Geo-information Standards in Action

Peter J.M. van Oosterom (Editor)

Geo-information Standards in Action

NCG / GIN Farewell Seminar Henri J.G.L. Aalders

Delft, 17 November 2004

Peter J.M. van Oosterom (Editor)

NCG Nederlandse Commissie voor Geodesie Netherlands Geodetic Commission 42

Delft, February 2005

Sponsors

Autodesk
Bentley
Delft University of Technology
ESRI
Geodan
Intergraph
RWS-AGI

Geo-information Standards in Action
NCG / GIN Farewell Seminar Henri J.G.L. Aalders, Delft, 17 November 2004
Peter J.M. van Oosterom (Editor)
Nederlandse Commissie voor Geodesie Netherlands Geodetic Commission 42
ISBN 90 6132 289 8

Published by: NCG, Nederlandse Commissie voor Geodesie, Netherlands Geodetic Commission, Delft, The Netherlands
Printed by: Optima Grafische Communicatie, Optima Graphic Communication, Rotterdam, The Netherlands
Cover illustration: Axel Smits

NCG, Nederlandse Commissie voor Geodesie, Netherlands Geodetic Commission
P.O. Box 5058, 2600 GB Delft, The Netherlands
T: +31 (0)15 278 28 19
F: +31 (0)15 278 17 75
E: ncg@lr.tudelft.nl
W: www.ncg.knaw.nl

The NCG, Nederlandse Commissie voor Geodesie, Netherlands Geodetic Commission is part of the Royal Netherlands Academy of Arts and Sciences (KNAW)

Content

Editorial

P.J.M. van Oosterom
Faculty of Technology, Policy and Management &
OTB Research Institute for Housing, Urban and Mobility Studies
Delft University of Technology, the Netherlands

17 November 2004

This publication is the result of the seminar ‘Standards in action’ on 17 November 2004 jointly organized by ‘Geo-Informatie Nederland’ (GIN, section Geo-ICT) and Netherlands Geodetic Commission, sub commission Geo-Information Models (NCG-GIM). The NCG is part of the Royal Netherlands Academy of Arts and Sciences (KNAW). 17 November 2004 is a bit of a special day. First of all, it is ‘World GIS day’, on which many organizations worldwide do show something of our profession to the outside world (and especially to the new generation; e.g. young school kids). Second, the seminar is organized in the context of the official farewell of Henri Aalders, who has taken the opportunity to enjoy an early retirement. However, for someone with so much enthusiasm for our profession it is not easy to stop completely and Henri decided to continue for a few more years one of his favorite tasks: the development of geo-information standards (both within the Dutch and European context). Therefore there was only one possible topic for his ‘farewell’ seminar and that was of course ‘geo-information standardization’.

Figure 1. World GIS Day 2004 in Delft.

World GIS Day

The World GIS Day has been organized a number of times before and this has always been a lot of fun. The section GIS Technology assisted by the other (former) Geodesy groups of the Delft University of Technology has participated since 2000, which makes 17 November 2004, the 5th

World GIS Day in which it participates. During World GIS Day users, vendors and educators open their doors to show something to the outside world of our beautiful profession with its important applications and fascinating technology. During the previous versions of World GIS Day in the morning, the section GIS Technology invited children at the age of 8 from a number of elementary schools in Delft to learn more about GIS. This program usually consisted of three parts: 1. a short lecture in which the use of GIS is explained, 2. the re-design with GIS of the town centre of Delft (always resulting in many colorful maps) and 3. go outside and play the 'GPS find the treasure' game. In the afternoon, the program usually consisted of a half-day seminar on some relevant topic (Mobile GIS, 3D GIS, GIS & Java,..) for professionals. This year it was organized a little different: a full day seminar, because of the official farewell of Henri Aalders. The figure below gives some impression of Henri Aalders in action during previous versions of the World GIS Days.

Figure 2. Henri Aalders in action during previous World GIS Days.

Standards in Action

The theme of the seminar was not just (geo-information) 'standards', but it was decided to put some additional focus on the actual implementation and use of standards in practice. As mentioned above, geo-information standards have always been one of Henri Aalders favorite topics (and specifically metadata and quality aspects) and therefore 'standards in action' is a very suitable topic for his farewell seminar to proof that the collective efforts in this domain have indeed been fruitful. As the NCG, sub commission GIM already organized a seminar on metadata, called 'GeoMetaMatica' (Heres, 2004) a good foundation has been created for the current seminar, which will again start with metadata. Then related topics, such as GML, (Dutch) geo-information policy, standardized basic and domain models and OpenGIS portals will be dealt with. However, it will not only be theory (presentation), the standards will also be used and tested in practice in front of the audience during the 3rd GML relay in the morning session and the 'OGC web services in action' session in the afternoon. Below an overview of the seminar and the contents of this publication in a little more detail are given.

Geo-information standards in action

In the first chapter Peter van Oosterom and Jaap Besemer (Delft University of Technology) give some background reflections for the day. Jaap Besemer was the chairperson of the seminar and Peter van Oosterom has organized the 3rd GML relay. The chapter explains the 'love-hate' relationship between geo-information research and geo-information standards and concludes that they really do need each other in order to reach an efficiently working Geo-Information Infrastructure (GII). This is valid at a global scale, but this paper also identifies specific roles for the Dutch geo-information standardization community: develop meaningful domain models (semantics based on formal tools) and actively participate in a number of specific base geo-information technology standards, which are very relevant for the Netherlands; e.g. 3D spatio-temporal models, web services, and metadata.

ISO TC211/Metadata

Dave Danko (ESRI, Inc., USA) is within ISO TC211 project leader for metadata (ISO 19115) and metadata XML schema implementation (ISO 19139). In his chapter he explains the important role of metadata. Not only today in the digital GIS era, but already for centuries in the analogue era of users interpreting the maps. These are all about imperfect representations of the real world, be it analogue or digital, and users need to understand the true value and meaning of the produced data (via metadata). This is getting more and more important in our current networked society as the array of sources and producers of geo-information is ever-widening. Proper metadata allows users across networks to locate, evaluate, extract, and employ geographic data. Metadata adhering to ISO 19115:2003 will be the key to global interoperability.

The Geography Markup Language (GML)

The third chapter is written by Clemens Portele (Executive Director of 'interactive instruments GmbH', Germany), whom is actively involved in the development of the Geography Markup Language (GML) within both OGC and ISO TC211. GML enables a vendor-neutral representation of geographic information – with a special emphasis on the web and web services. GML is based on the XML family of technologies developed by the W3C and implements concepts standardized in the ISO 19100 series of standards. The development of GML was started by the Open Geospatial Consortium, Inc. (OGC) and is an adopted OpenGIS Implementation Specification since February 2001. Currently, GML is being processed within ISO/TC 211 and is expected to be published eventually as ISO 19136. This standardization process is carried out jointly by both organizations. The chapter will explain in a little more detail what GML is about and why one should use GML at all. It also gives an overview of the GML developments from the first start within OGC in 1999 (within an OGC test-bed) until the expected adopting of GML3 by ISO TC211 in the near future.

The third GML relay

Marian de Vries and Peter van Oosterom (Delft University of Technology) give some context for the first 'in action' part of the seminar: the third GML relay. The Netherlands Society for Earth Observation and Geo-Informatics (the KvAG, now merged into GIN) organized the first and second GML relay (respectively on the 12th of June 2001 in Wageningen and on the 13th of December 2002 in Emmen). Purpose of these events was to show that interoperability between different software products based on the exchange of GML documents does really function (also in a non lab or test-bed environment). This did indeed work with more or less success during the previous relays and the goal of the third relay is now to show the progress in implementations. The same application schema will be used as during the second GML relay: Top10NL GML (tdn_strict2.1.xsd based on GML 2.1.2), which is also described in this chapter. It was considered important this time to proof that the most important main-stream Geo-ICT vendors show

GML is properly functioning within their standard products. The following seven vendors agreed to participate: Autodesk, Bentley, ESRI, Geodan, Intergraph and MapInfo. Henri Aalders will (life) draw the order of the participants within the relay. This will make the order random and proof that the relay is not a fake.

Policy and standards

In chapter five Noud Hooyman (of the Ministry of Housing, Spatial Planning and the Environment; VROM) describes the three policy programmes of VROM as the coordinating ministry for geo-information: 1. Standardization; promotion of national standards and conformation with European guidelines, 2. Research and Development programme ‘Space for geo-information’ coordination and 3. Streamlining of basic data/ authentic registrations. Most of the activities in this field are limited to coordination and steering except for the framework of authentic registrations of buildings and addresses for which VROM holds direct responsibility. These authentic registrations make part of the broader framework of authentic registrations that is or will be implemented by the Dutch government. The projected benefits of this framework will by far exceed the projected costs. Furthermore the expected effectivity for municipalities and other government bodies will increase and civilians will be asked only once to provide information.

A standard supporting semantics in a Spatial Data Infrastructure (SDI)

Marcel Reuvers (Ravi) explains in chapter six that though much attention is drawn to technical standards, a geo-information infrastructure is primarily about meaningful interchange of information. Therefore, a lot of energy has been put in the improvement of the Dutch standard NEN 3610 in order to enable the process of national (and international) geo-information harmonization. The original name of NEN 3610 being ‘Land-information terrain model’ is changed to ‘Basic Schema for Geo-information’, which better reflects its content. The new NEN 3610 is based on the international technical geo-information standards of OGC and ISO, which will enable effective implementation of this national standard. At the same time this will make sure that it will fit in the international context (European and global). This chapter will focus on the important role of semantics in the Geo-Information Infrastructure (GII) and the particular role of the Basic schema.

Geoportals and interoperability: The role of open standards and web service architectures

Theo Thewessen (Geodan IT BV) argues that interoperability can be described as: transparent access to data and functionality (services) in order to be able to look, to integrate, or to edit data. In this chapter several aspects of “interoperability” will be further examined: technical interoperability, semantic interoperability and the legal framework for interoperability. The chapter looks over the fence of Geo-ICT and considers general ICT standards and concepts, which are important for the further development of the (geo-information) interoperability. The following questions will be addressed in this chapter: What are the preconditions for interoperability?, How can technology help us?; How does the new architecture for the GI provision looks like?; Which opportunities these developments give for the Geo-information field?

OGC Web Services in action

The second 'in action' event of the seminar will show how some OGC web services of different vendors work together. In chapter seven Peter van de Crommert (Geodan IT), Frank Langelaan (Intergraph Benelux) and Jeroen van Winden (ESRI Netherlands) describe the basic concepts of OGC web services. This chapter is inspired by the evolution of Geographic Information Systems towards the web services model. Indeed, this model is rapidly materializing as a result of the advancements in general web service technologies and the focused efforts of the Open GIS Consortium in the areas of service categorization and interoperability of service interfaces. This chapter describes the use of several complementary and interoperable GIS Web Services to create customized solutions. This will be illustrated in the 'in action' part of these three vendors.

Farewell / thanks

In chapter nine and ten the more personal words to Henri Aalders in the context of his farewell can be found. First, in chapter eight by Boudewijn Possel (on behalf of the board of the student Union 'Landmeetkundig Gezelschap Snellius') giving some reflections of the role of Henri Aalders as teacher with specific focus on the survey camps of which Henri has been supervisor for 16 years. Finally, Theo Bogaerts (emeritus professor of the Delft University of Technology) concludes the day and this publication with some reflections on Henri Aalders as collogue and passes his thanks to Henri on behalf of all the former Geodesy colleagues for the many years of pleasant cooperation!

Acknowledgements

As editor of this publication I would like to thank all contributing authors (and presentors and 'in action' demonstrators). Further, I would like to thank the persons that assisted me in the production of this publication: Elma Bast, Elfriede Fendel and Frans Schröder. Finally, I would like to thank the sponsors of this seminar making it possible for everyone else to participate without any cost: Autodesk, Bentley, Delft University of Technology, ESRI, Geodan, Intergraph and RWS-AGI.

References

Heres, L. (editor), GeoMetaMatica. Inleiding van de studiedag over metagegevens voor geografische informatie, Subcommissie Geo-Informatie Modellen, Utrecht 18 mei 2004, uitgave van de Nederlandse Commissie voor Geodesie (NCG, KNAW), ISBN 90 6132 285 5, Delft, mei 2004 (in Dutch).

Geo-information standards in action

P.J.M. van Oosterom and J.W.J Besemer
Faculty of Technology, Policy and Management &
OTB Research Institute for Housing, Urban and Mobility Studies
Delft University of Technology, the Netherlands

This paper explains the 'love-hate' relationship between geo-information research and geo-information standards and concludes that they really do need each other in order to reach an efficiently working Geo-Information Infrastructure (GII). The motivation for not (only) using traditional means, such as paper maps (or clay tablets), but using digital data and tools (services) embedded in the GII is found in the fact that resources may be shared via modern ICT-tools, which is more effective than reinventing, rebuilding, recollecting, or copying geo-information services for every situation again. This is valid at a global scale, but this paper also identifies specific roles for the Dutch geo-information standardization community: develop meaningful domain models (semantics based on formal tools) and actively participate in a number of specific base geo-information technology standards, which are very relevant for the Netherlands; e.g. 3D spatio-temporal models, web-services, and metadata. At the same time the role in other geo-information technology standards could be limited to testing and evaluating within the context of international organizations, such as OGC and ISO. A similar approach is followed at the European level by CEN TC287, which decided to adopt the ISO (and implicitly the OGC) standards and to work on Europe specific profiles; e.g. in context of INSPIRE. Finally, this paper emphasizes the importance of the 'in action' aspect of standards and argues that only standards that are implemented and used at large scale do have real value.

Introduction

Research and standardization may seam to be very difficult to combine in practice or even result in contradictions as research is trying to discover or develop new knowledge and standardization, which is based on existing ('old') knowledge in order to make people or things work together. However, in many situations standardization and research are very closely related to each other and do influence each other in a very productive manner. Geo-information (and even information processing in general) is such a domain. One could state that without some form of standardization information is useless, because nearly all information is intended to be exchanged and used by several actors (either within the same organization or between different organizations). Internet based solutions for information processing require standards or protocols for the communication between the different actors. These standards have been developed (by W3C and related organization and this resulted in HTTP, SOAP, XML, OWL, etc.) and are being applied. However, the availability of these standards is also enabling new architectures for distributed information processing systems/networks (and with this possibly optimizing and changing the tasks of the involved organizations). Research is needed in order to create a sound theory and methodology for the design and development of these new generations of systems, sometimes classified as web-based service oriented architectures (SOA). So, the relationship between research and standardization is best characterized as a 'love-hate' relationship. Anyhow, it is a fact that many persons involved in standardization have a research background and often do work at universities or at R&D departments of industry/government organizations.

Geo-information processing is a good example of a domain with a close relationship between standardization and research and our university has been involved in this for a long time. At many levels (regional, national, international) and within many geo-information sub-domains (topography, cadastre, transport, water, subsurface, …) there is and has been a lot of activities. This paper will not try to give an overview of these activities, but we will mention the role of Henri Aalders of our organization, the TU Delft (currently chairman of the European geo-information technical committee CEN/TC287).

Geo-information is being and has been applied throughout the world for many centuries or even millenniums, so why bother doing scientific research in this area? The answer is that we want to improve our way of handling geographic information. The overall goal of the research of the section GIS technology is to provide/develop the technology, including the knowledge behind it, to stimulate the realization of the *Geo-Information Infrastructure* (GII) (Van Oosterom, 2003). While at the same time the section Geo-information and Land Development (GiLD) is focusing on the complementary legal and organizational aspects of the GII. Our current society is heading towards an information society; the impact of this may be varying for the different parts of our economy. However, in the geo-information business the impact and the potential advantages are enormous as our main product, geo-information and services, can be transported very well via (wireless) networks. This is the case in a global context but with specific attention for the Netherlands: this could be called 'the Virtual Netherlands'.

In order to avoid duplication of geo-information, with dangers such as out-of-dateness and in-consistency with the source, it is better to create geo-information communities, which share (against reasonable prices) the appropriate information in an efficient manner. This requires a good GII, which covers topics such as: geo-information foundation data sets, geo-information services (functions, analysis), networks, and geo-information protocols and standards. These topics in turn consist of many aspects, such as organizational, legal, financial and technical ones.

Geo-Information Infrastructure

In order to take full advantage of rich sources of geo-information it is necessary to process and archive data products and to make them widely available. To streamline and optimize this complex process, national and international GIIs need to be established. A large number of challenges may be identified here: how to collect data in real time and at modest cost from expanding global networks of sensors, many in remote locations; how to reconfigure networks for robust operations; how to ensure prompt delivery of data to users with time-critical needs while maintaining quality control and accessibility for lower-priority users; how to process heterogeneous data streams quickly enough to prevent data volumes from demanding managers and users; how to archive data in a way that enhances research capabilities. Such information management will require innovations in Internet connectivity, multimedia information processing and visualization techniques. To streamline and optimize the dissemination, national and international GIIs are being established (also called Spatial Data Infrastructures; SDIs).

Motivation for the GII

The GII provides a better access of geo-information and facilitates the use by more organizations/ individuals, who deal with spatial problems in one way or the other; consider for example the following tasks:

- What is the quickest route to go from A to B taking into account this morning's heavy traffic on the highway?

- What is the best method for a municipality to open up its zoning plans internally and externally (citizens, private companies)?
- What is the nearest restaurant, service station, etc. taking into account my current location?
- Which owners have to be notified by the Telecom Company about the construction of a new cable connection?
- How does the landscape look after the realization of a new railway?
- Which cables and pipes should be taken into account during the excavation at this location?

All these questions have in common that they need one or more geo-information sources to give the right answer. It is not effective for every organization to systematically collect and maintain their own geo-information in order to support all these different kinds of tasks, such as mentioned above. However, shared use of resources is the key to enabling more effective use (or even enabling the use) of geo-information in many tasks. Therefore, an important step is the creation of a shared GII for related organizations; the so-called information communities. By direct, controlled access of geo-information at the source, the exchange of copies of data sets between organizations will become superfluous in the long run. It requires good protocols, standardization such as the OGC, ISO and CEN interoperability standards in general and the feature geometry models, the metadata and catalogue services, the web mapping (and feature) server specifications, and the geography markup language specifically. The OGC has basically two levels of standards: abstract (comparable to 'official' CEN and ISO standards describing a certain domain) (OGC 2002a, 2003b) and implementation specifications/ standards (OGC 2002b, 2003a, 2004). In case there are other good standards available, the OGC adopts these standards. The implementation standards are an important added value of the OGC, describing the exact interfaces (protocols) of (a part of) an abstract standard in the context of a specific distributed computing platform.

Figure 1. The Geo-Information Infrastructure in action; taken from (Van Oosterom, 2003).

The GII will integrate sectors (areas), which have until now been separated. Besides re-using general geo-information knowledge (perhaps first discovered in one domain and then applied in other domains), the GII will also give an impulse to the use of geo-information and services from other domains. A prerequisite is that these different domains understand each other (share a common ontology). It was already difficult in the past to share the concepts within one geo-information domain (transportation, topography, geology, (ground) water, cadastre, elevation, land use, utilities, and so on), so one can image the difficult task ahead when concepts have to be shared between different domains.

Components of the GII

Geo-information services are used within (local, regional, central) governments, utility and other companies to support their core or primary business, which often depends heavily on spatially referenced data. Due to more and more exchange of geo-information within and between organizations and the wish to do this effectively, the need for a GII is growing. The GII consists of four, rather different basic components: geo-information, geo-information processing services (geo-DBMS), interoperability standards, and (wireless) networks. More in detail (Van Oosterom, 2001):

1. Basic (or authentic or foundation) *geo-information* in different domains: topography, elevation, cadastre, geology, companies, persons, etc. These data sets should be defined in an unambiguous way with respect to their data model, geometric and thematic contents, quality, accuracy, actuality and access (management, maintenance).
2. *Geo-information processing services* in general and the geo-DBMS specifically. The geo-data sets are maintained in these geo-DBMSs and are served to users from these geo-DBMSs via networks and/or traditional means. For these purposes, the DBMS has to support spatial data types and operators (simple analysis and selection oriented queries), spatial indexing and clustering (for large data sets), and if possible support for advanced analysis (topology based analysis). Also, temporal support is required in the form of some kind of future standard TSQL.
3. *Interoperability standards* are required to enable the integration of the different data sets and to combine the geo-information processing services. In fact, different organizations and individuals using each others geo-information in a digital environment can be regarded as parts of one distributed computing environment. One of the most obvious examples of this is an Internet GIS retrieving and combing on-the-fly data from different sources on the Internet. In order to be able to work in such a heterogeneous world (different types of hardware, networks, operating systems, geo-DBMSs) interoperability standards at many levels are required.
4. (Wireless) *networks* are obviously needed to transfer data and functionality (or 'services') between the involved parties. More and more this also includes a mobile communication partner, which often posses the possibility to determine its own position via GPS for example.

