics, and municipal administration.

Although of high quality (particularly, accuracy, and with the seal of authority), these products are not generally accepted in the market. Potential users complain that they come with too much or too little detail and inadequate possibilities for selection or aggregation. This is often not a problem of the base data as such, but of the lacking value chains linking them to end user needs and business models. Today the value chains of geographic information often consist, at best, of the data producer and the user alone. This constitutes a monolithic economic system with low efficiency.

In the past five to ten years a lot of innovative enterprises, e.g., data miners, data brokers, providers of virtual market places, and e-commerce start-ups have emerged. Yet, the socio-economic potential of both, data providers and value adders, still has to be exploited. This is not just an issue of data producers and users, but one of building value chains *(Niedzwiadek 1999)* and business networks *(Brox and Kuhn 1999)*, reflected in adequate service architectures.

Against this background, the current paper presents the fundamental premises and constraints that went into the design of the emerging Geospatial Data Infrastructure for Northrhine-Westphalia. It outlines the structure and contents of the reference model and shows the current status of its development.

2 The Project GDI-NRW

The Geospatial Data Infrastructure Northrhine-Westphalia (GDI-NRW) is a three year initiative of the *Land* Northrhine-Westphalia that started in January, 2000 *(GDI 2000)*. Its overall goal is to develop the Northrhine-Westphalian market for geographic information. This will be achieved by connecting the value chains of users, service providers, service enablers, integrators, data producers, and infrastructure providers. The success of a geospatial data infrastructure will primarily depend on the demand for geoinformation products and services. Consequently, the project partners represent an interdisciplinary team of institutional, commercial, and research organizations in the GI-market, shifting the focus from provider-oriented to consumer-driven initiatives. As scientific advisor, we have recommended a consensus procedure, modeled after the example of the Open GIS Consortium, where all links of the GI-market value chains contribute to the design and operation of a geospatial data infrastructure in NRW through interface agreements in a common service architecture.

Geographic data are now being transferred on a daily basis within and between organizations worldwide. The technical problems of data transmissions are largely solved and significant progress on transfer formats has been made by standardization bodies. However, an issue that had long been considered minor is rapidly becoming a primordial concern: the problem of transferring semantics, i.e., the meaning of the data and not just the data themselves *(Kuhn 1997)*. A service view of geospatial information provides the necessary conceptual framework to approach this issue.

The technological evolution that supports the shift of emphasis from data to information products and services is called *interoperability*. GDI-NRW will be developed in the context of distributed, interoperable system standards and open architectures like the Internet, CORBA, and OLE/COM. The solution provided will be based on the relevant ISO and OpenGIS standards for geographic information *(Buehler and McKee 1998)*. This will lower the costs for the producers and users and overcome the current proprietary limitations of the GI-market. The link to international standards requires that the project be carried out in international co-operation with the OpenGIS Consortium (OGC). Plans for a pilot or testbed project as part of OGC's interoperability initiatives are currently under discussion.

3 Research Approach

Based on the international state of the art in designing geospatial data infrastructures and according to international standards, e.g., OGC and ISO, we have defined seven research questions that need to be addressed for the success of the project.

3.1 What are the *requirements* of the users of geographical information in NRW and what are the consequences for the components of a geospatial data infrastructure?

The user is in the center of interest and drives the process of defining usable products. This reverses the traditional producer-oriented perspective on bringing geographic data to users. To develop the GI-market, designers should meet and develop the specific requirements of the users *(Riedemann 1999)*. In particular, they must have in-depth knowledge of users' tasks:

- the information needed to carry out the tasks (utility)
- the characteristics of the users and the contexts in which the tasks take place (usability).

3.2 What are the *successful mechanisms* of current international infrastructures and how can they be transferred and adapted to NRW?

One of our main tasks is to transfer the experience of innovative existing geospatial data infrastructures in other German states as well as in countries like Portugal, Australia, the UK, the Netherlands, or the US *(FGDC 1997; ANZLIC 1999; NGDF 1999; OGETA 1999; OXERA 1999; RAVI 1999; CNIG 2000; InGeoForum 2000; SAP 2000)* to the emerging infrastructure in NRW. We evaluate the institutional, economical, and technical success factors of these projects and develop strategies for adapting them to NRW. A reluctance to learn from others, reinforced by national (or state) pride and a deeply rooted belief of facing a "very special situation" (of whatever kind) is severly hindering the rapid development of national and regional geospatial data infrastructures today. However, the relevant economic and technological evolution is pretty much the same for large parts of the world. And there are much better ways to preserve cultural diversity than through a plethora of arcane national data formats and monolithic system architectures.

3.3 What solutions are offered by the *concepts of services and information products* to the problems of data integration, data migration, updating, and pricing?

The project targets methods for tailoring information products and services to user needs *(Kuhn and Timm 2000)*. Methods to assess contributions, account for costs and estimate fair shares of total benefits will be developed for each contributor in the value chain *(Frank 1999)*.