As mentioned earlier, it is important to realize that each of these components of the GII holds many aspects: organizational, financial, technical, etc. Nowadays Internet is being used intensively all over the world. The success of the Internet has shown the power and superiority of an open infrastructure. The open (public) standards and the decentralized architecture are responsible for the many free and non-free services. One of the most time-consuming tasks when implementing a GIS is obtaining geo-information. First, relevant data sets and sources have to be located and then these data sets have to be copied and converted into the local system/format. Some reasons why this process is so time-consuming are that it may be difficult to find the data, the data model of the source may be very different from the model implemented by the local system and the supported exchange formats of source and destination are different. The GII is trying to improve this situation by providing:

1. consensus on the geometric parts of the data model, both raster and vector data have to be supported (including different spatial reference systems);
2. how to describe the structure of the geo data sets (and geo processes), that is a metadata standard covering both the spatial and non-spatial aspects;
3. how to describe the actual meaning of the geo-information (formal semantics);
4. how to access and query the metadata and how to return the result of such a query, this is called catalogue services;
5. how to query the geo-information itself;
6. how to format (and transfer) the resulting geo-information.

By developing systems based on the above standards, a new model for implementing GIS applications becomes feasible. Instead of always copying and converting geo-information, it becomes possible to access the geo-information directly at the source. This model has a number of advantages. At the client side no data management (of copies) is needed anymore. Moreover the data can become available all over the word via Internet. However, the most important advantage is the fact that users have the guarantee that they have always the most actual and complete geo-information directly from the source at their disposal. Furthermore this model allows fair pricing of geo-information as every time data from the source is used (possibly through a local cache) the user can be charged for this. Currently, in the full data set copy model the user has to pay for the whole data set, even if certain data (regions) are not used at all (in a certain period). The new data at the source model allows fairer pricing, both viewed from the vendors and buyers point of view.

The role of the Netherlands in the geo-information standardization

Knowing the need of society with respect to geo-information (processing) standards and the activity of organizations such as OGC, ISO and CEN at international level, one could ask the very valid question 'What is the desired role of the Netherlands (and the local key players such as NEN and Ravi) in the international game of geo-information standardization?'. This is a question, which must have been in the mind of many people involved in geo-information standardization from the Netherlands. Of course, we can try to develop our own standards and indeed we have done this in the past; just think of examples such as NEN1878 and NEN3610 (and their predecessors). It will be clear that this standardization only works within the 'limits of our national border'. We have further contributed our knowledge at the European level within the context of CEN (TC287). But if we are honest our Dutch or European geo-information technology standards never have been a great success; the use of these standards in practice was relatively difficult and the tools did not very well support our standards. The result was that quite often 'de facto' industry standards were used. It is clear that this situation is not enabling a fair competition between the geo-ICT vendors. Therefore, it is good to observe that the 'tandem' OGC and ISO/TC211 is working very well and has resulted in many tangible results: GI standards are being developed, they are evaluated and refined in test-bed environments, and finally embedded in standard geo-ICT tools and used all over the world. This approach where users, industry and researchers get together, has resulted in formal standards, which are now accompanied with actual implementations, that is *standards in action!* The results are especially very clear in web environments, where the need for interoperability is the largest (catalogue servers, WMS, WFS, GML, etc.)

Recently, the CEN has taken the very wise decision (under the chairmanship of Henri Aalders) to accept the policy to adopt (take over) for Europe the ISO (and with that implicitly the OGC) geo-information standards and where needed to compliment with European profiles. This forms a solid, realistic technology basis for the European GII (as can be applied within, for example, INSPIRE). Under the inspiring guidance of the Ravi (specifically in the person of Marcel Reuvers), a lot of work has been done within the Netherlands to develop the new version of the NEN3610 'Base model geo-information' (Aalders et al, 2004). Within a constructive team with participants from Ravi, ICTO, Kadaster, Wageningen UR, and TU Delft (and a large group with representatives from the stake holders) it was decided that the new model had to be based on OGC and ISO standards (and in the future this then implies also the CEN standards). However, this is not the end of the story. We now do have a technological base, but we still do not have a meaningful description of the content though well defined objects (and their attributes, relationships and constraints). Therefore, based on the first version of NEN3610 ('Terreinmodel Vastgoed'), the new TOP10NL model (Bakker and Kolk, 2001), several domain specific models within the Netherlands (IMRO, IMWA, IMKICH, ...), and the wish list of the stakeholders, a shared set of main concepts/objects (features) was defined within the new NEN3610, version 2 'Base model geo-information'. Similar to OGC and ISO this model is now described (and documented) in UML (OMG, 2002). The (semantic) object definitions are also prepared for future delivery (over the web) in the GML3 format. This will make sure that there is support from the geo-ICT industry and a truly working national GII can be realized (and this will also fit within the European or Global GII).

So, the answer to the question 'What is the Dutch role with respect to the GI standardization?' is that we developed a formal semantic model (ontology) based on international standards. Now one could wonder whether our topographic, transportation, (ground) water, soil, cadastral, planning, etc. geo-information is that different compared to other countries? And the answer is 'of course not' (though there may be some relatively small differences). Therefore we can very well export from the Netherlands our (base geographic and specific application) domain knowledge in international context: starting with INSPIRE, but also within CEN, OGC, FIG, ISO, and so on; for example in the cadastral domain (Lemmen et al, 2003). Because also for international meaningful use of each others geo-information good, formal semantic based, object definitions are as needed as the lower level geo-information technology definitions of geometry, temporal, metadata, etc. Further, should we also not be active in the field of the basic geo-information technology standardization? Yes, for sure, we should also be more active over here: early testing of relevant new standards (and giving critical feedback/suggestions for further improvement), participating in the development of future standards, and so on. Perhaps not in the whole broad spectrum of geo-information standardization, but in a number of selected relevant area's for the Netherlands; such as web services, metadata, 3D/temporal models. In this way we also build the required local knowledge at an early stage (and have influence on for the Netherlands) important standards. These activities from the Netherlands should be organized by our coordinating ministry of VROM and would fit very well in the proposed plan 'Space for Geo-Information' (RGI, 2003)!

Standards in action

The value of standards lies in the actual use of these standards in practice. For a large part this depends on the suitability and ease of use for the involved organizations. Assume that there is the choice between a very good, formal and suitable standard (but without implementations) and a less good, proprietary and perhaps less suitable standard (but with many implementations), then organizations are inclined to use the later one. So, organizations often choose pragmatic solutions, even if these are sub-optional for the long term. In the past, there have been many meetings and symposia related to geo-information standardization (and metadata, clearinghouses, etc.) which were very good but did not really make the bridge to the application and implementation of these standards. After many years of discussing geo-information standards (with limited success in applications) and considering that standards are often not a very hot topic (sometimes even a bit boring), it could very well be the case that the involved organizations and persons get less motivated to participate in this important geo-information standardization process.

However, due to the fact the ever more ICT is applied within the involved organizations and the fact that ever more digital (geo-)information is exchanged between these organizations, the need for long term, sustainable (and not sub-optional, short term) standards is growing all the time. Therefore, the approach of OGC to develop standards or specifications based on test-beds (in which geo-ICT industry, users and academia work together) is very important: the paper documents are now often accompanied by true interoperable implementations within a relative short term. In addition, the agreement between ISO, TC211 and OGC to harmonize their geo-information standards does make this development even more strong. The involved standards are not only well implemented, but now also have a formal status, which has the strong preference of many government organizations above proprietary standards.

The NCG/GIN symposium of 17 November 2004 ‘Standards in Action’ tries to emphasize the importance of really using the standards in real world implementations, by not only discussing the standards, but also let them work in action. This will then make clear if all beautiful promises are indeed living up to the expectations in actual use in products/implementations. This tradition started with the earlier GML-relays (the first in Wageningen, June 2001 and the second in Emmen, December 2002), and is now continued in the third GML relay. The difference between the GML-relay and the OGC test-beds is that now implementations are used outside the, more controlled, lab environment and only (commercially) generally available software versions are used. Both approaches (test-bed and the approach followed in the GML-relay) are useful as they serve different but complementary purposes.

Somewhere in between OGC test-beds and the GML relay approach is the new concept of an OGC plugfest; a quote from the OGC website: “The First-Ever OGC Plugfest was held on Wednesday, June 16, 2004 in Southampton, UK in connection with the 50th OGC Technical Committee Meeting. This plugfest concentrated on testing interoperability between clients and servers that are intended to comply with Web Map Service 1.1.1 and Web Feature Service 1.0.”

However, GML is just one (though very powerful) standard for exchanging geo-information models and data. Therefore at the symposium of 17 November 2004, this concept is extended to other geo-information standards: the OGC web services. These include catalogue services (with metadata), web map/terrain/feature/coverage services, (reverse) geo-coding services, coordinate transformation services, routing services and so on. The nice thing about the OGC web services is that they fall within the category of service-oriented architecture (SOA) based on web technology. Meaningful ‘chunks’ of well defined geo-information data or well-defined geo-information functionality (together also labeled services) can be obtained from multiple sources and combined in building actual applications. Did this work? We will know this after 17 November 2004, because beside the third GML, also the ‘OGC Web Services (OWS) in action’ event is part of the program.

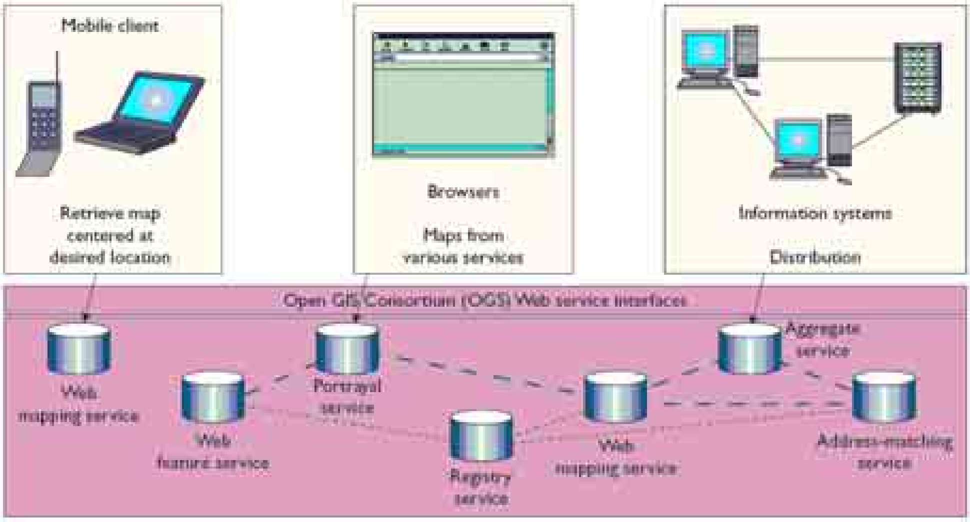


Figure 2. Simplified view of OGC web services; taken from (Alameh, 2003).

Conclusion

In order to avoid duplication of geo-information, with dangers such as out-of-date-ness and inconsistency with the source, it is better to create geo-information communities, which share (against reasonable prices) the appropriate information in an efficient manner. This requires a good GII, which covers topics such as: geo-information foundation data sets, geo-information services (functions, analysis), networks, and geo-information protocols and standards. These topics in turn consist of many aspects, such as organizational, legal, financial and technical ones. The GII will integrate sectors (areas), which have until now been separated. Besides reusing general geo-information knowledge (perhaps first discovered in one domain and then applied in other domains), the GII will also give an impulse to the use of geo-information and services from other domains. A prerequisite is that these different domains understand each other (share a common ontology).

Due to the fact the ever more ICT is applied within the involved organizations and the fact that ever more digital (geo-)information is exchanged between these organizations, the need for long term, sustainable (and not sub-optional, short term) standards is growing all the time. Therefore, the approach of OGC to develop standards or specifications based on test-beds (in which geo-ICT industry, users and academia work together) is very important: the paper documents are now often accompanied by true interoperable implementations within a relative short term. In addition, the agreement between ISO, TC211 and OGC to harmonize their geo-information standards does make this development even more strong. The involved standards are not only well implemented, but now also have a formal status, which has the strong preference of many government organizations above proprietary standards.

What should we do in the Netherlands with respect to applying geo-information standards in the context of using and producing geo-information? The development of NEN3610 version 2 ‘base model geo-information’ indicates the right direction: use (nearly) mature international (OGC/ISO) base geo-information technology standards and focus on the development of meaningful domain models (and make sure that these domains do understand each other). One of the most prominent data set is formed by the base or topographic data set. If we take a look at these data in the USA, we see that the USGS topo maps (about 55,000 map sheets at scale 1:24,000) are on the average 23 years old, with some data as old as 57 years. However, the ultimate goal of the USGS is that changes will be recorded within 7 days of a change on the landscape (USGS, 2001, Kelmelis et al., 2003). This ambitious goal can only be achieved via a new approach, embodied in the *The National Map,* which is (quote from http://nationalmap.usgs.gov): ‘the product of a consortium of Federal, State, and local partners who provide geospatial data to enhance America's ability to access, integrate, and apply geospatial data at global, national, and local scales.’ It is interesting to see that in their logo USGS has the text ‘science for a changing world’ and this is followed on their homepage with ‘125 years of science for America’. This typifies the American society: setting (incredible) high goals and realizing that they will need science to obtain these. In Europe there is a different attitude, perhaps less explicit in the ambition. However, in the Netherlands we already have a reasonable good record of working together within the geo-information community; e.g. the GBKN as joint ownership of utility companies, Kadaster, municipalities, water boards, KPN, etc. Supported by modern science and technology (networks, advanced sensors, geo-information models and standards), it should be possible to beat the USA in realizing our ´National Map´ in which several products are fused (GBKN, Top10NL, RWS DTBs, municipality maps, etc.), which is updated within a week!

Acknowledgements

This publication is the result of the research program 'Sustainable Urban Areas' (SUA) carried out by Delft University of Technology. We would like to tank Elfriede Fendel for proof read and correcting the draft version of this chapter.

References

Aalders, Henri, Jandirk Bulens, Paul Janssen, Peter van Oosterom, Marcel Reuvers, Harry Uitermark, and Wilko Quak. Basismodel Geo-Informatie, versie 0.9 (NEN3610, versie 2), Ravi report, 15 september 2004 (in Dutch).

Alameh, Nadine. Chaining Geographic Information Web Services, IEEE Internet Computing, September-October 2003, pp. 22-29.

Bakker, Nico and Bert Kolk. A new generation TOP10vector data in the Netherlands. In Proceedings of the 20th International Cartographic Conference ICA, Beijing, August 2001.

Lemmen, C., P. van der Molen, P. van Oosterom, H. Ploeger, W. Quak, J. Stoter, and J. Zevenbergen, ‘A modular standard for the Cadastral Domain’, in proceedings of Digital Earth Information Resources for Global Sustainability, Brno, Czech Republic, September 21-25, 2003.

Kelmelis, John A., Mark L. DeMulder, Charles E. Ogrosky, Nicholas J. Van Driel, and Barbara J. Ryan, 2003. ‘The National Map, From Geography to Mapping and Back Again’. Photogrammetric Engineering & Remote Sensing, Vol. 69, No. 10, October 2003, pp. 1109–1118. (http://nationalmap.usgs.gov/report/PERS_article_forviewing.pdf)

OGC, 2002a, Open GIS Consortium, Inc., The OpenGIS Abstract Specification, Topic 12: OpenGIS Service Architecture, Version 4.3 (OGC 02-112), Editor: George Percivall.

OGC, 2002b, Open GIS Consortium, Inc., Web Feature Service (WFS) Implementation Specification, version 1.0 (OGC 02-058), Editor: Panagiotis A. Vretanos.

OGC, 2003a, Open GIS Consortium, Inc., OpenGIS® Geography Markup Language (GML) Implementation Specification, version 3.0 (OGC 02-023r4), Editors: Simon Cox , Paul Daisey, Ron Lake, Clemens Portele, Arliss Whiteside.

OGC, 2003b, Open GIS Consortium, Inc., OpenGIS® Reference Model (ORM), Version: 0.1.2 (OGC 03-040), Editor: Kurt Buehler.

OGC, 2004, Open Geospatial Consortium, Inc., Web Map Service (WMS), Version: 1.3 (OGC 04-024), Editor: Jeff de La Beaujardiere.

OMG, 2002, Object Management Group, Unified Modeling Language Specification (Action Semantics), UML 1.4 with action semantics, January 2002.

Oosterom, Peter van, 2001. De geo-database als spin in het web, Intreerede, TU Delft, 6 juni 2001 (in Dutch).

Oosterom, Peter van, 2003. Vison for the next decade of GIS technology – A research agenda for the TU Delft, the Netherlands, Report to Faculty of Civil Engineering and Geosciences, Delft 2003, 55 p. GISt Report No. 20.

RGI Consortium (Ravi), 2003. Space for Geo-information (‘ruimte voor geo-infromatie’), Bsik knowledge project poposal, February 2003.

USGS, Cooperative Topographic Mapping Program, U.S. Geological Survey, U.S. Department of the Interior, ‘The National Map, Topographic Mapping for the 21st Century’, Final Report, November 30, 2001.

W3C, 2000, XML 1.0 (October 2000), *Extensible Markup Language (XML) 1.0 (2nd edition)*, World Wide Web Consortium Recommendation, Bray, T., J. Paoli, C.M. Sperberg-McQueen, and E. Maler, eds., <http://www.w3.org/TR/REC-xml>

W3C, 2001, XML Schema (May 2001), *XML Schema Part 1: Structures*, World Wide Web Consortium Recommendation, Thompson, H. S., D. Beech, M. Maloney and N. Mendelsohn, eds., <http://www.w3.org/TR/xmlschema-2/>

W3C, 2004, World-Wide Web Consortium, *OWL Web Ontology Language (Overview)*, W3C Recommendation, 10 February 2004.

ISO TC211/Metadata

D.M. Danko
Environmental Systems Research Institute, Inc., USA

Interoperability comes in different flavors, primarily technical and semantic. There are many factors that are required to make interoperability happen; two major factors are standards and metadata. ISO TC 211 is developing a suite of standards for the field of Geographic Information which include standards for metadata. Metadata has always played an important role in cartography. For centuries it has provided users with an understanding of maps. Metadata is equally important as we have moved into the digital environment. Because digital data is an imperfect representation of the real world, assumptions made during production need to be understood by users. With the proliferation of data from an ever-widening array of sources and producers, we need metadata to control and manage geographic data. Metadata is absolutely essential to spatial data infrastructures, clearinghouses, networks, and warehouses. Proper metadata allows users across networks to locate, evaluate, extract, and employ geographic data. Metadata adhering to the international standard, ISO 19115:2003, will allow global networks to operate, provide a common global understanding of geographic data, and promote global interoperability.

Interoperability

In today's world everything is integrated; no one person, or organization, can get along without depending on someone else. Mankind has survived and prospered by working together – as a family, as a village, as a tribe, as a team. This is more true today than ever. We depend on others for most of our needs in an integrated and mostly congruent society. "Think globally, act locally" – things that happen globally affect us locally and things we do locally affect the global community. Communication is a key enabler in all of this; and all this of course is possible because we interoperate. In fact the better we interoperate the better we communicate, the more efficient we are, and the higher the quality of what we do.

GIS has always required interoperability. GIS uses data from multiple sources and from multiple distributed organizations within a community. For years GIS has been merging different information types: raster, vector, text, and tables. As the use of GIS grows and moves into varied disciplines the need for interoperability increases. Today must GIS interoperate with a broad array of IT applications and is applied across diverse information communities. Web Services carry this need to new heights with loosely coupled, distributed networks.

ISO TC 211 is developing a suite of standards for digital geographic information and describes interoperability as "the ability to find data and services when they are needed, no matter where they are located. Once found, interoperability provides the ability to access, understand and employ these data and services whether local or remote and regardless of the platform that supports them."