In particular, the project investigates methods to

- identify *decisions* in end user work flows that require geographically related information
- assess the *value* of improving such decisions through intelligent services
- identify and locate necessary *components* for such services
- evaluate the *usability* of such components and of the resulting services
- translate service component requirements into *data requirements*
- evaluate data requirements against *data sources*
- *assess costs* for data and service information
- extract *best practice descriptions* of actual data uses.

3.4 Which kinds of *business networks* will be successful in the Northrhine-Westphalian GI-market?

To permit optimal use of existing geographic data, economically viable business models must be created. Current business models often consist of only two links of the geospatial value chain: data producer and end user. We propose business networks as a flexible response to the urgent need of generating information products that are tailored to the users' needs: Traditional and new providers of the GI-market with complementary core competences find together on users' demand and generate the desired information product. The challenge is to develop new methods and successful mechanisms for the communication and co-operation of (1) clients and providers and (2) providers and providers *(Brox and Kuhn 1999)*.

3.5 What are the *technical requirements* for successful business networks?

The organizational requirements of business networks, i.e. communication and co-operation between users and providers, and providers and providers, will be translated to technical requirements. We will focus on the technical aspects of the business network components and the user/provider and

provider/provider interfaces. Most of these technical requirements are currently being worked on within the OpenGIS Consortium.

3.6 What is the architecture of the technical solutions?

A general *architecture for services* will be described in a GDI-NRW architecture model. It defines the components and interfaces of the infrastructure and regulates their interaction. The model is based on the OpenGIS Service Model *(Buehler and McKee 1998)* for the access, exchange, management, processing, and presentation of geographic information.

3.7 What are the *measures of success* and how can the quality be proven?

Developing, testing and optimizing a prototype ensures in time the quality of the components and provides the basis for the integration of the components in an infrastructure. A first step is to define measures of success, based on the results of the preceding six research questions and a consensus procedure involving representatives of all links in GI-market value chains. The measures of success will be detailed and optimized in the advanced project phases (implementation and prototyping) and determine a test scenario for the GDI-NRW prototypes.

4 Realization

The overall project is structured into four phases:

1. identification of services,
2. design of a reference model,
3. implementation specifications, and
4. prototyping.

The project ends in December 2002. The result will be an infrastructure designed and therefore supported by all stakeholders of current and future geospatial value chains. The first year project phase completed the identification of services and the draft of a reference model. Initiated by the Interior Ministry of NRW, ten sub projects (executed by single companies or consortia) contribute

- Geodata servers (local, regional, vertical)
- Content providers (mainly on the basis of raster data)
- e-commerce platforms
- Business mapping solutions
- Visualisation tools

- Data access components
- Market studies
- Scientific research.

Our framework for design and communication amongst the project partners is a reference model. It consists of five sub models:

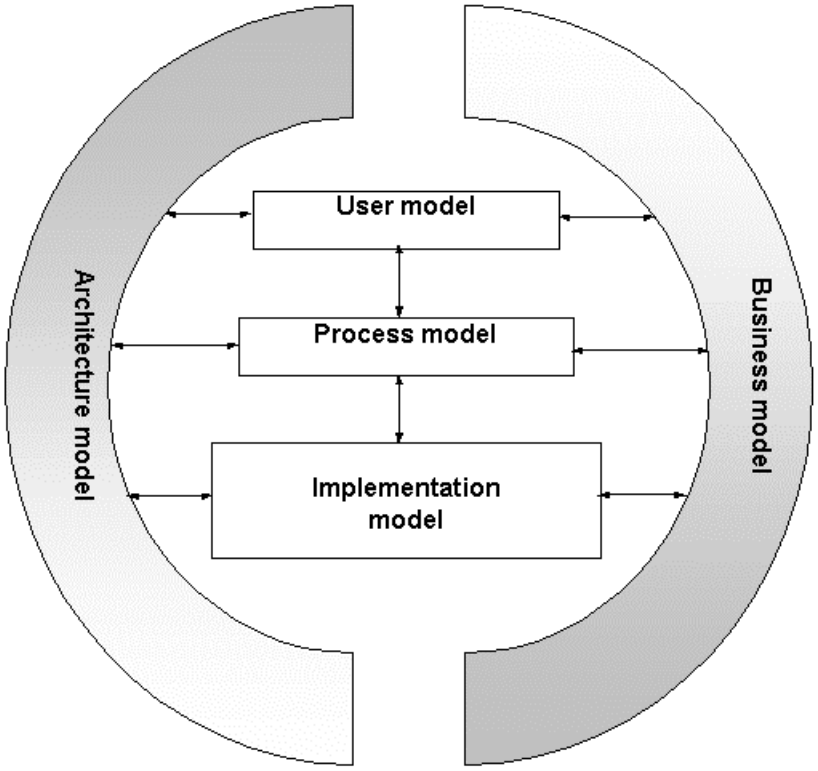

Figure 1: GDI-NRW reference model

1. The *user model* identifies the targeted end users of the infrastructure. It describes who they are and which tasks they have to fulfill, their requirements for information products and services, their experience, skills, and system configurations.
2. The *business model* defines the goals of the infrastructure. The overall objective is to support the Northrhine-Westphalian market for geoinformation. The model describes business goals, an information and communication platform, data, business processes, legal aspects, pricing, marketing, support of new innovative enterprises, and business networks.
3. The *process model* identifies the entities of the infrastructure, their interaction, and the process flow within, starting from the users´ request for information products. It describes which services and which data are needed to support the processes.

4. The *architecture model* defines the technical solutions that are necessary to fulfill the requirements identified in user, business, and process model. It describes client and server components, mandatory interface specifications, metadata and other relevant standards, data sources, and data models.
5. The *implementation model* defines technical details. It describes, for example, the specifications of server, clients and databases, network protocols, user interfaces, and object technology. The development teams of the sub projects bear the responsibility for this sub model. Our institute assesses the interoperability of components against the background of OpenGIS specifications.

All sub models look at the same "elephant" from different perspectives. Overlap is possible and wanted. This ensures the most complete handling of a complex system. A key approach is the use of scenario-based designs. Based on a user's concrete demand for an information product we follow the path through the geospatial data infrastructure, recognize problems of the current status, and find solutions.

5 First Results

The reference model is the main tool to design and communicate the (interim as well as final) results of the GDI-NRW project. The reference model version 1.0 was the starting point for the ongoing consensus process within the GDI-NRW project, leading to focused discussions and their consideration in the current version 3.0 of reference model (December 2000). The following chapters highlight the main ideas of GDI-NRW according to the five sub models of the reference model.

5.1 User model

GDI-NRW directly targets traditional and new, innovative business users and government users of the Northrhine-Westphalian market for geospatial information (software providers, service providers, decision makers, system integrators, service providers, data providers, information brokers). By this it also *enables* the GI value chain to deliver the needed services and information products for the individual, private end-users, including the future mass market for GI. The fulfillment of the end-users´ requirements is the overall mission of GDI-NRW and its components. GDI-NRW provides a platform for users who *sell* geographically related information products and services as well as users who *buy* them. GDI-NRW will present itself in German and English. A co-operation with the *Laender* of Germany and international users, companies and Geospatial Data Infrastructures is targeted.

In principle, all kinds of geospatial services and information products will be the output of GDI-NRW. During the ongoing project the focus should be on data sets adapted to users' needs; the prioritization will be a result of a GDI-NRW market study.

The services and information products of GDI-NRW are closely related to the system environment the users work with. After an initial focus on stationary computers, the inclusion of mobile devices in the next phase will be crucial to facilitate the use of geoinformation within mass market products and services for citizens.

5.2 Business model

The business model defines the business goals of the infrastructure. The overall objective is to expand the entire Northrhine-Westphalian market for geoinformation. The business model describes an information and communication platform, products, business processes, legal aspects, pricing, marketing, support of new businesses and business networks. The model describes concepts and rules for business processes within the geospatial data infrastructure and the companies that are participating. The goal is to expand the GI-market for traditional and new companies, not to provide restrictions for the specific business models of each company.

GDI-NRW - consisting of maintenance organizations for executing the business tasks of GDI-NRW, an information and communication platform, the evolving service architecture model, organizational provisions for maintaining GDI-NRW standards - does not and shall never compete itself within the GI-market. Solely the companies supplying components, e.g., geodata server, e-commerce platforms etc., that fill the infrastructure according to the concepts outlined in the reference model can be profit-oriented.

5.2.1 Maintenance organizations

After the accomplishment of the ongoing project two maintenance organizations are expected to execute the business tasks of GDI-NRW:

- A neutral and *independent organization* (possibly several organizations for various business tasks) will be conceptualized and initiated by the *GDI-NRW project management* to act as the executing organization behind GDI-NRW. The neutral and independent organization serves the overall goal of GDI-NRW to expand the GI market. Therefore, it does not compete with the providers and producers of the GI market, and it is open to the support and co-operation of all players of the GI market.

- A *member-based organization* will be open for all companies and organizations participating in the NRW GI-market. It will be created by a consensus procedure performed by the GDI-NRW project management. The rules for a membership still have to be defined, but in general, all players of the NRW GI market can become a member of this organization. The tasks, i.e. definition and maintenance of a metadata standard and specifications of data sets, services, and information products, will be executed in a consensus process.

5.2.2 Information and Communication Platform (GDI-NRW Portal)

GDI-NRW provides a platform for information and communication as a portal for all users and providers. Business tasks are

- information (e.g., metadata, metadata standards, yellow pages of providers, standards and specifications for services and information products, business information)
- communication (e.g., news group, discussion forum)
- additional services (e.g., enable business-business and business-customer transactions, hotline, partner search, access to e-Commerce).

5.2.3 Data sets

All geographic data sets (base data and application-specific data) can be the raw material for the business processes within GDI-NRW. The overall goal is to apply services on data sets in order to generate information products for the users of geospatial information. The GDI-NRW project will define priorities for the targeted data sets on the basis of the results of the market study. A certification of data sets by GDI-NRW has to be discussed.