There are many things that are needed to make interoperability happen. We need an infrastructure to support interoperability, a common architecture, and compatible technologies. We need authorization – both authorization to share our data and services with others, and authorization to uses other's data and services. We need to insure individual's and organization's intellectual property rights are not infringed; we need good copyright laws. We need business agreements and a business model; if it is of unequal benefit to both sides than there is no need to exchange information, no need for interoperability. Of course we need quality assurance; if the information in an exchange is no good then there is no reason to be interoperable. We need **standards**; standards allow us to communicate both technically – hardware and software working together; and semantically – using the same term for the same concept. The International Organization for Standardization Technical Committee for Geographic Information Standards (ISO/TC211) is developing an integrated suite of standards to address both technical and semantic interoperability. Of course we need to understand data and services; for true interoperability we need **metadata**. Metadata is an important part of the ISO TC 211 standards. Metadata provides a vehicle to locate and understand geospatial data which may be produced by one community and applied by another.

ISO/TC 211 – Standardization in the field of digital geographic information

In late 1994, the International Organization for Standardization formed a Technical Committee, ISO TC211, to establish standards for Geographic Information. The work is being performed in 5 working groups. The standards development effort is further divided into 40 Work Items with a project leader for each item. See Table 1.

ISO TC 211 Scope:

> This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.
> These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations.
> The work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

ISO TC 211 is a large committee compared to most ISO technical committees comprised of 28 Principle nations and 30 Observing nations. The work in ISO TC 211 is further strengthened through the active participation of over 30 Class A liaison members. Along with well developed requirements for standards, Class A Liaison members bring a wealth of experience in working with geographic information. Some instances of liaison members are the Open Geospatial Consortium, the Digital Geographic Information Working Group, the International Cartographic Association, CEN TC 287 for Geographic Information, the International Civil Aviation Organization, the International Hydrographic Bureau, the International Federation of Surveyors, many United Nations organizations, and many international committees concerned with geographic information.

The goals of the committee are to develop a family of international standards that will support the understanding and usage of geographic information; increase the availability, access, integration, and sharing of geographic information, enable interoperability of geospatially enabled computer systems; contribute to a unified approach to addressing global ecological and humanitarian problems; ease the establishment of geospatial infrastructures on local, regional, and global levels; and contribute to sustainable development.

Figure 1. ISO TC 211 Delegates at a recent meeting in Pallanza, Italy.

ISO TC 211 has been productive and to-date has produced 15 International Standards and Technical Reports with many more waiting in the wings, as Draft International Standards, soon to be completed. Many of these early standards can be considered foundational in defining geographic information such as Spatial Schema, Temporal Schema, Metadata, Quality, and Spatial Referencing by Coordinates. Additional standards are being produced which are based on these foundational standards such as Simple Feature Access, Web Map Services, and Geographic Mark-up Language (GML). For the future ISO TC 211 will be focusing on additional web service specifications, location based services, imagery related standards, and specific information community needs.

Project	**Issue**	**Project**	**Issue**
6709 - Standard representation of latitude, longitude and altitude for geographic point locations	IS 2006-12	19122 - Qualifications and Certification of personnel	TR 2004-10
19101 - Reference model	IS	19123 - Schema for coverage geometry and functions	IS 2005-08
19101-2 - Reference model - Part 2: Imagery	IS 2007-10	19124 - Imagery and gridded data components	RS
19103 - Conceptual schema language	TS 2004-04	19125-1 - Simple feature access - Part 1: Common architecture	IS
19104 - Terminology Introduction	IS 2004-06	19125-2 - Simple feature access - Part 2: SQL option	IS
19105 - Conformance and testing	IS	19126 - Profile - FACC Data Dictionary	IS 2006-08
19106 - Profiles	IS	19127 - Geodetic codes and parameters	TS 2004-10
19107 - Spatial schema	IS	19128 - Web Map server interface	IS 2005-08
19108 - Temporal schema	IS	19129 - Imagery, gridded and coverage data framework	TS 2005-04

Project	Issue	Project	Issue
19109 - Rules for application schema	IS 2004-12	19130 - Sensor and data models for imagery and gridded data	IS 2006-12
19110 - Methodology for feature cataloguing	IS 2004-10	19131 - Data product specifications	IS 2006-04
19111 - Spatial referencing by coordinates	IS	19132 - Location based services possible standards	RS
19112 - Spatial referencing by geographic identifiers	IS	19133 - Location based services tracking and navigation	IS 2005-08
19113 - Quality principles	IS	19134 - Multimodal location based services for routing and navigation	IS 2006-02
19114 - Quality evaluation procedures	IS	19135 - Procedures for registration of geographical information items	IS 2005-09
19115 - Metadata	IS	19136 - Geography Markup Language	IS 2006-08
19115-2 - Metadata - Part 2: Extensions for imagery and gridded data	IS 2007-03	19137 - Generally used profiles of the spatial schema and of similar important other schemas	IS 2006-04
19116 - Positioning services	IS	19138 - Data quality measures	TS 2005-05
19117 - Portrayal	IS 2004-06	19139 - Metadata - Implementation specification	TS 2004-12
19118 - Encoding	IS 2004-06	19140 - Technical amendment to the ISO 191** Geographic information series of standards for harmonization and enhancements	Several amendments
19119 - Services	IS 2004-06		
19120 - Functional standards	TR		
19121 - Imagery and gridded data	TR		

Note 1 Full title of projects are prefixed with "Geographic information -".
Note 2 See ISO/TC 211 website for the status of each project (programme of work).

Table 1. ISO/TC 211 Projects.

Introduction to metadata

Everyday researchers may:

- be required to perform a critical analysis that requires the use of many data samples, from many sources around the world;
- need to pick the perfect dataset to fill a special requirement from thousands of datasets available through an on-line catalog;
- work with 50 datasets at the same time, covering the same area of interest;

– have data so old that no one in the organization will remember anything about it;
– be required to make a life-or-death decision using someone else's geospatial data.

In all of these situations researchers will need to know:

– What geographic data is available?
– Where is it?
– How to obtain it?
– Is it the best data available to make a decision?
– Is it up to date?
– Is it accurate?

These and many other questions require a good understanding of data. They require that data be well documented; they require complete and correct metadata. As we move into the age of spatial data infrastructures, knowledge about data is essential, allowing users to locate, evaluate, extract, and employ geospatial data. Diverse communities with a common understanding of metadata will be able to manage, share, and reuse each other's geographic data, making global interoperability a reality. The ISO Standard for Geographic Information - Metadata (ISO 19115) will provide this common understanding.

Documenting geographic information

Metadata is not new; it is used every day in library card catalogs, Compact Disc (CD) jackets, user's manuals, and in many other ways. Geographic data has a long history using metadata. The marginalia on maps and charts are, of course, metadata. The title, source, scale, accuracy, producer, symbols, navigation notices, warnings, and all of the information found in the borders of maps and charts are metadata. This metadata is very user oriented; just about anyone can pick up a map, understand the metadata, and use the map. Map catalogs are another traditional use of metadata. Typically, map catalog metadata is limited to information such as area coverage, series identifiers (subject matter and scale), publication dates, and distribution information.

Why document geographic information?

Non-geographers using geospatial data: A revival in the awareness of the importance of geography and how things relate spatially, combined with the advancement in the use of electronic technology, have caused an expansion in the use of digital geospatial information and geographic information systems (GIS) worldwide. Increasingly, individuals from a wide range of disciplines outside of the geographic sciences and information technologies are capable of producing, enhancing, and modifying digital geospatial information. As the number, complexity, and diversity of geospatial datasets grow, a method for providing an understanding of all aspects of this data grows in importance.

Geospatial data is imperfect: Digital geospatial data is an attempt to model and describe the real world. Any description of reality is always an abstraction, always partial, and always just one of many possible "views". This view, or model, of the real world is not an exact duplication; some things are approximated, others are simplified, and some things are ignored - there is no such thing as perfect, complete, and correct data. To insure that data is not misused, the assumptions and limitations affecting the collection of the data must be fully documented. Metadata allows a producer to fully describe a dataset; users can understand the assumptions and limitations and evaluate the dataset's applicability for their intended use.

Increasingly, the producer is not the user: Most geospatial data is used multiple times, perhaps by more than one person. Typically, it is produced by one individual or organization and used by another. Proper documentation provides those not involved with data production with a better understanding of the data and enable them to use it properly. As geospatial data producers and users handle more and more data, proper documentation provides them with a keener knowledge of their holdings and allows them to better manage data production, storage, updating, and reuse.

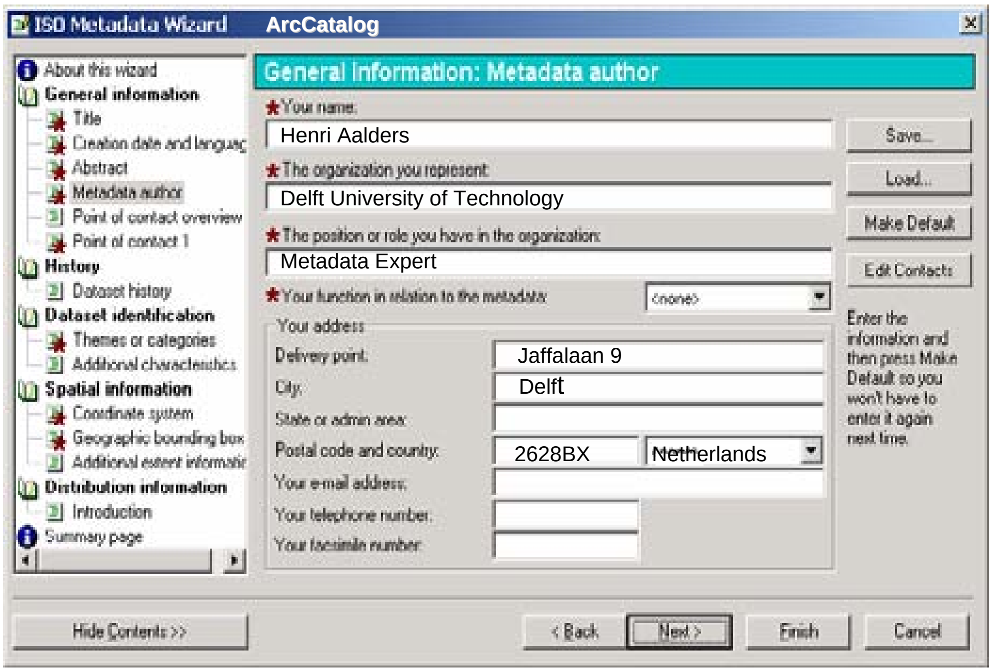


Figure 2. Metadata production should make use of templates, forms, and automation to make documentation as easy and efficient as possible.

Where should geographic information be documented?

Metadata is required in at least four different circumstances and perhaps in different forms to facilitate its use: in a catalog for data discovery purposes; imbedded within a dataset for direct use by application software; in a historical archive; and in a human readable form to allow users to understand and get a "feel" for the data they are using.

Catalogs: Metadata for cataloging purposes should be in a form not unlike a library card catalog or on-line catalog. Metadata in a catalog should support searches by subject matter/theme, area coverage/location, author/producer, detail/resolution/scale, currency/date, data structure/-form, and physical form/media.

Historical Records: Metadata should support the documentation of data holdings to facilitate storage, updates, production management, and maintenance of geospatial data. Historical records provide legal documentation to protect an organization if conflicts arise over the use or misuse of geospatial data.

Within a geospatial dataset: Metadata should accompany a dataset and be in a form to support the proper application of geospatial data. GIS and other application software using data need to evaluate data as it applies to a situation. In this form the metadata may be incorporated into the structure of the data itself.

Human readable: Metadata in a form in which a computer can locate, sort, and automatically process geospatial data greatly enhance its use, but eventually a human must understand the data. One person's, or organization's, geospatial data is a subjective abstract view of the real world, it must be understood by others to ensure the data is used correctly. Metadata needs to be in a form which can be readily and thoroughly understood by users.

Applying geographic information documentation

Metadata supports many applications; these can be classified into four primary functions (see Table 2):

Locate: Metadata enables users to locate geospatial information and allows producers to "advertise" their data. Metadata helps organizations locate data outside the organization and find partners to share in data collection and maintenance.

Evaluate: By having proper metadata elements describing a dataset, users are able to determine its "fitness for an intended use." Understanding the quality and accuracy, the spatial and temporal schema, the content, and the spatial reference system used, allows users to determine if a dataset fills their needs. Metadata also provides the size, format, distribution media, price, and restrictions on use, which are also evaluation factors.

Extract: After locating a dataset and determining if it meets users needs, metadata is used to describe how to access a dataset and transfer it to a specific site. Once it has been transferred, users need to know how to process and interpret the data and incorporate it into their holdings.

Employ: Metadata is needed to support the processing and the application of a dataset. Metadata facilitates proper utilization of data, allowing users to merge and combine data with their own, apply it properly, and have a full understanding of its properties and limitations.

	Catalog	Within Dataset	Historical Record	Human Readable
Locate	X		X	X
Evaluate	X	X	X	X
Extract	X	X		
Employ		X		X

Table 2. Metadata Usage Reference Matrix.

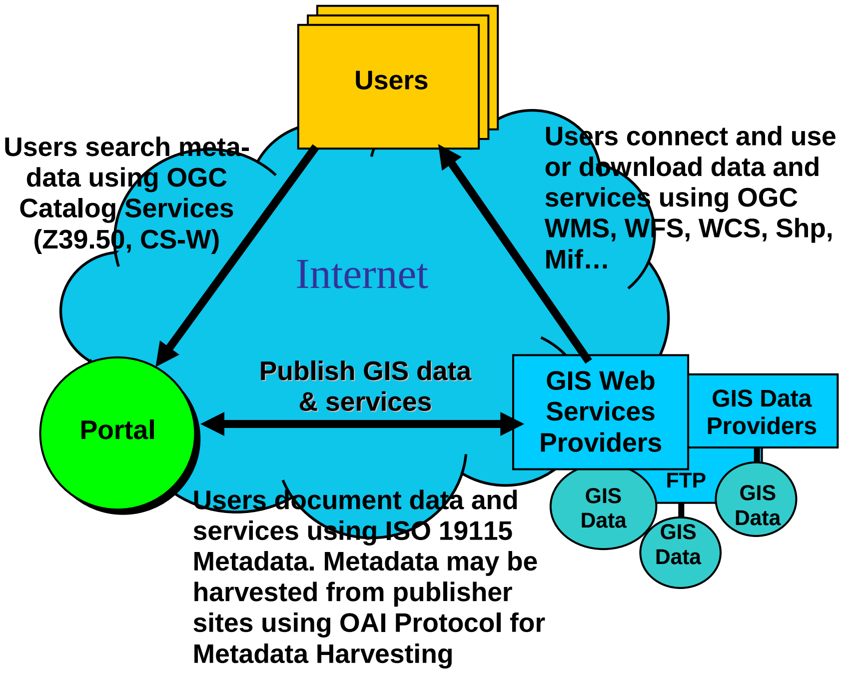


Figure 3. Metadata Web Portal Architecture. Following the W3C Service Oriented Architecture, 14 November 2002. *Metadata provides the basis of a portal architecture. Allowing producers to publish metadata about their data and services and users to locate, evaluate, and access the data and services that meet their requirements.*

Conclusions

The need for interoperability has been around for a long time. This need increases as the world becomes more integrated. The need for interoperability for GIS increases as GIS moves into mainstream information technology (IT) applications and with the increased use of web services' loosely couple networks. Standards and metadata are two important factors that make interoperability possible. Now that ISO TC 211 has established some 15 foundational standards, and is well underway establishing many more, committees like CEN and organizations like OGC can develop profiles and implementation specifications, respectively, based on this foundation, to increase international interoperability. ISO TC211 developed ISO 19115:2003 which became an international standard in May 2003. This standard is beginning to play a role in allowing providers to promote, and users to find and understand data and services, world-wide. National, Regional, and information community profiles of this standard will further its use. Ideally these profiles should follow ISO 19106 and the International Standardized Profile process; this international coordination will ensure interoperability between global communities. ISO 19115:2003, a somewhat abstract standard, provides "semantic" interoperability; in early 2005, ISO TC 211 will establish a technical specification (TS), ISO 19139 Geographic information – Metadata – XML Schema Implementation. Based on ISO 19115:2003, this TS will provide "technical" interoperability; it will go much further broadening the use of standardized metadata in portals, in a variety of applications, and in commercial GIS around the world

References

Danko, D.M., 2001, International Standards, Interoperability and GIS, Presentation, Database 2001 Tokyo, Tokyo, Japan.

Danko, D.M., 1998 (June), "Metadata for a Global Spatial Data Infrastructure," *Geographic Information Systems: Information Infrastructures and Interoperability for the 21st Century Information Society*, Brno, Czech Republic.

ISO TC 211, 2004, *Programme of work*, http://www.isotc211.org/

International Organization for Standardization, 2003, *ISO 19115 Geographic information – metadata*, Geneva, Switzerland.

W3C World Wide Web Consortium, 2002 (November), *Service Oriented Architecture*.

The Geography Markup Language (GML)

C. Portele
interactive instruments GmbH, Germany

The Geography Markup Language, GML, enables a vendor-neutral representation of geographic information – with a special emphasis on the web and web services. GML is based on the XML family of technologies developed by the W3C and implements concepts standardized in the ISO 19100 series of standards:

- *The XML Schema language is used to model GML Application Schemas, i.e. XML grammars for applications / information communities. Xlinks (hyperlinks) are used to encode associations between objects.*
- *GML provides a comprehensive collection of standardized XML Schema components to be used in application schemas. Where available, these schema components implement types from the conceptual model of the ISO 19100 series.*
- *Like the ISO 19100 series, GML is feature centric. A GML instance document is typically a collection of features. The document must be valid against a GML Application Schema.*

The development of GML was started by the Open Geospatial Consortium, Inc. (OGC) and is an adopted OpenGIS Implementation Specification since February 2001. Currently, GML is being processed within ISO/TC 211 and is expected to be published eventually as ISO 19136. This standardization process is carried out jointly by both organizations.

Overview

The next section ("What is GML?") introduces the scope and basic concepts of GML. The subsequent section ("Why GML?") discusses the reasons that prompted for the development of GML and highlights the role GML can play as a *lingua franca* of the geo-spatial web. GML Application Schemas, the GML Schema, and GML Documents are explained in the following section. Finally the roles of the Open Geospatial Consortium and ISO/TC 211 in the development and standardization of GML are discussed.

What is GML?

The Geography Markup Language (GML) is a framework to encode features with specific support for geographic information in accordance with the conceptual framework specified in the ISO 19100 series of International Standards. GML enables a vendor-neutral exchange of geographic information.
As GML is designed for the World Wide Web and Web Services in particular, GML uses XML as the encoding language and Xlink to encode relationships between objects.

Unlike other XML languages (for example SVG), GML does not provide a fixed grammar but provides a meta-language that enables an information community to describe the characteristics of the features relevant to their application. Thus, GML is also a modeling language for features, the XML Schema language is used to describe such application schemas.
To help modelers and enable interoperability across applications, GML provides a comprehensive set of standardized components that can be used by applications dealing with geographic

information. These standardized components are – where available – implementations of concepts defined in the ISO 19100 series.

As a result, the scope statement in the current GML specification document (version 3.1) is as follows:

The Geography Markup Language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modeled according to the conceptual modeling framework used in the ISO 19100 series and including both the spatial and non-spatial properties of geographic features.

This specification defines the XML Schema syntax, mechanisms, and conventions that:
- Provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects;
- Allow profiles that support proper subsets of GML framework descriptive capabilities;
- Support the description of geospatial application schemas for specialized domains and information communities;
- Enable the creation and maintenance of linked geographic application schemas and datasets;
- Support the storage and transport of application schemas and data sets;
- Increase the ability of organizations to share geographic application schemas and the information they describe.

Implementers may decide to store geographic application schemas and information in GML, or they may decide to convert from some other storage format on demand and use GML only for schema and data transport.

The first large data content provider that has adopted GML was the Ordnance Survey UK in their OS MasterMap product. Others have followed or are evaluating GML; for example, the surveying and mapping agencies of the German states will migrate all their cadastre and topography products to GML: GML and Web Feature Service are the core specifications in their standards-based exchange interface (NAS) in their AFIS-ALKIS-ATKIS specification.

Why GML?