5.2.4 Provision of Information Products and Services

On the basis of geographic data GDI-NRW provides information products and services by distributed nodes. The specification of information products and services will ensure the definition of metadata for information products and services, providing different levels for searching and for judging the quality. To guarantee a wide acceptance in the national and international GI-market this GDI-NRW metadata specification should be linked to a standard based upon ISO TC/211 19115 Metadata Standard CD 3 or later.

5.2.5 Access to Information Products and Services, e-commerce

The access to information products and services is possible via

- direct access to the providers
- information brokers
- e-commerce platforms.

In addition, GDI-NRW enables the user to enter GDI-NRW by the GDI-NRW portal and search, order, receive, and pay any (complex) product by the user interface of a chosen platform. Similar to other e-commerce transactions like those for books, the user shall not be bothered with organizational or technical issues hiding behind the user interface.

5.2.6 Business Networks

We propose business networks where traditional and new providers of the GI-market with complementary core competences find together on users' demand and generate the desired information product.

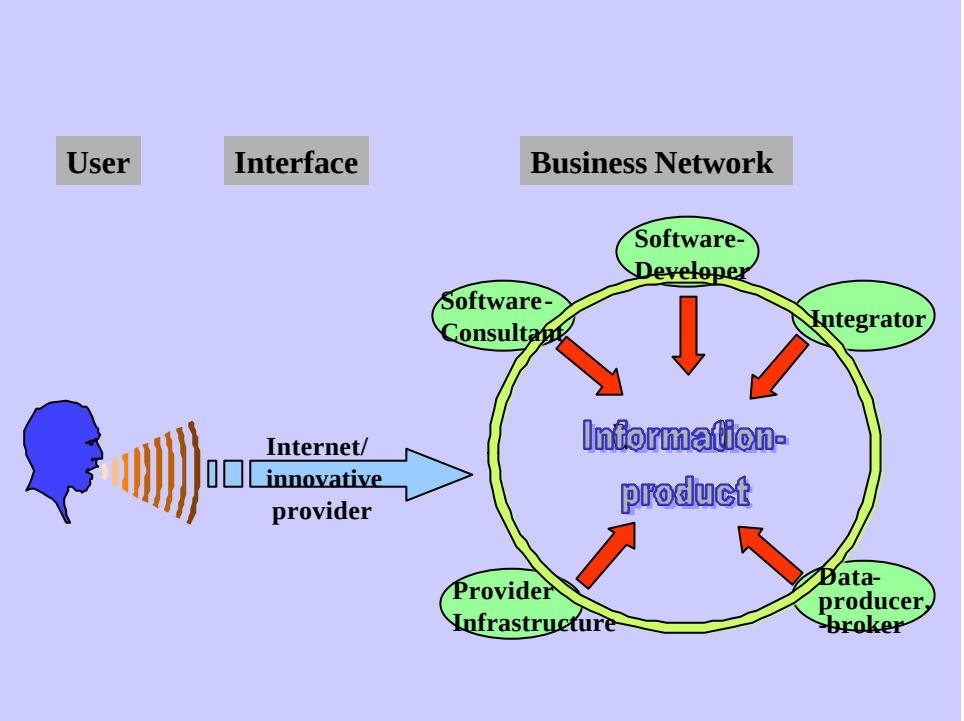

Fig. 2: Business networks

In other businesses, such models are already operational. For example, if you want to build a house, architects, bankers, construction companies, electricians and many others find together on your demand to construct your new home. Adapting this idea to geospatial information represents a promising and ongoing research challenge as well as a business task of GDI-NRW.

Useful and usable information products can only be provided by a network of companies coming from different sectors of the GI market. *(Niedzwiadek 1999)* describes "five categories of geospatial industry players who work together to meet the needs of end users over the Net".

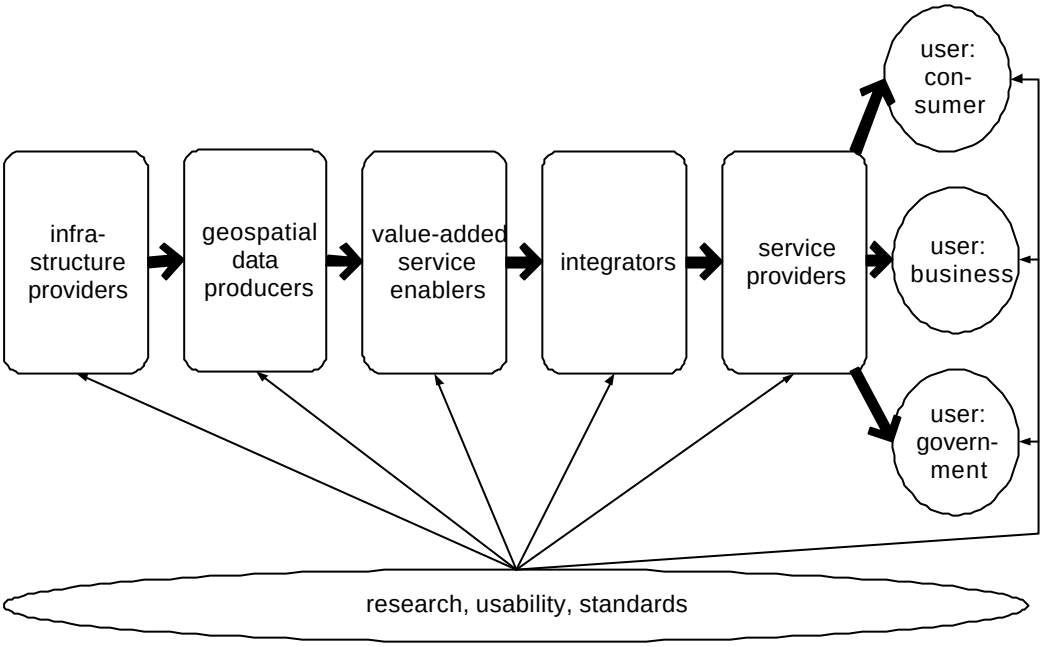

Fig. 3 Value chain of geographic information, derived from *(Niedzwiadek 1999)*

An information product, consisting of data and services of different providers, can be generated automatically. Organizational aspects like access rights, copyright, and usage have to be defined. The more complex case of generating a complex information product is the integration of non-automatic procedures into the workflow, e.g., consulting by an information broker. Solutions have to be provided:

- access to information about technical and organizational services
- access to information about providers of GDI-NRW
- models and mechanisms for the co-operation of providers with providers
- models and mechanisms for the pricing of complex information products.

An approach of the IT world is the mySAP.com Marketplace *(SAP 2000)*. SAP offers an online marketplace with

- the possibility of a one step business transaction for every business partner
- a horizontal marketplace as a basis for the co-operation for all business partners
- several vertical and regional marketplaces for the specialized markets, e.g., oil and gas industry
- business information and branch news.

A transfer of ideas to GDI-NRW has to be further discussed.

5.2.7 Legal Aspects and Pricing

Access, copyright, and usage of data are handled differently in the Geospatial Data Infrastructures worldwide. Legal and economic aspects have a great influence on usability and acceptance of data. For GDI-NRW it will be an ongoing business task to identify legal impediments and initiate solutions. International examples, e.g., SNIG, Portugal *(CNIG 2000)*, show the importance of lobbying in politics and economics for a sustainable success of a geospatial data infrastructure.

Geographic information very often is marketed through pricing schemes that reflect production costs rather than value *(Krek and Frank 2000)*. An ongoing task of GDI-NRW is to initiate new, customer-driven pricing schemes for information products and services.

5.2.8 Marketing

GDI-NRW has to be made public. Firstly, traditional and new users of geoinformation have to know about its opportunities and chances. Secondly the goal is to integrate traditional and new providers as components of GDI-NRW. Thirdly, as mentioned before, lobbying in politics and economics can be counted on being an appropriate marketing strategy. It is not sufficient to create a high-quality product GDI-NRW. During the project and afterwards, marketing measures are essential for a sustainable success of GDI-NRW.

Advanced marketing strategies could be to observe needs of the GI market, identify and suggest new market segments and developments of new information products and services, and market the solutions into international markets increasing trade and recognition in both foreign and domestic markets *(Mercator_Alliance 1997)*.

5.2.9 Support of new, innovative businesses / education and training

The GDI-NRW project designs and executes strategies to support new, innovative businesses. This includes an ongoing support, e.g., a helpdesk, for potential GDI-NRW providers within the information and communication platform. GDI-NRW actively supports educational programs and training initiatives within the GI market, e.g., the education initiative within the framework of the larger "Software-Initiative NRW" (*media NRW 2000*).

5.3 Process model

The GDI-NRW objective is to create a market driven infrastructure for geospatial services. This implies that geospatial information is to be sold and bought similar to consumer commodities in the form of geospatial information products. These can be in the form of a set of digital cartographic map sheets, map tiles, database subsets, etc. Public and private sectors that sell information products and geospatial services will serve different vertical markets (banking, insurance, landscape planning, environment, etc.). Therefore interoperability should not be cast as a fixed block of specifications. We need a loosely coupled cooperative infrastructure for buying and selling information products online.

In an ideal information infrastructure, information products can either be physically stored in databases or it can also be created on the fly once a user request is received. The first case is similar to products in stock of a retailer. The second case is called the "just-in-time" in which the user sends a request for a product and a series of processes are triggered (either offline or online) to create the final product. Workflow analysis and business process reengineering have powerful and proven approaches to help decide which products (or parts of products) should be in stock and which should be created on the fly. For example, some of the raw data used for the production may change more frequent than others. Reduce cost of production may be achieved by applying the "just in time"-concept instead of frequently creating the products and storing them.