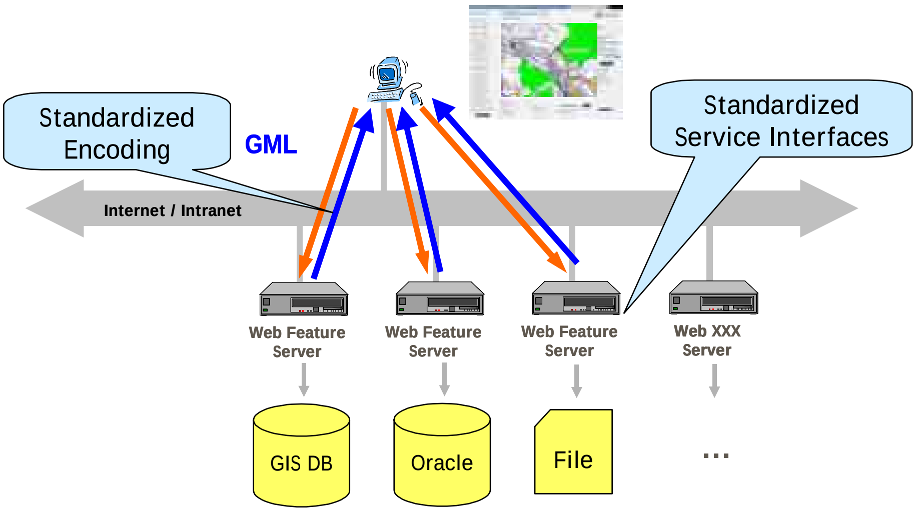
The World Wide Web creates new possibilities and increased requests for on-demand access to all kinds of information including geographic information. The recent activities for the development of Spatial Data Infrastructures (SDIs) within regions or organizations is a response to this. On-demand access to geographic information and networked resources of geographic information is of prime importance to support, for example, risk or disaster management scenarios, location-based services or many e-Government applications.

Disaster management is a prime example. Whenever an unforeseen disaster occurs, quick and integrated access to high quality information is required to minimize the impact and organize countermeasures. Geographic content seldom has been and is available in a way that allows on-the-fly access to and processing of distributed information.

Therefore, the emerging SDIs typically address a range of problems. Among these are (this is by far not a complete list!):

- Overcome organizational and legal barriers to the use of geographic information.
- Improve the existence and availability of geographic content.

– Publish geographic information via services and not as plain data sets so that the geographic content can be accessed in a way that is immediately useful for the requestor.
– Establish registries of geographic content and services so that the information can be found and processed by software applications and human users.



Plug-and-play of different software components in a SDI requires the use of a common architecture and standards. Such standards are required, for example, for services (e.g. the Web Map Service, the Web Feature Service and the Catalog Service) and content encodings (e.g. GML Application Schemas and ISO 19139). The encoding of features and especially geographic properties is only a part, but an essential part, of any SDI architecture – including INSPIRE.

Issues as sustainability and quick market-uptake are best addressed by open standards, i.e. ones that are – among other things – maintained in an open, international, participatory process as well have free rights of distribution.

GML addresses all these requirements.

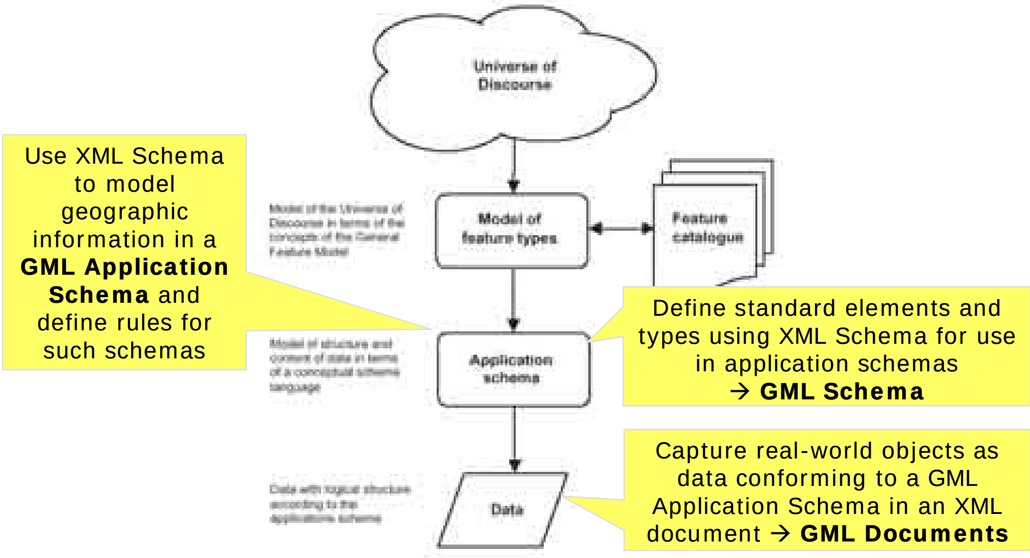
GML Application Schemas, the GML Schema, GML Documents

The figure below illustrates the concepts of a GML Application Schema, the GML Schema and a GML Document based on the modeling process as described in ISO 19109.

GML Application Schemas

The core concept of GML is the feature. A feature is an abstraction of the phenomenon in the real world. Every feature has a feature type, a named classification of a fact of the real world. Examples are roads, administrative areas, signposts, persons, vehicles, etc. As a result, the real world can be represented – in terms of an application domain – by a collection of features.

A geographic feature is a feature that is associated with a location relative to the Earth.



The state of a feature is described by a set of properties, in which every property is in principle represented by a triple (name, type, value). Note that spatial properties are those properties that have a geometrical or topological GML object as defined in the GML Schema as their value (e.g. a point or a face) and that temporal properties are those properties that have a temporal GML object as defined in the GML Schema as their value (e.g. a time period). As a result, spatial and temporal properties are “nothing special” in GML and it is not uncommon to define more than one spatial property of a feature, e.g. the surface and a representative point of a parcel or the centerline and the covered surface of a road section.

A key characteristic of GML is that properties may be local values or references to remote objects. Features with a similar characteristic are grouped to feature types, those features will share a similar set of properties. This structure is specified in a GML Application Schema.

An example from the Top10 NL GML Application Schema used in the third GML Relay, the definition of the GeografischGebied feature type:

```
<element name="GeografischGebied" type="tdn:GeografischGebiedType"
    substitutionGroup="gml:_Feature"/>

<complexType name="Top10ObjectType" abstract="true">
    <complexContent>
        <extension base="gml:AbstractFeatureType">
            <sequence>
                <element name="top10_id" type="integer"/>
                <element ref="tdn:bronRef"/>
                <group ref="tdn:Temporeel"/>
                <element name="dimensie" type="tdn:dimensie"/>
                <element name="tdncode" type="integer"/>
            </sequence>
        </extension>
    </complexContent>
</complexType>

<complexType name="GeografischGebiedType">
    <complexContent>
        <extension base="tdn:Top10ObjectType">
            <sequence>
                <element name="type" type="tdn:typeGeografGebied"/>
                <element ref="gml:geometryProperty"/>
```

```xml
                    <element name="naam" type="string"/>
                </sequence>
            </extension>
        </complexContent>
    </complexType>
```

The GML Schema

The GML Schema is not focused on a specific application domain, but provides common constructs and concepts which are used by different application domains. Most GML objects implemented in the XML Schema elements of the GML Schema are implementations of conceptual types defined in the ISO 19100 series. The GML Schema provides a comprehensive set of predefined schema components that can be used in GML Application Schemas. The following list illustrates the thematic coverage of these components:

– GML object and feature model, base schema
– Geometric primitives (0d, 1d, 2d, 3d)
– Geometric composites (0d, 1d, 2d, 3d)
– Geometric aggregates (0d, 1d, 2d, 3d)
– Topology (0d, 1d, 2d, 3d)
– Coordinate reference systems
– Temporal information
– Dynamic features
– Definitions and dictionaries
– Units, measures and values
– Directions
– Observations
– Coverages
– Default styling

The content model of the GeografischGebied feature type is derived from the base type of all GML feature types, AbstractFeatureType. In addition, the feature type uses the pre-defined GML object types “Polygon” (a 2d geometric primitive with planar interpolation) and “_Geometry” (any geometric object).

GML Documents

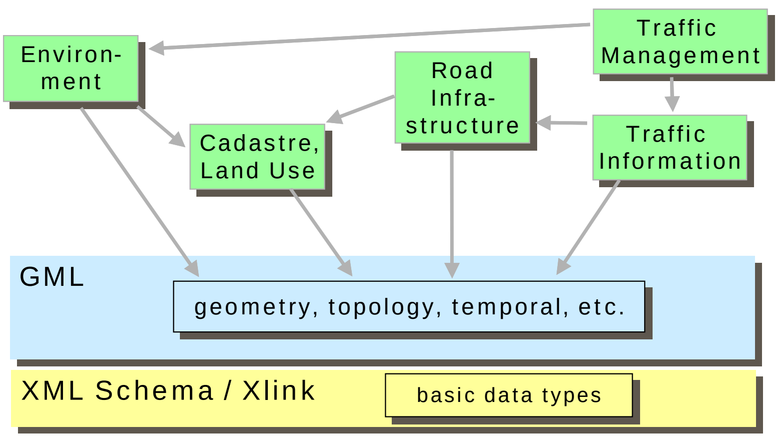
A typical GML Document is a XML document consisting of a collection of GML features. The XML document is valid with respect to the GML Application Schema. Again, as an example an excerpt from the GML Document used in the third GML Relay:

```xml
<?xml version="1.0" encoding="iso-8859-1" standalone="no"?>
<tdn:Top10Themas xmlns:tdn="http://www.gdmc.nl/tdn" xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.gdmc.nl/tdn tdn_strict2.1.xsd">
    <gml:description>Situatie op 20020101</gml:description>
    <gml:boundedBy>
        <gml:Box srsName="EPSG:28992">
            <gml:coordinates>105000,447000 107000,449000</gml:coordinates>
        </gml:Box>
    </gml:boundedBy>
    <!-- ... -->
    <tdn:top10ThemasMember>
        <tdn:GeografischeGebieden>
```

```xml
        <gml:boundedBy>
          <gml:Box srsName="EPSG:28992">
            <gml:coordinates>105000,447000 107000,449000</gml:coordinates>
          </gml:Box>
        </gml:boundedBy>
        <tdn:geografischeGebiedenMember>
          <tdn:GeografischGebied fid="TOP10.400275">
            <tdn:top10_id>7450001</tdn:top10_id>
            <tdn:bronRef xlink:type="simple" xlink:href="metadata.xml#TOP10.9000005"/>
            <tdn:object_begindatum>2001-12-17T13:24:10+02:00</tdn:object_begindatum>
            <tdn:versienummer>1</tdn:versienummer>
            <tdn:versie_begindatum>2001-12-17T13:24:10+02:00</tdn:versie_begindatum>
            <tdn:dimensie>2D</tdn:dimensie>
            <tdn:tdncode>8813</tdn:tdncode>
            <tdn:type>Polder</tdn:type>
            <gml:geometryProperty>
              <gml:Polygon srsName="EPSG:28992">
                <gml:outerBoundaryIs>
                  <gml:LinearRing>
                    <gml:coordinates>106387.98,448375.274 106329.216,448400.843
106139.542,448452.645 106118.39,448479.283 106059.964,448513.636 106008.725,448536.77
105934.689,448553.263 105860.885,448553.05 105610.426,448410.852 105624.208,448304.179
105579.736,448113.294 105452.447,447909.89 105419.799,447852.662 105395.562,447762.889
105397.954,447643.341 105416.841,447540.84 105740.271,447269.259 106109.88,447000 107000,447000
107000,447617.149 106857.727,447610.441 106770.673,447653.137 106737.194,447690.019
106714.068,447730.252 106708.339,447763.079 106657.019,447988.415 106624.657,448046.864
106589.18,448182.232 106536.359,448261.69 106464.23,448328.673
106387.98,448375.274</gml:coordinates>
                  </gml:LinearRing>
                </gml:outerBoundaryIs>
              </gml:Polygon>
            </gml:geometryProperty>
            <tdn:naam>Oostpolder in Schieland</tdn:naam>
          </tdn:GeografischGebied>
        </tdn:geografischeGebiedenMember>
        <!-- ... -->
      </tdn:GeografischeGebieden>
    </tdn:top10ThemasMember>
</tdn:Top10Themas>
```

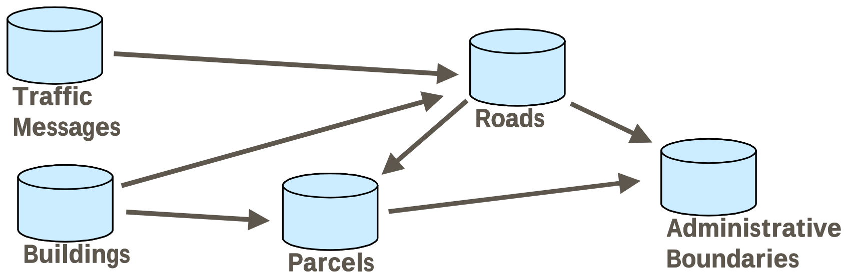
The Geospatial Web

GML Application Schemas can be defined not only re-using schema components of the GML Schema, but also re-using schema components defined in another application schema. Using this capability will be a major step towards overcoming the current situation of isolated islands of geographic datasets where no dependency from other data exists, because today's infrastruc-



ture is not able to support this. Instead, models and third party data were duplicated and slightly changed or adapted.

Once the application schemas describing geographic content are aware of and using other application schemas as shown in the figure above, it will also be possible to link the geographic datasets and, eventually, create a web of geographic features.

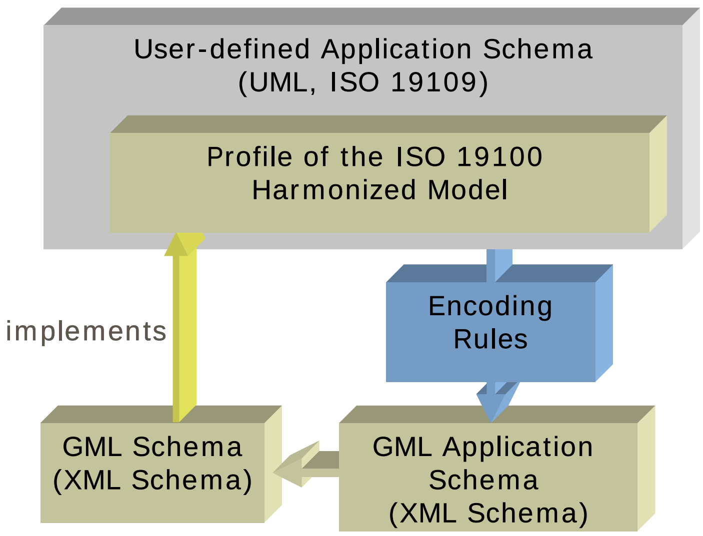


GML, OGC and ISO/TC 211

Development of GML

GML has been created by the Open Geospatial Consortium, Inc. (OGC). As a result of the Web Mapping Testbed (1999) the first version of GML was specified and published (May 2000). This version was still work in progress and not yet an adopted OpenGIS Specification.
GML 2.0 (February 2001) was the first adopted version of GML and the fundamental principles of that version remain unchanged in the current version, 3.1.
GML 3.0 (January 2003) was a major update of the specification adding mostly additional schema components in the GML Schema and rewriting the specification document to prepare GML for the ISO standardization process.

Since then, GML has been jointly developed by OGC and ISO/TC 211, the ISO Technical Committee responsible for the ISO 19100 series. The result is the current version GML 3.1 which is identical to ISO CD 19136, a Committee Draft in the ISO standardization process which is expected to eventually lead to GML being published by ISO as ISO 19136.



Beside ensuring the compliance of GML with the individual standards of the ISO 19100 series, an important part of the integration into the series is the specification of a mapping from UML Application Schemas according to ISO 19109 to a GML Application Schema and vice versa. The following diagram illustrates a simplified view of the relationship between the conceptual ISO 19100 standards and the implementation by GML.

Currently, an ISO Editing Committee is revising GML 3.1 based on comments received by OGC and ISO/TC 211 members. This process is expected to be completed early 2005.

Relationship with metadata standards

Encoding of metadata is not within the scope of GML. GML "only" includes a mechanism to reference metadata application schemas from a GML Application Schema and to identify metadata properties.

The encoding of metadata in GML Documents is left to other specifications. In case of ISO 19115 conformant metadata, the encoding specified by ISO/TS 19139 shall be used. ISO/TS 19139 is, like ISO 19136, work in progress. ISO 19139 and GML provide the key XML encodings for geographic content within a SDI.

Conclusions

GML is well positioned to become a core language for encoding geographic information in spatial data infrastructures and the geo-spatial web. It is based on the widely supported XML technologies, is an adopted OpenGIS Implementation Specification and plays a key role in the OGC Web Service Architecture. It implements concepts of the ISO 19100 series of standards and is on its way to become an International Standard.

Still, more work is required. For example, since GML is a comprehensive specification, more and better educational material and ready-to-use software tools are required to make it easier to develop GML aware software components. Another example is that the specification of consensus-based GML profiles by content providers and software vendors could help to speed up the integration of GML support in major commercial-off-the-shelf software products. These and other issues are recognized and activities are in progress to address them with the goal to increase the usability of GML and strengthen its position.

References

AFIS-ALKIS-ATKIS http://www.adv-online.de/exteng/index.jsp
– Publications
– AFIS-ALKIS-ATKIS

Geography Mark-Up Language, Foundation of the GeoWeb; Ron Lake et al., John Wiley & Sons Ltd., 2004.

GML 3.1 http://portal.opengis.org/files/?artifact_id=4700

GML Schema repository http://schemas.opengis.net/gml/

ISO/TC 211 http://www.isotc211.org/

Open Geospatial Consortium Inc. http://www.opengeospatial.org/

OS MasterMap, Technical Information
http://www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/technicalinformation/index.html

ShapeChange, UML-to-GML-Application-Schema tool
http://www.interactive-instruments.de/ugas/

World Wide Web Consortium http://www.w3.org/

The third GML relay

M.E. de Vries and P.J.M. van Oosterom
OTB Research Institute for Housing, Urban and Mobility Studies
Delft University of Technology, the Netherlands

This chapter gives some context for the first 'in action' part of the seminar: the third GML relay. The Netherlands Society for Earth Observation and Geo-Informatics (the KvAG, now merged into GIN) organized the first and second GML relays (respectively on the 12th of June 2001 in Wageningen and on the 13th of December 2002 in Emmen). Purpose of these events was to show that interoperability between different software products based on the exchange of GML documents does really function (also in a non-lab or test-bed environment). This did indeed work with more or less success during the previous relays and the goal of the third relay is now to show the progress in implementations. The same GML application schema will be used as during the second GML relay: Top10NL GML (based on GML 2.1.2), which is also described in this chapter. It was considered important this time that the most important mainstream Geo-ICT vendors show GML is properly functioning within their standard products. The following six vendors agreed to participate: Autodesk, Bentley, ESRI, Geodan, Intergraph and MapInfo. Henri Aalders will (life) draw the order of the participants within the relay. This will make the order random and prove that the relay is not a fake.

Introduction

A relay can only happen with a relay stick, which one participant can pass to the next participant. In the GML relays the stick is a GML document developed as a prototype for the new TOP10NL product of the Dutch Topographic Service. The next section will give some background information on the design goal of this, currently GML2 based, prototype. The next section then considers some improvements made possible by the advent of GML3. For the final (product) version of the TOP10NL it has to be further investigated which new features of GML3 will be used. The goals and the results (both successes and problems) of the previous two GML relays are then presented, before the goals and the organization of the third GML relay is discussed. The last section concludes this chapter with some reflections on future developments.

GML 2: Top10NL

The Dutch Topographic Service (formerly TDN, now TDK) is supplier of the TOP10vector, a digital vector file with topographical information of the Netherlands territory at a scale of 1:10,000 (Van Asperen, 2000; Bakker and Kolk, 2001). Since the creation of the first digital topographic data set by TDK there has been a need for adequate exchange formats. This has always been a difficult issue and point of discussion. At the same time, users expressed additional requirements. Most current topographic data products are a mixture of geographic data and cartographic presentation. In the design for a renewed product in the Netherlands, a clear distinction is made between a Digital Landscape Model (DLM) and a Digital Cartographic Model (DCM). The focus is on the design of the DLM, meeting current and future user requirements. In parallel the exchange format problem is tackled by using the new OpenGIS standard: Geography Markup Language (GML).

At the moment the data in TOP10vector is maintained as lines, points, and text-features. Polygons are generated when the data is distributed to end-users. There are no unique object-IDs, and the only attribute information available is a classification code (‘tdn-code’) for basic cartographic purposes (to choose the right colors and symbols for ‘road’, ‘building’, ‘pasture’, ‘river’, etc.). In order to get ‘richer’ topographic geo-information, user organizations in the Netherlands have asked the TDK to re-engineer their topographic data into a more object-oriented data model. For this purpose, a new data model is now defined for the Top10NL that meets these requirements. Important characteristics of the new conceptual model are: unique object-IDs, a partitioning of the surface as the basis for geometry (exceptions occur in case of overlap, e.g. road segments in tunnels or road segments on bridges), 2.5D objects with z-coordinates, possibility of complex features (an aggregation of road segments into one – or more – ‘named’ roads) and the incorporation of metadata and temporal data for each object instance (versioning). The last characteristic opens the way for ‘change only’ updates distributed to user organizations (see also Badard and Richard, 2001).

Since there is also a growing demand to distribute the data in a more open transfer format, a prototype of the new data model is implemented using GML. GML 2.0 was accepted as recommendation by the OpenGIS Consortium in February 2001 (OpenGIS Consortium, 2001). The rationale behind the choice of GML is the fact that it is based on the worldwide accepted XML standard and that a rapidly increasing number of tools is available to generate, check and interpret XML/GML (Van Oosterom, 2001).
The advantages of XML in general are: that it is well readable by humans and machines (in contrast to binary formats); it is international (support of Unicode for non-western languages); it is easy to read and process with standard software, e.g. use XML Style Sheet Transformation (XSLT) to convert a DLM into a DCM; domain-specific XML is extensible with organization-specific parts (using the ‘XML Schema’ language (W3C, 2000)); and XML is very well supported by all kinds of software in the market (ranging from browsers to DBMSs).
So, GML has XML as its technical format. This is already an important asset, because of the advantages of XML. The second main advantage is that GML is based on a core conceptual model for geographic (or spatial) data: the Simple Features Model (Open GIS Consortium, 1999). This conceptual model forms the basis for the data model of GML. Recently ISO and the OpenGIS Consortium have decided to harmonize their (geospatial) data models; as a consequence GML will eventually be a combined ISO/OpenGIS standard.
The article by Reichardt (2001) gives a short overview of GML 2.0 and discusses the benefits of using GML.

The project ‘Object Orientation Top10NL’ is carried out by the Dutch Topographic Service (TDK) in co-operation with the Centre for Geo Information of Wageningen University (CGI), the International Institute for Geo-Information and Earth Observation (ITC) and the Section GIS Technology of Delft University of Technology (TU Delft). The Section GIS Technology of TU Delft is responsible for the GML application schema(s) as implementation of the new data model and some GML documents (files) with real-world data. These prototype GML documents and schemas have been used in the first and second GML relay, and will also be used in the third relay.

In order to make a GML prototype for the new TOP10NL product, many engineering decisions had to be taken. The first step was to make a technical UML model of the conceptual UML model designed by ITC (Knippers and Kraak, 2001). The main guidelines during the creation of the technical model have been: 1. the conceptual model, 2. XML/GML principles, 3. aim at a model that is elegant and readable, and 4. to use as much as possible the standard GML possibilities.

GML 2 is described by two XML schemas: the geometry schema and the feature schema (technically also a third one, to be able to define xlink references). When these schemas are 'imported' in a GML application schema, the tag names and element types of the GML standard can be (re-)used in that application schema.

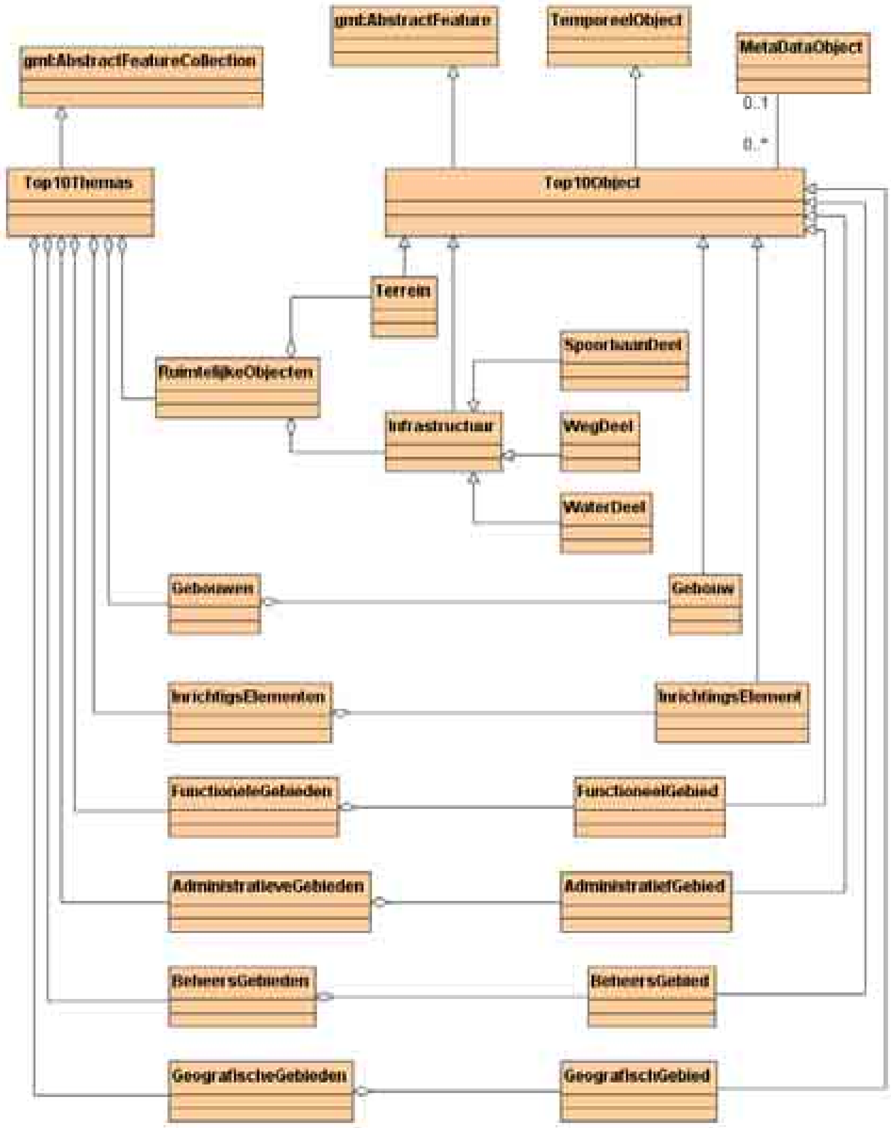


Figure 1. UML model of second TOP10NL GML prototype.

Figure 1 shows the basic structure of the (second) TOP10NL GML prototype. This is the version of the TOP10NL GML that will be used now, in the third GML relay, and that was also used in the second relay in 2002.
It is possible in GML to organize the 'features' (the real geo-objects, with the geometry and with the other, thematic attributes) into 'feature collections'. For the TOP10NL prototype it was decided to use this possibility. Apart from the 'root' feature collection ('Top10Themas'), there are seven other feature collections:

- RuimtelijkeObjecten
- Gebouwen

– InrichtingsElementen
– FunctioneleGebieden
– AdministratieveGebieden
– BeheersGebieden
– GeografischeGebieden.

The 'RuimtelijkeObjecten' feature collection contains four feature types: SpoorbaanDeel, WegDeel, WaterDeel en Terrein. These four types are in one collection because together they form a partitioning of the space, without 'holes' and almost without overlap (the exception being tunnels, bridges, flyovers and aqueducts). The other six feature collections are more homogeneous: they only contain one feature type each.
For the modeling of the geometry in the TOP10NL GML it was decided only to use the standard GML geometry types. In GML2 these are: gml:Point, gml:LineString, gml:LinearRing, gml:Polygon, gml:Box, and the multi-geometry types gml:MultiPoint, gml:MultiLineString and gml:MultiPolygon (see Figure 2).

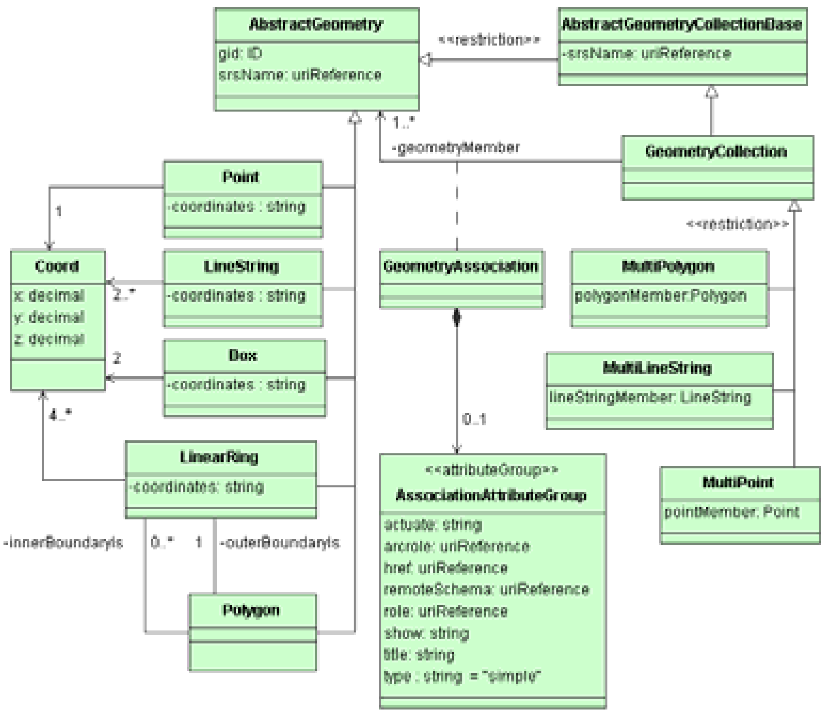


Figure 2. GML 2.1 Geometry model.

There were also no user defined ‘geometry property’ types introduced (the 'association' elements between a feature and its geometry). The two geometry property elements used were: gml:polygonProperty and gml:geometryProperty. The use of gml:geometryProperty needs some explanation, because it is a very 'loose' type: it can contain all kinds of geometry, from gml:Point to gml:MultiPolygon. The prime reason to use gml:geometryProperty in the case of tdn:WegDeel, tdn:SpoorbaanDeel and tdn:WaterDeel was the fact that these infrastructure feature types have a polygon geometry (for the area) as their first geometry, plus either a point or a line geometry as their second geometry (for either intersection node or centerline).

The ‘inheritance’ structure of types and subtypes in the UML diagrams was followed closely in the design of the TOP10NL GML application schema. In the conceptual model there is a

Top10Object class, with the common properties of all the topographic object classes; in the GML schema this same Top10Object is also present as super type for all topographic feature types. One aspect of the UML class diagrams could not be copied one-to-one to the GML application schema however: in UML ‘multiple inheritance’ is possible, but in XML Schema (the language for defining a GML application schema) a type can only inherit properties from one super type at the same time. E.g. in XML Schema Top10Object can not be a subtype of both TemporeelObject (for the versioning data) and gml:AbstractFeatureType (for the link with the GML standard) (see Figure 1). When multiple inheritance like this occurred, we used the 'group' construct. In this way the properties that in the UML class model are inherited from a super class can be recognized more easily in the GML application schema as belonging together.

For the first and second TOP10NL prototype the conversion from UML model to GML application schema has been done ‘manually’. Research is going on to perform automatic conversion from UML class diagrams to GML application schemas (e.g. Gronmo, 2001).

From GML 2 to GML 3: new possibilities

Since January 2003 GML version 3 is available. It offers many new possibilities relevant for the TOP10NL product: additional geometry types (Bezier, Bspline, Circle), topology, real 3D (the ‘Solid’ type), support for metadata and temporal aspects, and default styling.
Also important are the harmonization efforts between ISO and OGC: GML3 will become the first version of GML that will also be an official ISO standard (ISO 19136), probably starting with GML version 3.2.

Due to limitations of GML2 several TOP10NL model aspects (metadata, temporal attributes, etc.) are included in the TOP10NL GML application schema, which is created on top of the GML2 base schemas. The drawback of putting this 'knowledge' (semantics) in an GML application schema and not using standard constructs from the GML specification, is that one cannot expect software implementations of the GML standard to ‘understand’ the semantics of the data model in the application schema. The best one can hope for is that the implementation shows the values of the attributes and relationships correctly. It is too much to ask for, e.g. in the case of the temporal attributes, that any GIS edit software understands how to use and fill the application specific attributes ‘begin date’ ('begindatum') and ‘end date’ ('einddatum'). However, once part of the standard, one can expect correct semantic support for this.

The drawback of not having a topology structure in the present GML prototype of the Top10NL is obvious: there is quite a lot of data redundancy and it is now very difficult to make sure that there are no unwanted gaps or overlaps between the different features within an intended partition of the ‘RuimtelijkeObjecten’ (see Figure 1). It was explicitly decided (by the Topographic Service) not to introduce own topology structures in the TOP10NL application schema. It is interesting to note that the Ordnance Survey in Britain did choose to put own topology structures in the application schema for their MasterMap GML (Ordnance Survey, 2001).

However, with the advent of GML 3 it is now possible to remove certain parts of the current Top10NL application schema and to use the provided standard; e.g. for the temporal and metadata attributes. Furthermore, because GML 3 does support standard topology structures and these structures are obviously very important (also during exchange and for visualization purposes), it should be investigated whether and how to extend the current Top10NL application schema to incorporate the new possibilities offered by the GML 3/ISO topology model.

The previous GML relays of the KvAG

The GML standard can be seen as a (ISO) agreement about the way geo-information should be modeled in a data file or data stream (in case of Web services), to make geo-data exchange between different software environments possible.
In order to show and test the potential of GML as standard for (vector) data, the Netherlands Society for Earth Observation and Geo-informatics (KvAG) organized a number of GML relays, the first one in 2001, the second one in 2002.

The first relay: Wageningen, June 2001

The first GML relay took place on the 12th of June 2001 at the University of Wageningen, (the Netherlands). Purpose of the event was to see whether it was already possible to exchange GML data between software products of different vendors, in a 'life' situation.
One month before the relay, each participant (Laser-Scan, Ionic Software and Intergraph) received data in GML 2.0 format. In this first GML relay, the first prototype of the TOP10NL was used (De Vries et al., 2001). Each participant in the relay did (try to):

- read GML (2.0) data from a diskette into the system;
- edit this data (add or modify a few features);
- save the edited data in GML 2.0 and write it to a diskette as input for the next participant.

Both Laser-Scan and Ionic were able to read the GML data with their software. A few polygons posed a problem for both products. After analysis of the GML start document it became clear why: these were polygons with self-intersecting boundaries, which is not allowed in most geo-database software. Ionic Software also showed how to edit the GML (a road object was deleted) and successfully exported the data back to an output GML document.
Intergraph did a test with a beta-release of their software 'offline'. This beta-release did not yet support the nesting of feature collections. Because the GML data set used in the relay contained five feature collections (besides the root level feature collection), the GML could not be imported without prior modification.
The GML Relay in 2001 was probably a bit early (the GML 2.0 specification had only been approved in April of that year.) For that reason there was another, comparable session in December 2002.

The second relay: Emmen, December 2002

On December 13th, 2002 the KvAG organized its 2nd GML relay in Emmen, at the office of the Dutch Topographic Service. As input data for the relay a GML test set based on the second TOP10NL prototype was used (area of Tiel). The relay was therefore also a good opportunity to test whether the TOP10NL GML prototype (data and schema) could be successfully imported and used (viewing, editing and exporting back into GML) in existing geo-software environments. Seven companies accepted the invitation to show the GML capabilities of their products: Intergraph (GeoMedia), eXQte (reseller of FME), Bentley (MicroStation), ESRI (ArcGIS), Snowflake (GO Loader), Oracle (Oracle Spatial) and Laser-Scan (Radius Topology). Some of these companies teamed up and combined their software to import and export the GML data: eXQte and Bentley used FME in combination with MicroStation, Snowflake and Oracle used GO Loader in combination with Oracle Spatial. Laser-Scan used a combination of GO Loader, Oracle Spatial, its own Radius Topology and Intergraph's GeoMedia.

This 2nd relay was successful for two reasons: not only were seven companies present, but – and that was an important result – they all succeeded in reading the TOP10NL GML data into their respective software environments. Intergraph, Bentley and Laser-Scan performed a few edits (creation of new buildings, removal of part of a river, update of a boundary) on the imported GML features. The data also had to be exported again into valid GML documents. When analyzing the exported GML the following observations can be made:

- For visualization it is important that the bounding box (the minimal extent) is also provided in the GML document. Some of the export files did not contain bounding box coordinates (lower left, upper right); in another case the extent was not correct.
- The same goes for the reference to the Spatial Reference System used. For the Dutch 'RijksDriehoeksmeting' this is EPSG:28992. Some of the export files did not contain this srs-information. The export from Oracle had the reference, but not in the EPSG notation (but in the internal Oracle notation (SDO:90112)). In one case the wrong coordinate system was chosen (see Figure 3).
- In some cases there was loss of information somewhere in the import or export process: in the original TOP10NL start document it is possible to have multiple occurrences of a street name, or of 'originated-from'. These multiple occurrences were not there in the export file(s).
- The original TOP10NL start document contained unique 'fids' for each feature. In some export files these ‘fids’ had disappeared, or they were not unique (or zero).
- Some products could handle the 'object oriented' nature of the basic GML conceptual model better than others. In the GML output exported from GeoMedia and Oracle the data structure of the TOP10NL GML was left intact: e.g. each Road (WegDeel) not only has a polygon geometry, but also either a line or a point geometry.

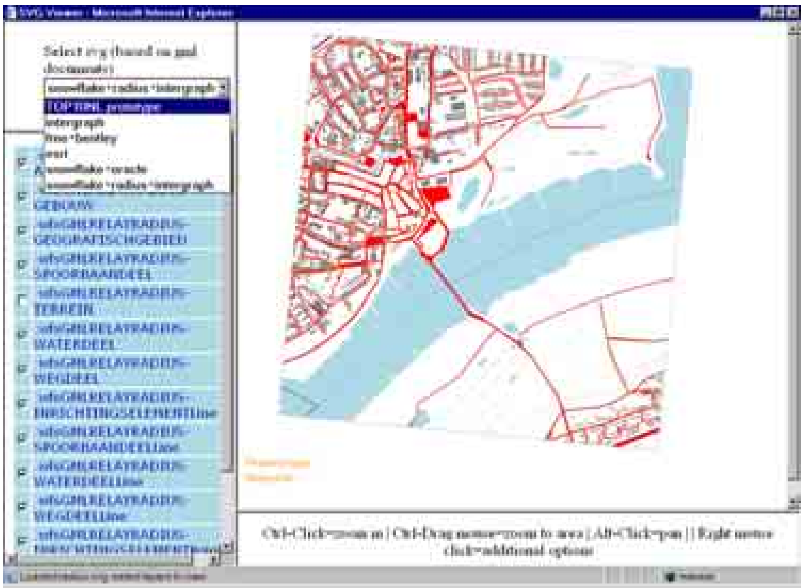


Figure 3. Area of Tiel, exported in the wrong coordinate system (second GML relay).

Despite of these issues, as a whole the 2nd GML relay proved that support for GML in geo-software had much increased since 2001. The most important difference between the various software products appeared to be: support for more than one geometry attribute per feature type or not. Another conclusion was, that the more 'advanced' characteristics of the TOP10NL GML prototype could more easily be handled by import/export software that uses the XML schema document to 'understand' the data structure (see also Curtis, 2002).

The third GML relay

In the third relay (17 November 2004, Delft) the exact same GML application schema will be used as in the second relay: Top10NL GML (tdn_strict2.1.xsd based on GML 2.1.2, see: De Vries et al., 2002). The data set is not the region 'Tiel', but 'Gouda'. Though at this date GML3 is already available, it was decided not to use it this time (but keep this for the fourth GML relay, in 2005). It was considered more important that this time, mainstream Geo-ICT vendors with offices in the Netherlands could show that GML is really working with their standard products (and not so much to demonstrate the latest improvements in GML3). The following six vendors agreed to participate: Autodesk, Bentley, ESRI, Geodan, Intergraph and MapInfo. A number of Geo-ICT vendors without offices (or resellers) in the Netherlands also indicated they wanted to participate, among them were: Laser-Scan, Galdos, Cadcorp and Ionic. However, due to non-functional reasons (no office in the Netherlands) and the fact that the time for the third GML relay is limited (as it is part of a larger seminar with other presentations and events) it was agreed that they would not participate in this relay. With the other participants the following procedure was agreed on:

1. Henri Aalders (the seminar is organized because of his farewell at the TU Delft) will (life) draw the order of the relay. This will make the order random and prove that the relay is not a fake. If there is sufficient time, the first participant should also read the result of the last participant.
2. The whole GML document is read/written according to the structure defined in the TOP10NL application schema and one object is edited (both geometry and attributes). Metadata (tdn:bronRef via an xlink: reference) does not have high priority.
3. Everybody brings his own laptop with software, and exchange of the data will be via an USB memory stick. Every time a new name (or directory) will be used (with the name of the participant and number in the relay); e.g. gouda_esri_1.gml.
4. In case of errors, there is no discussion, but we will go back to the start GML document (after the event the error will be solved and the exported GML will be put on the website www.gdmc.nl/standards together with all the other exported files).
5. Participants can practice in advance by off-line testing, but this is completely up to the participants (and their self-confidence).
6. Every participant gets the same amount of time for the GML relay, that is 15 - 20 minutes (and the remaining time after read/edit/write may be used to explain GML related developments).