To provide services in GDI-NRW that permit a loosely coupled cooperative infrastructure we need to specify the processes that are needed to fulfill certain business objectives described in the user and business model. We will specify the information flow and activity states between businesses (or actor) in typical GDI-NRW workflows (i.e. building an information product "on-the-fly" by cooperation of different companies). This will lead us to a clear understanding of the behavior of the overall system where certain classes of objects are triggered (i.e. enabled or disabled) by the activities of certain actors. The relationship and messaging between those objects yield by GDI-NRW workflows are then specified by the architecture model.

A business process is as a set of activities that represent methods of performing the work needed to achieve a business objective. We utilize the Unified Modeling Language (UML, see *Booch, G., Rumbaugh, J., and Jacobsen, I., 1999*)) to describe GDI-NRW workflows by organizing activity diagrams that show the information flow from activity to activity within a business process for certain actors. This leads us to the specification of software components and objects providing certain services that will be described and specified by the GDI-NRW architecture model.

5.4 Architecture model

The architecture model defines the main technical components that reflect the user and business requirements. The GDI-NRW Service Architecture provides a logical model for distributed geospatial services.

5.4.1 The GDI-NRW Service Taxonomy

According to the ISO/TC 211 Service Architecture for Geospatial Services (*see ISO/TC211, 2000*) we distinguish between Information Technology Services (IT Services) and Geospatial Information Services (GI Services). IT Services are common services in a distributed computing environment, like processing services that perform large-scale computation involving substantial amount of data, system management services for encoding and transfer of data across communication network.

GI services are specialized IT services that define capabilities that are specific to the manipulation, transformation, storage, and exchange of geospatial information. The GDI-NRW Service Architecture defines GI services wherever common IT services do not meet specific GI requirements.

The main purpose is to provide interoperability in information viewpoints. To achieve information model interoperability two systems must be both *syntactically* and *semantically* interoperable.

"The information viewpoint […] describes the information that flows in a system and is processed by a system. It focuses on the structuring of semantic information, typically that will be stored in a database and communicated between the components of a system. An information model is used to describe the information viewpoint. This information model defines the structure and semantics of the information used in system by defining objects, their properties and relationships." (*ISO/TC211, 2000 – Geographic Information Services*)

Furthermore, each service will need to define its syntactical interfaces through operation signatures and its semantic through description of the meaning of the operations and their legal sequencing.

A first step towards a description of relevant services and their context within any architecture model is the taxonomy for services. The purpose of those service categories is to have one way of identifying geospatial extensions to various existing service types. The ISO/TC 211 Service Architecture defines such services categories that we adopt for GDI-NRW related services as a blueprint (see (*ISO/TC211, 2000*) for further details).

5.4.2 Technical Component in GDI-NRW

In its initial phase the GDI-NRW Architecture Model focuses on web services. Since the World Wide Web is considered to be one possible distributed computing platform for interoperable geoprocessing the specification of web services is part of each of the adopted specifications (*Buehler & McKee 1998*). Currently, software components are developed that enable GDI-NRW to support the following basic geospatial services:

- *GDI-NRW Search and Discovery Services* – specify organization, discovery, and access of geospatial information.
- *GDI-NRW Access and Retrieval Services* – specify each access to geospatial information that is outside the scope of the catalog services.
- *GDI-NRW Web Mapping Services* – specify distributed web mapping.