The future

We have stated that GML3 (to become ISO standard 19136, see the section 'From GML 2 to GML 3: new possibilities' of this publication) offers a lot more possibilities than GML2. The important question is how fast software vendors will implement these new constructs (new geometry types, topology, 3D, default styling). Of course it is very understandable when a GIS or CAD software product cannot deal with all the new possibilities that are now offered in GML3: a vendor will select only certain subsets of GML3. This has to do with the fact that GML3 is the 'union' of the geometry and spatial types plus topology of existing GIS, CAD and object-relational geo-environments. In the GML3 specification itself this aspect is already taken into account: the possibility is created to define 'profiles'.

The extensive possibilities in GML3 should not be an excuse not to start with implementing GML3; it can mean however that it will take some time before software vendors have adapted the relevant import/export modules to fully GML3 enable their software. In the meantime: GML

2.1.2 has been around now for two years. Therefore it should be expected that at this moment, November 2004, using modern XML technology and tools, it must be possible for mainstream GIS and CAD software to import and export GML2 data documents without problems.
We have to remember that, before the advent of GML, there was no non-proprietary, international exchange standard for geographic vector data (where non-proprietary stands for: vendor-neutral, open, standardized by a standardization body). We have non-proprietary, but national exchange standards (e.g. the Dutch NEN1878, the Swiss INTERLIS), and international, but proprietary exchange formats (e.g. ArcExport, MIF/MID, DXF). With GML we have the chance to change that situation and move towards geo-data exchange that is based on a set of standards that are both international and vendor-neutral.

Acknowledgements

This publication is the result of the research program 'Sustainable Urban Areas' (SUA) carried out by Delft University of Technology.

References

Badard, T. and D. Richard, Using XML for the exchange of updating information between geographical information systems. *Computers, Environment and Urban Systems*, 25(1-5):17-31, 2001.

Bakker, N. and Bert Kolk, A new generation TOP10vector data in the Netherlands. In *Proceedings International Cartographic Conference ICA*, August 2001.

Curtis, E. XML Schema: Reconciling Diversity with Standardisation. In *GML Developers Conference*, Vancouver, Canada, July 2002.

Buehler, K. and L. McKee, The OpenGIS Guide - Introduction to interoperable geoprocessing. Third edition, The Open GIS Consortium, Inc., June 1998.

De Vries, M.E., C.W. Quak, T.P.M. Tijssen, J.E. Stoter and P.J.M. van Oosterom, Topographic data, object orientation and GML. In *EOGEO 2001/Digital Earth Congress*, Fredericton, New Brunswick, Canada, June 2001.

De Vries, M.E., T.P.M. Tijssen, J.E. Stoter, C.W. Quak and P.J.M. van Oosterom, The second GML prototype of the new TOP10vector object model, GISt Report no. 12, Delft 2002.

Gronmo, R., Supporting GI standards with a model-driven architecture. In *Proceedings of the 9th ACM international symposium on advances in Geographic Information Systems,* Atlanta, USA, November 9-10 2001.

Knippers, R. and M.-J. Kraak, Objectgerichte beschrijving TOP10vector - concept ontwerp gegevensmodel, versie 1.0, ITC, mei 2001 (in Dutch).

Open GIS Consortium, Inc. Simple Features Specification for SQL. Revision 1.1, OGC, May 1999.

Open GIS Consortium, Inc. Geography Markup Language (GML). Version 2.0 (01-029), OGC, February 2001.

Open GIS Consortium, Inc. Geography Markup Language (GML). Version 2.1.2 (02-069), OGC, September 2002.

Ordnance Survey. DNF geometry and topology - DNF release 1 product data: specification of the geometric data types used in the DNF data product, and other geometry and topology information. OS, May 2001, version 1.0.

Reichardt, M., OGC's GML 2.0 - a new wave of open geoprocessing on the Web. *GeoInformatics*, Vol. 4, July/August, pp. 18-21.

Van Asperen, P., Objectgerichte beschrijving TOP10vector - concept ontwerp gegevensmodel, versie 1.0, Topografische Dienst Nederland, Augustus 2000 (in Dutch).

Van Oosterom, P., OpenGIS technologie als basis voor de nieuwe TDN datastructuur. In Nederlandse Vereniging voor Kartografie (NVK) studiemiddag, Alterra, Wageningen, April 2001 (in Dutch).

W3C. XML Schema Part 1: Structures and XML Schema Part 2: Datatypes, W3C Recommendation, May 2001.

Policy and standards

N. Hooyman
Ministry of Housing, Spatial Planning and the Environment (VROM): coordination of geo-information, the Netherlands

To fulfil its task as the coordinating ministry for geo-information VROM has several policy programmes. Most of the activities in this field are limited to coordination and steering except for the framework of authentic registrations of buildings and addresses for which VROM holds direct responsibility. These authentic registrations make part of the broader framework of authentic registrations that is or will be implemented by the government. In June 2004 the government officially agreed with the implementation of the authentic registrations for buildings and addresses and a derived legislation will be presented in 2006 to the Parliament to be legally implemented in 2009. Municipalities will be the holders of the related information on buildings and addresses and for supra local data distribution a national facility will be created. The projected benefits are large as for instance benefits gained by efficiency increase far exceed costs. Furthermore will effectivity of municipalities and other government bodies increase and are civilians only once asked to provide information. In short a win-win situation.

Policy of VROM

The Minister of VROM holds responsibility for the coordination of geo-information in the Netherlands. To realise a national geo-information infrastructure VROM has set out the following policies:

- Standardization: promotion of national standards and conformation to European guidelines;
- Research and development (R&D programme Space for Geo-information);
- Streamlining of basic data: Setting up of basic geo-data registrations (buildings, addresses, cadastre and topography).

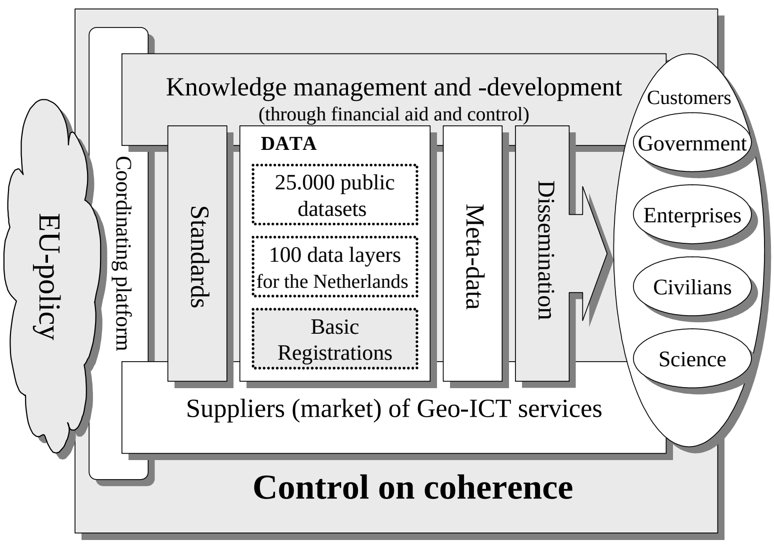


Figure showing Geo-information policy in the Netherlands: responsibilities of VROM are shaded.

Policy on standardization is focussed on the promotion of development and use of open standards by and in the field of geo-information related domains. VROM will not take part in this activity itself but will only, when appropriate, create a legal framework. This will be the case in relation to authentic registrations and for instance with the implementation of IMRO as the national standard for interchange of digital spatial plans. The realisation of the Basic Schema for Geo-information and IMRO as a related standard thereof, is a good example of this domain driven approach and developments of open-standards: broad involvement and participation of the work field and therefore a high level of acceptance and implementation.

National activities have to be inline with European standards and guidelines. VROM acts as a subsidiary when necessary for national bodies to participate in European standardization committees. Furthermore will VROM evaluate the European guideline INSPIRE and if accepted steer its implementation in the Netherlands. The Basic Schema for Geo-information as well as INSPIRE both contain elements on semantics. It is therefore important that the Dutch Basic Schema is harmonized with the INSPIRE proposals. VROM will take care that this harmonization process takes place.

In the realization of a national geo-information infrastructure it is crucial that relevant knowledge is at hand or is being developed. VROM is subsidiary to the national research and development programme Space for Geo-information (2004 – 2009) to an amount of 20 million euros. The programme plan Space for Geo-information is leading in the execution of the programme but, the Minister has included two accompanying conditions:

1. research and development needs additionally be directed at the improvement of the national coordination of geo-information;
2. use of geo-information needs to be stimulated by innovation of concepts and mechanisms on information clearance, that should directly be applicable for a national clearinghouse.

Both conditions will secure that the knowledge being developed will contribute to the realization of a national geo-infrastructure.

Fore mentioned activities are stimulated and financed by VROM, but not directly executed. The realization of basic registrations of buildings, addresses, parcels and topography do however fall directly under responsibility of the ministry. At the ministry a project organization is set up for the implementation of basic registrations for buildings and addresses. I will therefore in this article focus on the policy on streamlining of basic data and specifically on the realization of basic registrations of buildings and addresses.

Streamlining of basic data

The government has to properly manage its proper data. Only when this requirement is met it is possible to realize important policy goals that are in accordance with the cabinet programme ‘The other Government’. Relief of administrative burden, fraud fighting and active services (for instance a digital integrated office for VROM licences) can only then be realized when the back-office of the government is properly organised.

The governmental programme called Streamlining of Basic Data, which ended in 2003, described a framework of authentic (basic) registrations that are considered as being indispensable to a modern and dynamic government:

– that does not work along the usual paths (relief of administrative burden);
– that is demand oriented and pro active;
– that is not fooled around with (fraud fighting);
– that is well informed about its targets (policy making and monitoring);
– that is properly organized and cost effective (effective and efficient).

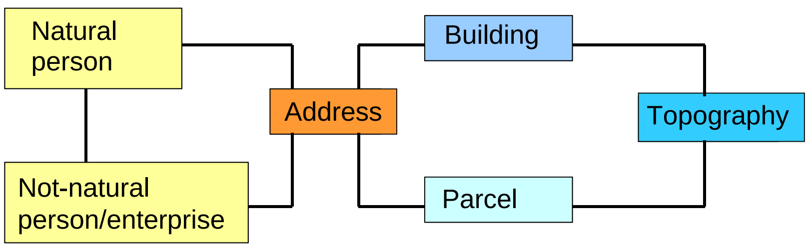
Authentic registrations and basic registrations

The government is targeting at a coherent framework of authentic registrations, in such a way that onetime capturing and multiple use of data is guaranteed. An authentic registration serves as a unique source of data, has a legal basis, its use is obligatory within the government and the quality and related responsibility and financing are secured. In short all governmental bodies have to use these basic registrations and have and can trust upon its quality. The civilian is only asked to provide the data once. Typical examples of possible authentic registrations are: license plate register, population register and address register.

You might expect that these registrations do already exist and are fully operational; however this is truly not the case. Examples are of municipalities that have more than 50 address registers or 28 different building registers. By law a municipality is forced to maintain and manage a GBA but is not forced to use the register in its own work processes!

In the envisaged framework of authentic registrations six are considered to be crucial: registrations for persons, enterprises, buildings, addresses, cadastral parcels and topography.

A diagram of the framework shows as follows:



For insiders: this shows large similarity with the proposals presented in the 'Structuurschets Vastgoedinformatie' drawn up in the early nineties (figure below).

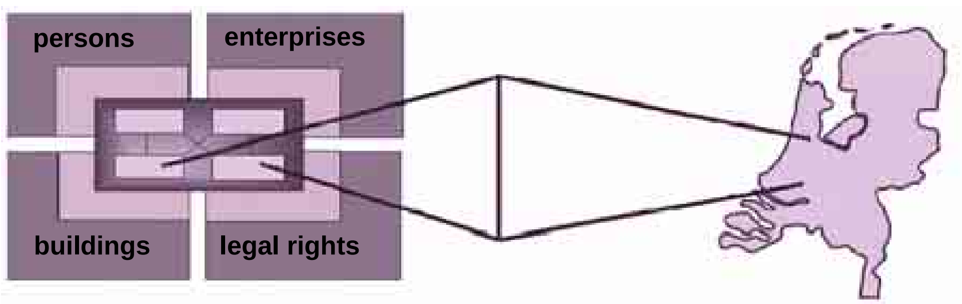


Figure 'Structuurschets vastgoedinformatie' as interpreted in the early nineties.

The interdepartmental programme Streamlining of Basic Data came to a close 1-1-2003. For each specific registration agreements were set about a possible incorporation into the framework of basic registrations and about the specific government body concerned. VROM in this context is responsible for geo-registrations, buildings, addresses, parcels (Cadastre) and topography, 1:10.000 core topography and the GBKN (Large scale Basic Topography of the Netherlands).

In 2004 the Streamlining programme was reinitiated by the Minister of Governmental Innovation. Primary concern is the actual putting into practice of a coherent framework of Basic Registrations in stead of six stand alone registrations.

State of affaires Basic Building Register and Basic Register Addresses

For the Basic Register Addresses a feasibility study was successfully executed in 2002. It was decided that for practical reasons the introduction of addresses should be linked to the building register. Details that then were still unanswered like incorporation of zip code and how to write NEN or GBA are filled in now.
Some municipalities have even started or are willing to, building up an Address Register. To stimulate this process, and secure the investments already made, the National Government officially informed the municipalities on its programmed decision on introduction of the basic registration addresses and that the already developed guidelines and principles (processes and standards) will be followed.

In 2003 practical tests were executed in five municipalities to test the Building Register. Results thereof have lead to the definition of the concepts of a Basic Building Register with municipalities (what and how). These concepts were basically agreed upon by the large municipalities (as well as by the pilot municipalities). The overall feasibility study was ended in 2004. Part of this study was a process analysis (what will in the future be improved and what will be different?); a cost benefit analyses was made and implementation of a possible national facility (for data users like the national tax service, chamber of registration and VROM) was investigated.

Based on the feasibility and pilot studies with municipalities the cabinet decided in June 2004 to actually implement an authentic Basic Building Register (BGR) combined with a Basic Address Register. The related plan of financing is according to the cost-benefit analysis. The municipalities are owner of the register and are accountable for their own costs. Benefits are coming from a great win by efficiency improvements of internal processes. Costs of projects are the responsibility of VROM and the exploitation costs of national facilities are being met by the users of these facilities.

Importance of a Basic Building Register

Interest at the level of municipality

There are many processes within municipalities that make use of property information including information about buildings. We practice the ground rule that an estimate of 70 % of the activities include to a large or lesser extent this kind of information. Examples are processes like granting and controlling of licenses in the field of environment, property use, monuments and construction activities, implementation of the WOZ, etc.
The feasibility study BGR included amongst other things a process analysis at municipalities (what is different and what will be improved with a BGR). It was concluded that an implemen-

tation of a BGR in itself will not fundamentally change the ongoing processes but will positively effect efficiency and effectivity of many activities.

I present some examples of processes positively effected by the setting up of a BGR:

- The proposed core dataset will make many activities (like procurement, registration and data verification) much more efficient;
- Streamlining of data on buildings will also lead to streamlining of applications which in its turn will lead to increased efficiency;
- Quality of processes will improve (better information in planning processes, increase of benefits through real estate tax, better registration of public use limitations etc.;
- Improved regional cooperation and exchange of information. This is important for example in the case of public security. Fire departments will directly go to the proper address and by forehand are informed about type of building, construction etc;
- The municipality will more often act as data producer (transparent government).

In short the introduction of a BGR will be an important catalyst for the realisation of ‘the other government’.

One of the largest bottlenecks with the introduction of such infrastructural facilities is in financing. Who will pay and who will benefit? If these are different parties, then, considering the autonomy of governmental layers in this country, things will become complicated.

However the cost-benefit analysis executed by Ecorys-NEI is not only positive, but costs and benefits are also directed to the proper parties. Municipalities hold the largest part of the costs but, their benefits are even higher. In other words: next to a quality improvement it also amounts to a gain in efficiency. A BGR results in an efficient back office of municipalities!

National interest

There are of course national users of building data that have an interest in a unambiguous, up to date and nation wide uniform authentic set of building data: tax service, ‘waarderingskamer’, VROM (rent subsidy), CBS, etc. Of course at best these data are provided by a facility operating at the national level so not all individual municipalities have to be contacted or separately provide information. When these data can be combined with to the buildings related WOZ-data (property value tax) then they will be the principal beneficiaries. This principle is clearly shown by the framework: the basic registrations, combined with process registrations will streamline government processes.

A feasibility study has been executed to investigate the potential of a common infrastructure for dissemination of local governmental registrations. Concerning the realisation of such a national infrastructural facility VROM will be in consultation with the major players. Technology is only of minor importance (centralized or decentralized databases). Predominant issues are autonomy, data use, and privacy (Big Brother is watching you?!). For now first will be investigated if a connection can be made with the national facility for the GBA (basic registration for persons).

Win-win situation

In my opinion the introduction of a Basic Building Register in the Netherlands will lead to a win-win situation.

Municipalities will be more efficient and effective in executing their processes. The return on investment will be significant. National (and of course regional and provincial) government bodies will obtain uniform and up to date data on buildings and the citizen has to bring in his basic data only once. Enterprises could make use of the data and in doing so even enrich data content.
The time is right (and the minds are set) for a Basic Building Registration in combination with a Basic Registration for Addresses.

Epilogue

Noud Hooyman is employed with the Ministry of Housing, spatial Planning and the Environment, department Personnel, Organisation and Information, part of the Concern Staff. He holds responsibility for the coordination of geo-information in the Netherlands. Realisation of basic registrations for buildings, addresses, parcels and topography are important projects in this respect.

Parts of this article can also be found in an earlier article of the author presented in the annual report 2003 of the 'Waarderingskamer'.

References

Related Websites:
www.vrom.nl/basisregistraties (cost benefit and process analysis Buildings and Addresses)
www.andereoverheid.nl
www.ictu.nl (programme streamlining basic data)
www.ruimtevoorgeoinformatie.nl

Minister of the Interior and Kingdom Relations: Letter to the Parliament end report programme Streamlining Basic Data, March 3rd, 2004.

Minister of Housing and Planning: Letter to the Parliament Introduction Building Registration, June 11th, 2004.

A standard supporting semantics in a Spatial Data Infrastructure (SDI)

M. Reuvers
Ravi, the Netherlands

Though much attention is drawn to technical standards a geo-information infrastructure is primarily about meaningful interchange of information. The Dutch standard NEN 3610 has been importantly revised and improved to play a structured role in the process of national and international harmonization. The original name of NEN 3610 being Land-information terrain model is changed to Basic Schema for Geo-information which better describes its content. This chapter will explain the role of semantics in the Geo-Information Infrastructure (GII) and the particular role of the Basic Schema.

Standards and SDI

The principal objective of a Spatial Data Infrastructure (SDI) is to bring geo-information to the people and the people to the geo-information. Even more challenging is to do this using the internet facility to realise a run-time environment with an interactive communication between supply and demand. Paramount to a proper functioning SDI is that aspects of organizational kind, data policy, technology and standards are sufficiently taken care of.

Standards can be subdivided in technical and semantic standards. Technical standards will guarantee interaction between different software-systems among other things by providing common or shared interfaces. The standards provided by the Open Geospatial Consortium (OGC) largely contribute to this field of standardisation. Apart from the technical requirements for communication, semantics of the information being communicated need to be transferred properly. Semantics imply that information for instance provided by different organisation at different moments in time and for different purposes can unambiguously be interpreted and if necessary integrated. In short: technical standards will make you connected; semantic standards will make you understood.

Semantics, what is it all about?

Over the years the interchange of information with a spatial component, geo-information, became and will become ever increasing. A multitude of different kinds of organisations are all operating in the same spatial context and therefore obviously need an active communication of results, products, policies etcetera, to effectively realise their mandates.

To explain the need of semantics we take the following example. The information-element road can be defined by attributes as name, width and identification. Furthermore can be defined that the name is of the data type string, width is defined in meters and the identifier has to be unique. All these attributes are considered as syntax of the object road. Having this description of the object it is still not clear what we mean by road. Does it include the roadside? Are bicycle tracks included? What is meant by width of the road if it is not clear what parts the road consists of? These parts of the description are referred to as the semantics of an information-element. When exchanging information a common understanding of semantics is crucial.

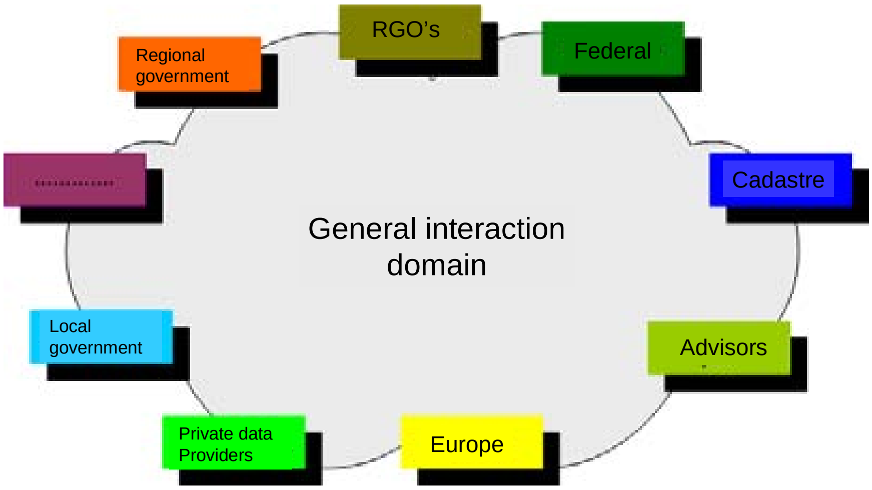


Figure 1. Overview of organizations operating in the same geo-spatial domain.

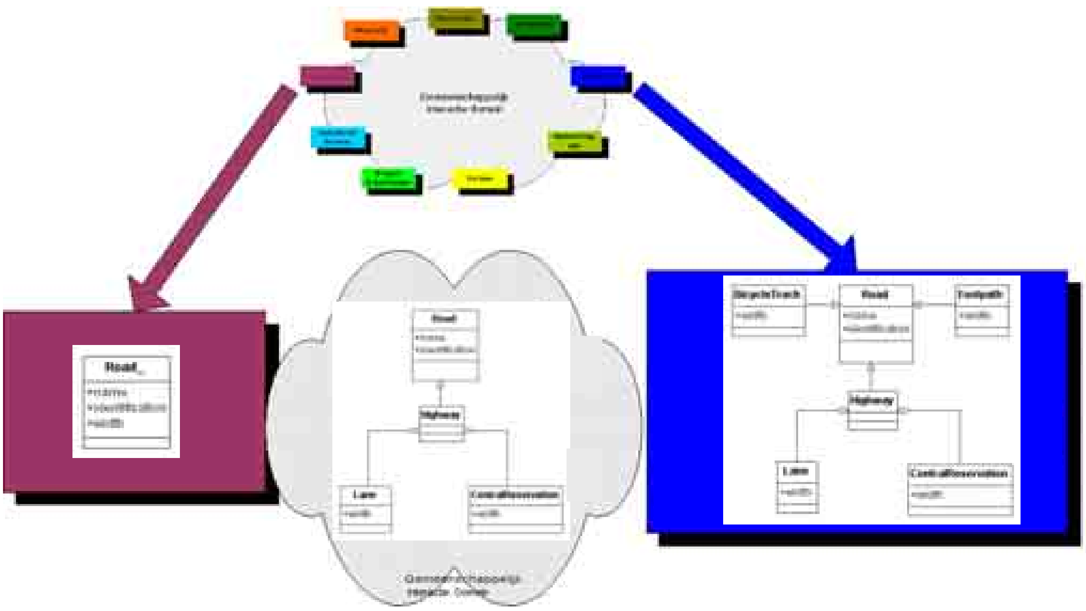


Figure 2. A common understanding of the semantics of the concept 'Road'.

The latter is made clear in this figure. Two organisations can have different internal semantics concerning a road. But when they want to exchange the width of a road it is necessary that they have common external semantics concerning this information. The figure describes a model of a common domain of interaction and the related information model. This information model contains the common interchangeable information and is the result of semantic standardization. The model describes the common interaction domain in which semantics is added by describing relations between objects.

Need for semantics

Geo-information as up until now is mostly being used directly by humans, will in the future increasingly first be processed by machines before human interpretation takes place. As humans are mostly capable to interpret different concepts by implicitly using contextual (meta) information (which domain, providers). Machines need this information explicitly if proper results are to be expected. The network (information) society, with the internet as the predominant tool for communication, does imply that self explaining information is obligatory. A major part of the formal and structural explanatory information related to concepts (objects being modelled) are explained by the relations or associations an object has with other objects.

Harmonization of attribute domains

Within one specific sector domain it already is a challenge to accomplish a common, shared set of concepts and definitions thereof, let alone achieving this in a multi sector context. In the Netherlands several different domain standards are operational (IMRO/ spatial planning, IMWA/water management, IMKICH/cultural history, GRIM/ agriculture, environment, Subsoil Infrastructure, topography, cadastre, soil units etcetera). Often standards for concepts are reached after internal sector harmonization. Many of the recently developed or modified models are described using UML (Unified Modelling Language) a formalised language for description of models. Harmonization of sector models into intersectoral and national models is important as is international harmonisation of sector models (for instance within the context of the European initiative of INSPIRE). Needless to say that internationally even larger discussion will take place than at the national level (think for instance of legal frameworks which nationally are defined in more detail than internationally).

Internationally different languages need to be supported which forces a (correct) translation of concepts and definitions. Words can have double meaning leading to different interpretation as well do subtle differences in meaning. Differences which can usually be overcome by human interpretation but machines can not.

It is obvious that in our network society, semantics and semantic translations will play an increasing role. How complicated it may be, harmonization between sectors, nationally and internationally has to be taken care of.

How to harmonize?

From the mid nineties onwards there is a Dutch standard for interchange of geo-information that defines concepts of common objects and attributes (NEN 3610). Implementation of this standard produced the experience that the low level of semantic description prevented a wider use.

As mentioned, the former terrain model NEN 3610 has been developed with the principal objective to model object classes in a very generic way without including too much semantics. According to the specific applications of the model (sector applications) semantics and structure were added. Different sectoral applications lead to different semantics. Resulting in a not-coherent set of sectoral models which prohibited a successful interchange of information between sectors. As well as started a continuous discussion on semantics in and between sectors. To cope with this situation a strong management of the terrain model was needed. Use of geometric attributes (location, geometry and topology) were not clearly defined but was referred to NEN 1878. Leading to inconsistencies between the model standard and the interchange standard, most clearly presented in the different versions of the interchange standard (NEN 1878, NEN 1878 LKI, NEN 1878 for IMRO). Since the first release of the Terrain model there have been many activities in the field of international standardization. These developments were not yet reflected in the Terrain model.

The need for semantic operability within the geo-information infrastructure has made Ravi decide to start a project called “Framework for Geo-information Interchange”. Last year this project was executed with the objective to develop a semantic model in which terms and definitions are defined unambiguously. The original name of NEN 3610 being Land-information terrain model is changed to Basic Schema for Geo-information which better describes its content. The project was commissioned by the Information systems Innovation platform of the Ministry of the Interior (BZK/IIOS) and the Geo-information department of the Ministry of Housing, Spatial Planning and the Environment (VROM/Geo-information). The project was jointly executed by ICTU, WUR, TU-Delft, Cadastre and Ravi.

To reach a commitment within the geo-information work field a sounding board was formed with representations of public and private enterprises (stakeholders).

Sounding board is composed of:
Alterra – Centre for Geo-information, Municipality of The Hague and Vlaardingen representing the VNG, Provinces (IOG-GEO), ICTU program on Open-Standards and Open-Software, Streamlining of Basic data and the Electronic Government, IDsW (Information Desk Standards Water), Cadastre, Topographical Service Cadastre. LSV GBKN, NCGI, NEN, Platform of GI enterprises, ONRI, PorRail, TNO-NITG. Ministry of the Interior and Kingdom Relations, Ministry of Housing, Planning and the Environment, Ministry of Transport, Public Works and Water management, Ministry of Agriculture, Nature and Food quality, Ministry of Defence, Ravi, Technical University Delft – section GIS technology and the Wageningen University.

These organisations were investigated for their proper requirements concerning an appropriate schema for interchange of geo-information. These requirements are presented in the so called stakeholders analysis.

Parallel to this analysis for some sectoral applications of the former NEN 3610 the schemas were described. These sectoral schemas include for large scale topography LSV GBKN, municipalities of Vlaardingen and The Hague, Service for Buildings, Works and Terrains of the Ministry of Defence (DGW&T) and ProRail. Mid scale topography TOP10NL of Topographical Service Cadastre and the municipality of The Hague (representing the four large municipalities). For the sector of spatial planning IMRO is described and for the water sector IMWA. The latter adjusted for the European guideline for Water management.

After these requirements were agreed upon by the representation of the stakeholders the actual research and design of the Basic Schema for Geo-information could be started with. Starting point was the original terrain model NEN 3610. This model was translated and described in conformance with the concepts as advocated for the new Basic Schema for Geo-information (OGC and ISO conformity). Furthermore was the schema modified to meet the set of requirements. In an iterative process the result was presented to the sounding board for evaluation.

The process of redefining of NEN 3610 is now concluded and below a brief description of the Basic Schema for Geo-information will be presented.

NEN 3610 – Basic Schema for Geo-information

Basic Schema and sector schemas

The Universe of Discourse, the principal domain, of the Basic Schema for Geo-information constitutes all objects that have a geographical dimension. Not all these object have the same relevance regarding specific fields of attention. The entire domain is therefore subdivided into sectors that all add a domain specific implementation to the Basic Schema. The Basic Schema supplies the common ground of understanding on basic concepts that are used throughout different sectors. A situation visualised in the so called pyramid of conceptual Geo-information schemas (figure 3).

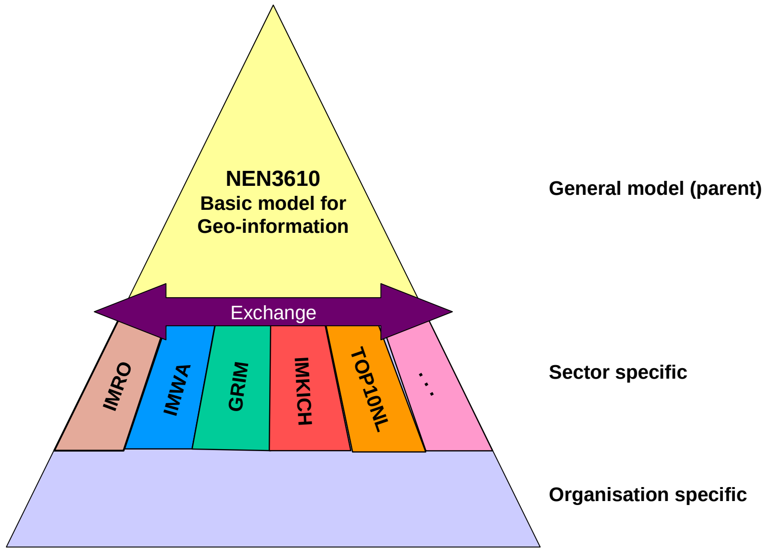


Figure 3. Pyramid of conceptual geo-information schemas.

The pyramid shows a hierarchy from generic to specific. The generic level is more abstract and should be applied for all domains dealing with spatial information. The exchange format defined at this level is crucial for communication between domains. At the sector level sector specific domains are modelled according to the sector requirements but in conformance with the general rules set at the generic level. As is to be expected, there will be a certain overlap between the different domains. That is where standardization will help to communicate unambiguously. In the next figure this is illustrated.

The domain of the Basic Schema is the set of shared concepts between different sector schemas. This shared area is dynamic and will be subject to developments in society as they will influence the content of sector schemas as well as the Basic Schema. A continues harmonization of sector and Basic Schema is therefore necessary.

Harmonization is also carried out at the Euro regional (FIG) as well as European (INSPIRE, EuroGeographics) and international level. As the Basic Schema is developed in conformance with international standards a connection with this harmonization process is taken care of.

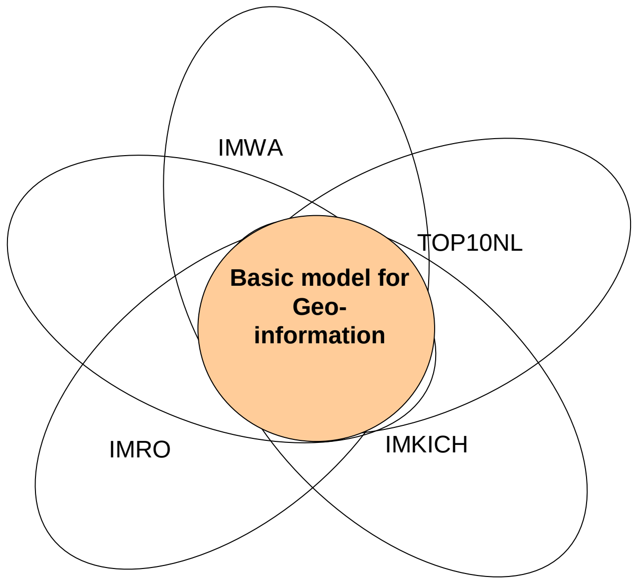


Figure 4. The Basic Schema for Geo-information is the area of interaction between different sectors and sector schemas.

Semantic model

A semantic model is a collection of terms, concepts and definitions that are of relevance to a particular domain. Terms and concepts are unambiguously defined. This results in a common understanding of the domain (universe of discourse) shared by different parties. The Basic Schema for Geo-information is such a semantic model for the field of geo-information. The Basic Schema is also an abstract model. The universe of discourse is described at the conceptual (abstract) level. The universe of discourse is evaluated for objects that are of relevance to the field of geo-information. These objects constitute the conceptual model which therefore is dependent on the definition of this geo-information domain. The Basic Schema has the highest level of abstraction. Implementation of the Basic Schema in sectors leads to Sector Schemas which have a lesser level of abstraction. Only when implemented in real applications these schemas are translated to logical and technical schemas.
The Basic Schema for Geo-information is laid out in a combination of 'normal'- and a 'formal' language. The normal language is used to define concepts and provide a description of the schema. The formal language is to describe the structure of the schema. The formal language UML (Unified Modelling Language) is used. UML class-diagrams are applied to describe the structure and the structural components which are of importance to the Basic Schema.

Object oriented

The Basic Schema for Geo-information is object oriented. It provides information about the objects which can be defined in the universe of discourse. The object is the basic unit of which characteristics are described. The term introduced for this basic unit is the Geo-object, with the following definition:

Geo-object:

Abstraction of a real world phenomenon, directly or indirectly associated with a location relative to the Earth.

The definition consists of three components:

1. Phenomenon
   An identifiable occurrence.
2. Object
   An object is an abstraction of a real world phenomenon
3. Geo-object
   An object that is directly (by coordinates) or indirectly (by address, zip code etc.) associated with a location relive to the Earth.

This definition is in line with the ISO term geo-information and feature. The Basic Schema in this sense is feature based rather then grid/raster based.

Characteristics of objects

Geo-objects are described by their characteristics. This is done at the level of abstraction that is of relevance and shared by the whole field of geo-information. The level of abstraction used in the Basic Schema has to fit in with the level of abstraction used in the sector schemas. The following types of characteristics are identified:

- Identifying
- For the management of objects, for instance to follow objects in object-chain relations through unique object identifiers.
- Descriptive
  To classify the descriptive characteristics
- Geometry
- Geometric characteristics define the geometry of an object. Open Geospatial / ISO specifications are used to implement these characteristics.
- Temporal
- To for instance serve monitoring purposes each object will have temporal characteristics.
- Metadata
- In the Basic Schema reference is made to the international metadata-standard ISO 19115.
  Metadata at the geo-object collection as well as the geo-object level.

Conceptual framework

An application schema of the universe of discourse can only be designed if a framework of used concepts is firstly taken care of. This conceptual framework provides definitions of objects. Definitions should unambiguously point to defined types (classes) avoiding overlapping class definitions. In conformance with the ISO terminology the term feature catalogue is introduced.
A feature catalogue provides definitions and description of object classes, object attributes (characteristics) and object associations together with operations that apply. The Basic Schema for Geo-information is described in an UML class diagram in conformance with ISO 19109 (application schema) / ISO 19110 (feature catalogue) standards.

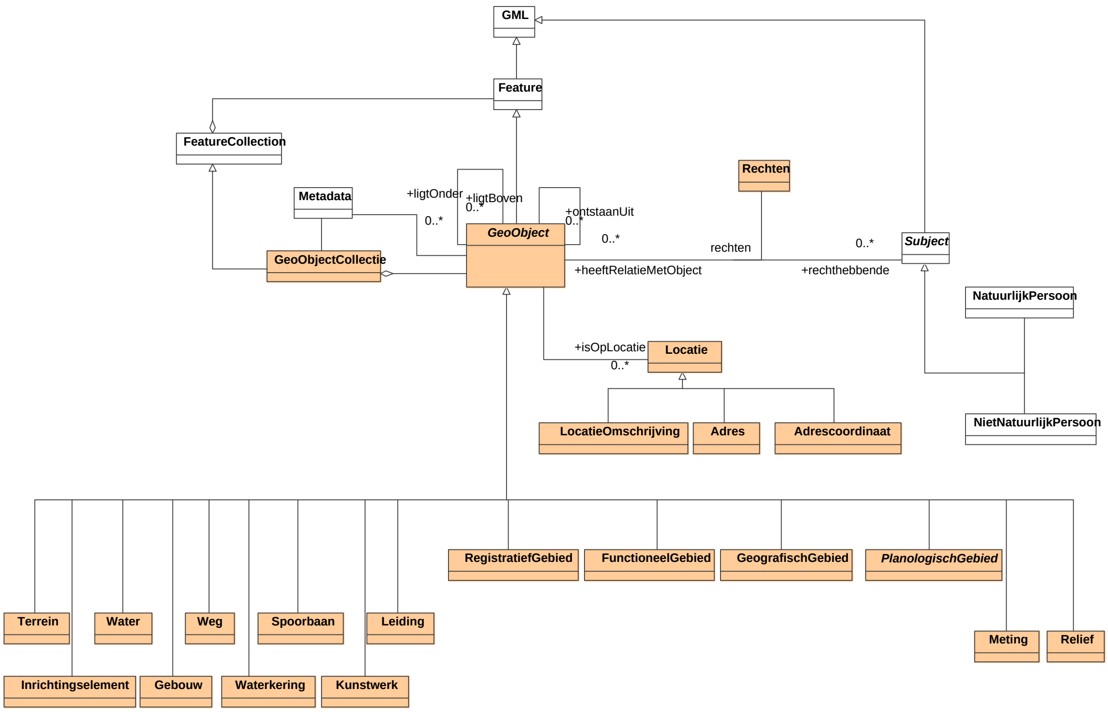


Figure 5. Application schema for geo-information.

Interchange of information

Geography Markup Language (GML) is a XML based codification to model geographical information. With GML can both the spatial as the non-spatial characteristics of objects be described. GML as being part of the family of internet languages, has the advantage that it supports both interchange by transaction as by interaction (web services). Because of its structure, GML is very appropriate to interchange semantics. At the same time is GML readable for human beings as well as computer systems and is the structure controllable by use of general available tools. The Basic Schema is described in an application schema. For translation of the UML class diagram to XML schema, use is made of the 'UML-to-GML Application Schema Encoding Rules' in annex E of the GML standard (GML3.1). This schema provides the framework which can and should be used and further detailed for each specific application. When every provider or user of geo-information is conforming to this Basic Schema clear understanding about the information is possible. Furthermore the schema will offer technical specifications for information interchange. Both will clear the road for an unambiguous interchange of information without the risk of loss or misinterpretation.