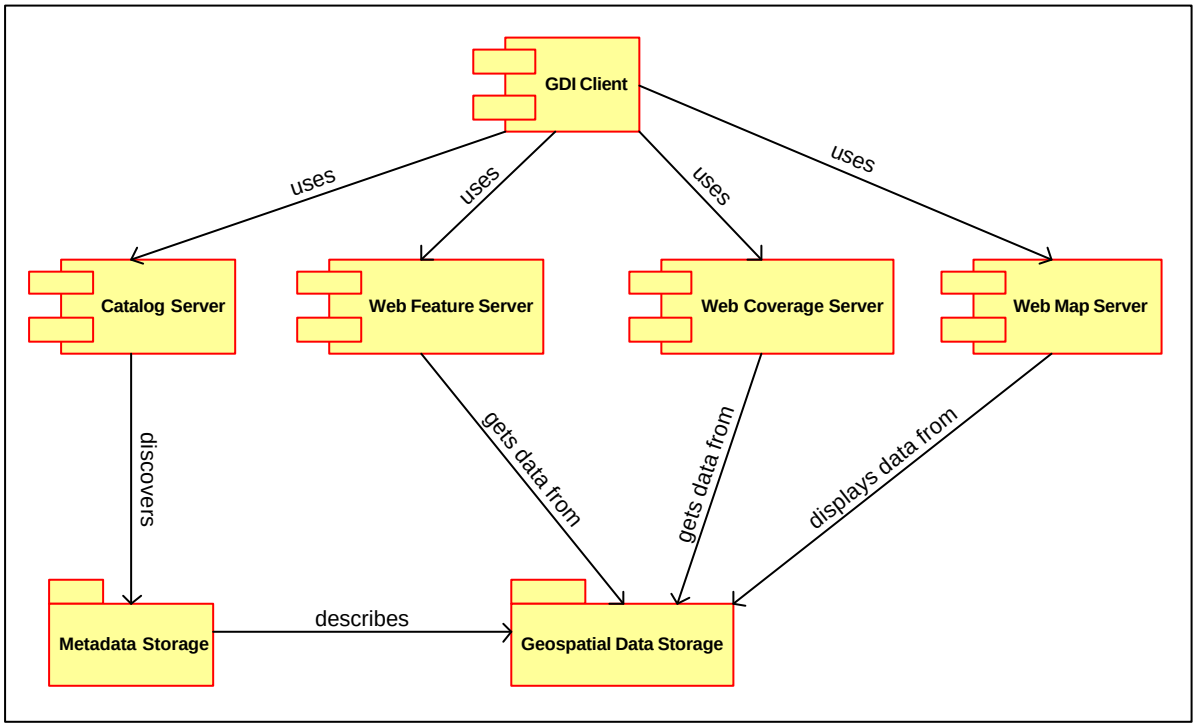

Fig. 4: Component diagram GDI-NRW

By specifying the services provided by the components show in fig. 4 we take over the specifications of the OGC yield by Web Mapping Testbed I&II, that is:

- Catalog Server – implements services for search and discovery of geospatial data and services through its metadata
- Web Map Server – implements services for distributed web mapping
- Web Coverage Server – implements services for access to coverage data

- Web Feature Server – implements service for access to feature data

A client (e.g. a standard web browser) has access to any kind of data distributed in GDI-NRW through well defined interfaces provided by the servers. For example, a client might:

- Search geospatial data and services – e.g. location based services via Catalog Server
- Display data/ results – via Web Map Server
- Directly access geospatial data – "in-stock"- or "on-the-fly"-information products, whereas GDI-NRW does not specify how data is organized in the database.

The components are linked together using a transport layer based on the Hyper Text Transport Protocol (HTTP). Each specification adopted by GDI-NRW provides (or will provide) both HTTP GET and POST mechanisms to handle request between a client and a server A GDI-NRW communication between clients and servers is enabled either via CGI-Style URL-Encoding or XML-based encoding. This decision depends on the coupling mechanisms preferred by the related specification.

To describe any possible data set and geospatial service there is a certain need in GDI-NRW for a descriptive vocabulary. This is an ongoing discussion among the participants an takes into account the ISO Metadata approach for geospatial data *(ISO/TC211, 2000)*, the ISO approach for description of geospatial services *(ISO/TC211, 2000)* and the metadata schema yield by the national ALKIS initiative.

Two different metadata contents are required, one for local metadata and the other for global metadata. Whereas global metadata (i.e. stored in a clearinghouse server) provide more coarse grained information, local metadata (i.e. stored at local distributed servers) provides finer grained information. The reason is that most users require a metadata service that is broad and relatively limited in term of its data contents. In the beginning there is little demand on user side for metadata containing detailed technical information. Once a user has determined that the available information fits to his purposes, more detailed information is needed to make a final judgment *(Bishr, Y. and Radwan, M., 2000)*.

5.5 Implementation model

The design of implementation specifications is in the responsibility of the development teams. They organize themselves in Special Interest Groups (SIG), which discuss common developments and interfaces between their products. The scientific consultation occurs against the background of interoperable technologies, in particular, OpenGIS specifications.

5.6 International and national views of SDI

"(In general a) Spatial Data Infrastructure (SDI) is an initiative intended to create an environment which enables a wide variety of users, who require coverage of a certain area covered by the SDI, to access and retrieve complete and consistent data sets in an easy and secure way." In this function it "starts at a local level and proceeds through state national and regional levels and is completed by developing a Global Spatial Data Infrastructure" *(Rajabifard et al. 2000)*.

In the process of developing a GDI for Northrhine Westphalia it is important to reflect different views on SDI. The objective is to illustrate the importance of spatial data infrastructures and thus to explain the motivation of Northrhine-Westphalia to construct one. Different international infrastructures serve as example concerning the reason for and the technical aspects of GDI-NRW. The analysis was based on the information published in the worldwide web and on the responses given to a questionnaire addressing the responsibles. It was not always possible to retrieve more background information than that published in the web. Thus the final selection of examples was taken from a total of 13 analyzed infrastructures according to the importance and the accessibility of information of the international example. These are Australia, United Kingdom, Portugal, United States of America, Global Spatial Data Infrastructure (*ANZLIC 1999, CNIG 2000, CSDC 2000,Ec-GI & GIS 2000,FGDC 2000, GSDI 2000,NGDF 1999, OXERA 1999, RAVI 1999, SAP 2000)*.

The main problem concerning the exploitation of geo-data is seen in the differences that can basically be put down to the decentralized and federative structure, the legal and technical barriers as well as to the immense quantity of data sources, data producers and stake holders. From this result problems like availability of and access to data, its exchange and compatibility. Cause and problem are increased by the missing transparency of available geo- and meta-data.

The economic and commercial importance of public-private partnerships has not yet been fully recognized in this domain. Nevertheless efforts are being undertaken at the state levels to improve the situation. The *Land* NRW sees geo-information as a possibility to combine purely professional application with value adding economical exploitation of information. This could entail the strengthening of the *Land* in its role as a business location. The problem of heterogeneous data sets recurs on this level. The exchange of data between the local authorities and the *Land* proves to be difficult. Once more the fault lies in the missing flow of information and the ignorance of standards.

Following the international examples mentioned above an infrastructure is being constructed that will be based on international standards. Different working groups are collaborating to progress

toward a commonly supported infrastructure. Input taken from the examples was useful for the elaboration of the third reference model. As the political structure of every country differs, only certain ideas were taken into consideration in GDI-NRW. Elements from infrastructures all over the world were combined. Concerning the architecture, user and business model for GDI-NRW the effort was made to find out those standards that are the most common amongst the other infrastructures. In most cases a suitable solution was found by combining the ideas of the working groups with those taken from the international examples. The business model got information about political lobbying, marketing initiatives from SNIG Portugal, ideas about interoperable services, copyright and pricing from GSDI. Furthermore the definitions of core data and security measures were looked into. The model could be completed in a satisfactory way with information about designing market places, business processes, legal framework of NRW, educational programs etc. by combining solutions found in Canada, Portugal, USA or Germany itself. The same steps were undertaken for the other models. Thus similar to the infrastructure in Australia the definition of metadata for information products and services, providing different levels for searching and for judging the quality, will possibly be the task of a member-based organization. It was of special interest to find out in how far the other infrastructures exist physically and are not only theoretical constructs.

In the English infrastructure the NGDF Board is made up of a wide variety of people from both Government and Private organizations. The Central Management Team is responsible for driving forward the NGDF initiative on a day-to-day basis. In Northrhine Westphalia, too, it is planned to initiate two maintenance organizations (neutral and independent organization; member-based organization) that are expected to execute the business tasks of GDI-NRW.

Concerning the architecture model, the following, already existing, elements will be integrated in the system. Hence GDI-NRW distinguishes between Information Technology Services (IT services) and Geospatial Information Services (GI services) in accordance to the ISO Service Architecture for Geospatial Services (*ISO 2000*). Furthermore the GDI-NRW Architecture Model focuses on web services in its initial phase. The specification of web services is part of each of the adopted specifications since the World Wide Web is considered to be one possible distributed computing platform for interoperable geoprocessing (*Buehler & McKee 1998*). Concerning e-commerce solutions GDI-NRW looks to the other *international attempts* on a technical solution dealing with interoperating business processes, electronic data exchange, pricing etc. Examples are ebXML (OASIS), Universal Description, Discovery and Integration (UDDI) or RosettaNets' Partner Interface Process (PIP) Specification.

It is evident that worldwide initiatives will only succeed if every single infrastructure considers interoperability, standards and already existing specifications as far as possible. Nevertheless it must not be forgotten that each country needs to meet its users' demands and thus certain peculiarities will always exist. However GDI-NRW tried to take into account as many international examples as possible to allow the infrastructure to be as open as possible.

6 Conclusions

The reference model defines the concepts of GDI-NRW based on

- state-of-the-art of ongoing international and national infrastructure projects
- relevant international standards, e.g., OGC's and ISO's
- cutting-edge research and
- feedback of GDI-NRW project partners.

The reference model reflects the comprehensive approach of the GDI-NRW project. Rather than a sectoral technology or a sectoral approach GDI-NRW represents the value chain for geographic information connecting users and data sources. Only this comprehensive approach enables GDI-NRW to achieve the overall goal to expand the market for geographically related information products and services by

- establishing a user-driven market and
- providing usable geographic information.

The reference model is a living entity. It will be an ongoing task to prove and detail the concepts and to add organizational and technical services for the users of geographic information.

For further work we describe the key issues within the sub models of the reference model. The *user model* provides a high level concept of the users' needs. We suggest to focus on specific users, e.g., banks and insurance companies, in carrying on case study projects in order to detail the required services and information products. The *business model* describes an organizational framework and the business tasks of GDI-NRW. The next step is to establish maintenance organizations for execution. The results within user model and business model will affect further details of the required and realizable information products and services. The processes of their provision will be described within the *process model*.

The next steps within the *architecture model* will be to specify and implement further GDI-NRW services. Again, specifications yield by WMT-1, WMT-2 and GSF-1 will be taken into account. Those are, among others:

- Portrayal and Presentation Services – display geographic information
- Ordering and Payment Services – support online procurement, pricing services and e-ommerce services
- Security Services
- Authentication Services
- Gazetteers.

In addition, an appropriate e-commerce framework that supports business networks and online procurement in a heterogeneous environment needs to be specified.

A key issue of GDI-NRW is to ensure its own acceptance in the market place. We have therefore suggested continued consensus procedures within the GDI-NRW project and within the Northrhine-Westphalian GI market during the forthcoming project phases of implementation specification, prototyping, and beyond.

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