Conclusions

The implementation of the Basic Schema for Geo-information as a standard for semantic operability will greatly contribute to the realisation of the Open Standards policy formulated in the ICTU programme OSOSS. The importance thereof is underlined by BZK by acting as co-financer for the NEN 3610 framework project. Furthermore will this standard lead to harmonization in the process of inter sectoral dissemination of the framework of governmental registrations. Regarding its coordinating role in supply of geo-information the Ministry of VROM has acknowledged the importance of this standard and acted as co-financing party.

A framework of standards for description, interchange and integration of geo-information is one of the components of a national geo-information infrastructure. Hence, a semantic standard is of importance for reaching the goals set in the programme Space for Geo-information. Up to 70 % of the INSPIRE activities are targeted at harmonization of geo-information to reach a standard on semantics to facilitate interchange and integration of data. Because of its relation with INSPIRE and its conformance to international standards the redefined NEN 3610 will play an important role as a semantic standard for cross border data dissemination. In the nearby future this will clearly be experienced in the Netherlands cooperation with Nordrhein-Westphalia and implementation of the European Guideline for Water management. In this respect the Basic Schema can act as a starting point for Europe and therefore be in a leading position.

For now the implementation of the Basic Schema is high on the agenda. Another important point is the need to develop a Dutch meta-data profile. Of importance is the harmonization of different existing schemas and evolve to one meta-data profile (a minimum set) for the Netherlands.

References

Basic Schema Geo-information (NEN 3610), Ravi, October 2004 (www.ravi.nl).

The Basic Schema Geo-information is implemented on the ISO 19109. The ISO 19109 standard presents the rules for drawing up application schemas for interchange of geo-information. ISO 19109 in its turn is implemented on a series of other ISO standards presented in the following list:

ISO 19101: *Geographic information – Reference model*
ISO 19103: *Geographic information – Conceptual schema language*
ISO 19107: *Geographic information – Spatial schema*
ISO 19108: *Geographic information – Temporal schema*
ISO 19109: *Geographic information – Rules for application schema*
ISO 19110: *Geographic information – Feature cataloguing methodology*
ISO 19112: *Geographic information – Spatial referencing by geographic identifiers*
ISO 19113: *Geographic information – Quality principles*
ISO 19115: *Geographic information – Metadata*
ISO 19118: *Geographic information – Encoding*
ISO/IEC 19501-1: *Information technology – Unified Modelling Language (UML) – Part 1: Specification*

For the technical format of interchange of geo-information is referred to ISO 19136 and GML 3.1.

GeoPortals and interoperability:
The role of open standards and web service architectures

T. Thewessen[1]
Geodan IT BV

Introduction

Geographic Information Systems (GIS) are justified, at least for an important part, by their ability to integrate information based position or location. On the base of location sources can be combined and integrated. Herewith location is a unique key: all data with a X, Y coordinate in principle can be related to each other in one way or the other. Therefore, it is logical that the geo-information (GI) community has a rich tradition in the wish to be able to integrate, to cooperate, to share. The term "interoperability" made its entry early within the GI field. Interoperability can be described as: transparent access to data and access to functionality in order to be able to look, to integrate, or to edit data. In this chapter the term "interoperability" will be further examined. Also will be looked over the fence of Geo-ICT: which general ICT standards and concepts are important for further development of this interoperability?

The following aspects will be discussed in this chapter:

- *What are the preconditions for interoperability?*
- *How can technology help us?*
- *On the way to a new architecture for the GI provision.*
- *Which opportunities these developments give for the Geo field.*

Interoperability: more than only technology

To interpret the term interoperability, consider the following three aspects:

- *Technology (technical interoperability)*
  Guarantees a transparent (physical) access to all geo-data types and geo processing services. In fact it does not matter in which system the data are managed: one can access and process in its own environment. In this domain we refer to the general ICT-standards of ISO and W3C (WWW-consortium) and to the standards of the OGC (Open Geospatial Consortium).

- *Semantic (content interoperability)*
  Guarantees a transparent integration of data content, with semantics geared to one another. Definitions of objects have to be tuned if one wants to combine different sources. In the Netherlands we herewith mean the semantic standards of NEN/Ravi, namely NEN3610-2 (Basic model Geo-Information) as follow up of the NEN 3610. On the base of NEN 3610-2 several domain specific standards have been developed (IMRO and IMWA) and the next years probably many will follow. Beside that the development and legal base of authentic registrations is a crucial development and the foundation by creating some municipal basis registrations.

[1] Translated by Elma Bast from Dutch into English.

– *(Legal) Arrangements and guidelines*
  That means laws, rules and covenants for the use and exchange of data. Think of guidelines according the streamlining of basis/authentic data, initiatives to develop infrastructures on European and International level (INSPIRE, NCGI) and domain specific legislation and guidelines. The last issue nowadays is the availability of cable- and pipeline information. To prevent digging damage and to get a better view under the surface, legislation is in development in which spatial data are to be opened.

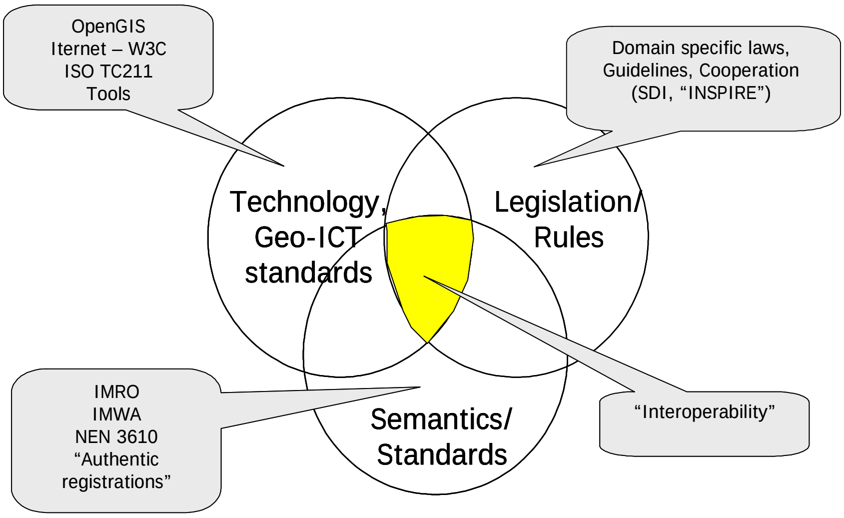


Figure 1. Interoperability: issue of technology, semantics and rules.

Speaking about full interoperability these three forms have been equally worked-out. Is one of the three aspects missing, than there will be no interoperability. So it is necessary to develop all three tracks equally. A technical transparent environment won't help much if the data in no way can't be semantically meaningful integrated. Idem, if the technology and content are okay but there is no permission (covenant, instruction) to even use the data.

In this chapter notice the focus will be on the development of the technical operability within the geographic information provision and the opportunities that are provided by this for the further development of an interoperability environment. Especially attention will be given to the development and the chances that the new web service architectures provide in a GIS environment.

From GIS to Geo-services

How the information technology can help us? To bring the most recent developments in the field of technical interoperability into perspective it is nice to overview the evolution of GIS in a nutshell:

– In the first phase heavy workstations and mainframe computers were needed to run the standalone GIS applications. Expert users operated these systems. The costs were, inclusive software, around € 40.000 per workplace (!). It were closed, monolithic systems in which all functionality (data management, editing, and presentation) were integrated.

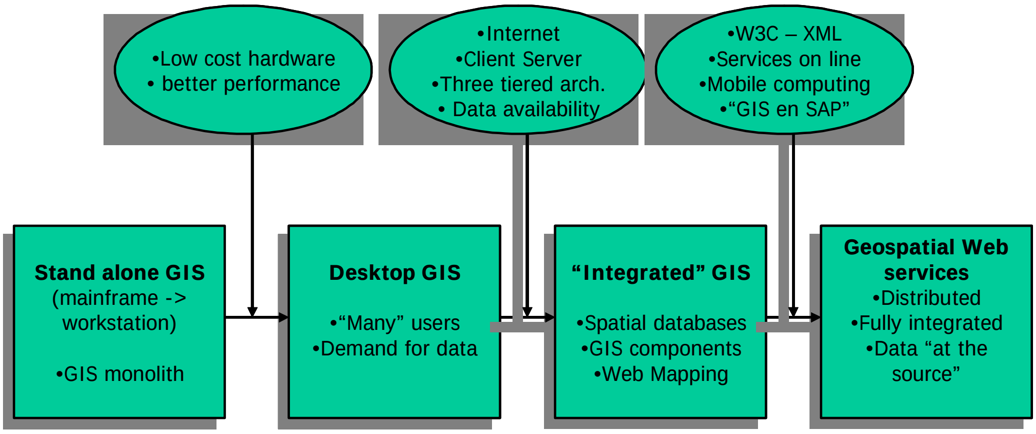


Figure 2. Phases in the development of GIS.

- In the middle of the nineties, these systems were followed by relative cheap and fast desktop GIS environments on the PC. GIS functionality was available for a relative large group of end users. The costs per workplace descended to € 5.000.

- Soon the requirement to be able to integrate between GIS environments and administrative databases occurred. Generic IT developments like Internet, components technology, client-server- and multi-tiered architecture were used in the newly introduced Spatial Datawarehouses and web mapping applications. In the meantime the infrastructure thinking was rising. Central powerful servers were used to serve a large group of users via custom-made applications – if possible within a standard browse environment at the client side. Because of this GIS was now available for large public against relative low costs per user.

- In the next phase we see a development to services. Functionalities appear on Internet as web services. Applications are formed by, via Internet, coupling to distributed web services (so called "service chains"). Because of this a service-oriented architecture arises (SOA). The whole is well supported by new general IT-standards of ISO and W3C, and by new spatial standards of the OGC. Important motivation is the availability of geo-data: for the users it is no more needed (and possible) to keep all data in their own management. Another motivation is the development of mobile computing, on base of wireless technology and thin clients. Applications can be put into action on the workplace. All processing power and data is available on-line in the from of services.

Now we are in the transition to the last phase.

Evolution of technical interoperability within GIS

Within this framework it is interesting to see how the interoperability has developed within the GIS systems. In the first phase interoperability only was possible by physical conversion of data from system A to system B. In the second phase the 'direct read' solutions appeared. Examples are SDE of ESRI (at that time under the name "ArcStorm") by which many formats for a GIS system were directly supported in their native format. It is not necessary anymore to explicitly convert data physical from system A into system B. In the third phase a development towards the integration at the DBMS level appeared. In particular the rise of the spatial databases makes it possible to integrate data on database level. Important was the possibility to integrate geographical data and the other data into one database. In the last phase the interoperability is arranged by giving services and exchange based on open standards (XML/GML). The technology behind that and the storage formats are not important anymore: the data stays at the source and is opened up by services, either for consulting (web mapping services) or for editing (web feature services). Remark: also in the nowadays GIS use all four named methods are of great importance. Powerful conversion tools like FME are still amazing popular!

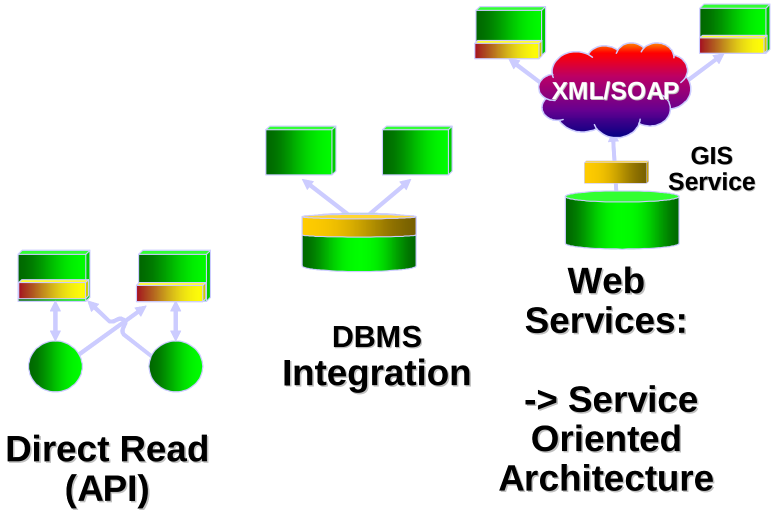


Figure 3. Development interoperability in GIS (source: ESRI, 2004).

Service Oriented Architecture

The above mentioned web (map and feature) services play an important role within the further evolution of GIS. They are the basis of full technical interoperability. In fact this technology delivers exactly what the GIS community has been asking for many years. Just think of all the possibilities that come in reach when the GIS community is provided with a powerful network of GIS data and functionality (services) on the Internet, which then form the foundation of all kind of applications within a Geo-Information Infrastructure. The concept is even older than one might have expected: in 1993 already (!) IBM mentioned the phenomenon “web services”. In their definition the web services formed the basis of a new sort of application that:

– are self documenting and modular;
– can be published (deployed), located, and called via the web;
– contain functions: ranging from simple requests to advanced business processes; and
– can by the means of chaining be integrated into applications.

Also the term “SOA”: Service Oriented Architecture is used in this context. Simply stated, a web service architecture is not more than an implementation of SOA based on internet (for the experts: based on SOAP and WSDL). The current ICT developments point in this direction in an increasing degree. Also the complex ERP systems are developed on base of this technology, anticipating the model by which companies will more and more outsource their ERP functionality and open up via the web. In the world of ICT this concept will be leading at the support of complex business processes. An interesting development where the GIS community can take its profit. In the service-oriented architecture according the W3C three aspects of the information processing are central, namely (see figure 4):

– the user of information services (service consumer);
– the provider of information services (service provider);
– the broker of information services (service broker).

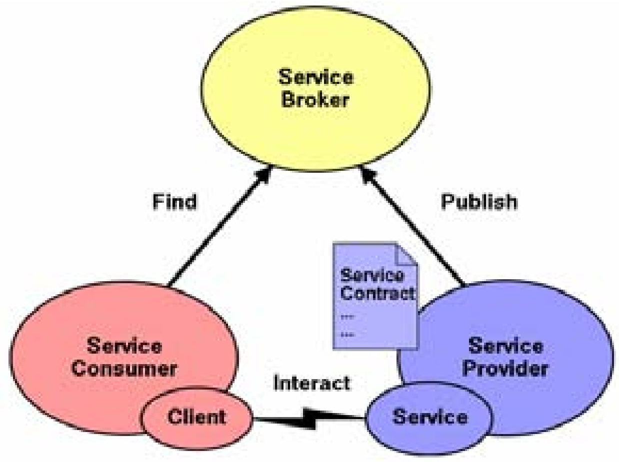


Figure 4. Find, publish and interact principal, source W3C.

The Service Oriented Architecture has the following characteristics:

– It is focused on processes and chains of processes and not so much on the underlying technology. This is a very important quality. Discussions will not go about the technology behind it, but will concern the semantics. Crucial is the question: What can a service give to me and does it fit within my information model? Nowadays the discussion is still to often about the (impossibility of) technology and the conversion of data.
– It works perfect in a heterogeneous environment. It is possible that services communicate with each other being implemented in total different environments. It does not matter what kind of software and hardware are used.
– The architecture model can integrate domain specific services with basic services. This model suites perfect with the semantic exchange standard NEN3610-2.

The model is therefore the foundation for the integration within GIS systems and chains. From the GI-perspective it is important to know that the new OGC Web services (OWS2) are fully adapted to this architecture (WMS, WFS, WCS, WRS, GML, etc …). Also NEN en Ravi's semantic exchange standards (NEN 3610-2, IMRO, IMWA, etc.) fit into this architecture and are based on XML/GML.

Chances Service Oriented Architecture for the GI work field

More specific this architecture provides the following advantages for the GI work field (without being exhaustive):

– *Data at the source:* Data don't have to be copied physically into the own environment. Especially for GIS users (data hunger, great datasets) this is an important move. Nice example is the disposal of the GBKN by web services (under the name 'Basiskaart On Line', BKOL).
– *Integration is more conveniently arranged: Framework for GII:* Through this architecture it is possible to built up a network with nodes that offer domain specific data and functionality.

In fact this is de dominant model for the realization of a GII. Besides, think what this concept can mean for the realization of e.g. the DURP concept: spatial development plans (data) and probably also functionality will be available through services. By the way, in this context one should better use the term DORP ('Digitale Ontsluiting van Ruimtelijke Plannen') instead of DURP ('Digitale Uitwisseling van Ruimtelijke Plannen').

- *Integration within organizations:* Also within organizations these concepts will lead to further integration of processes, even without the "legacy systems" being adapted. On top of the legacy systems, in this architecture, services are developed that open up the data and functionality.
- *Standardization turns more towards semantic and processes (less towards technological details):* Discussion will focus less on the technology, but more on the semantics: what can I do with the concerning services and how should I integrate them in my applications. But also: Which services have not been developed yet? Who is responsible for the delivery of a specific service?
- *Thin clients, mobile applications:* The model enables mobile applications on locations in the field. In this concept there is no need for computing power and data at the client side. A mobile connection with the Internet, and a simple browser application will do. Especially for data collection and entry, checks at the actual location in the field is a big step forward, certainly if the devices in the field have been equipped with technology for positioning and orientation (GPS, Cell-ID, Wifi, etc.).

Standard GIS web services

In the coming years within the GI domain there will arise all kind of web services. There can be made difference between data services, processing services and registry services. Some examples are named here:

- Data services: Visualization (web mapping), Integration, Editing;
- Processing services: Overlay, Projections, Buffering, Find nearest neighbor, Geo coding;
- Registry, Catalog services: Registration, Classification, Find.

Service Chaining and choreography

In the future GIS applications will more and more be rebuilt from a sequence of web services. In this context one speaks of "Service Chaining". In the figure 5 this is illustrated with a simple example (source: Nadine Alameh, 2004): A user wants administrative data of a certain area to be positioned on orthophotos. The data of the concerning orthophotos are offered by different services (web coverage services). Through a 'portrayal service' the data are integrated to a seamless picture. These data are put in the requested projection by a re-projection service. The administrative data are next added in the right projection by a feature service and integrated in the end picture.

Challenge in the web services concept is to know who has control over this process: Where is the process defined. Who can "call" the process, etc. Within the W3C there are now activities on the development of standards to define service chains. One speaks in this connection also about the "choreography" of a process within a web service architecture. In this context two models are important: "user defined chaining" versus "workflow managed chaining". In the figure 6 this is explained. In the first approach one speaks of user defined chaining: the application itself decides which services are to be executed and in which sequence. In the

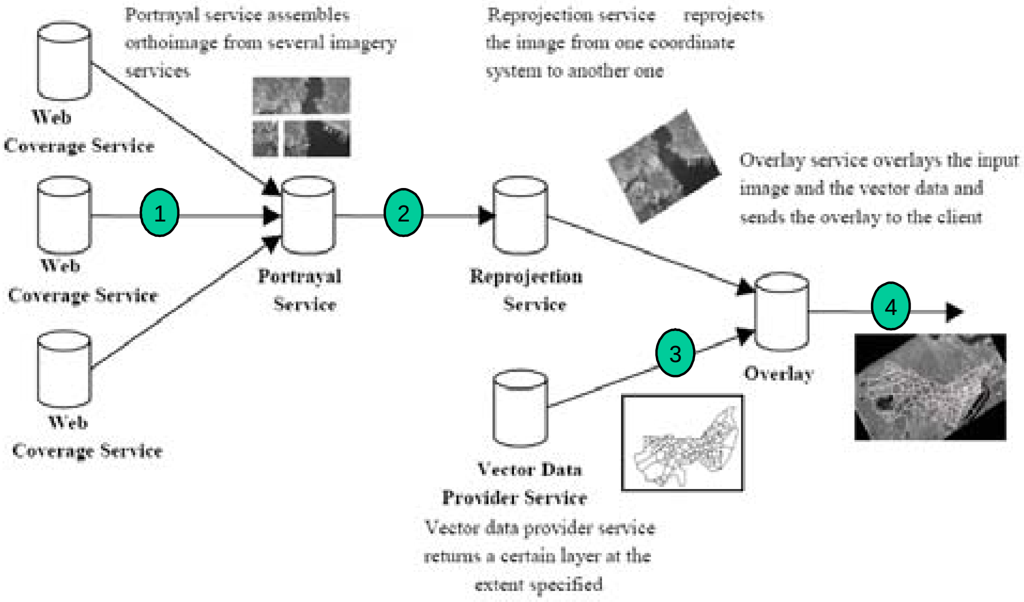


Figure 5. Example of service chaining – source Nadine Alameh, 2004.

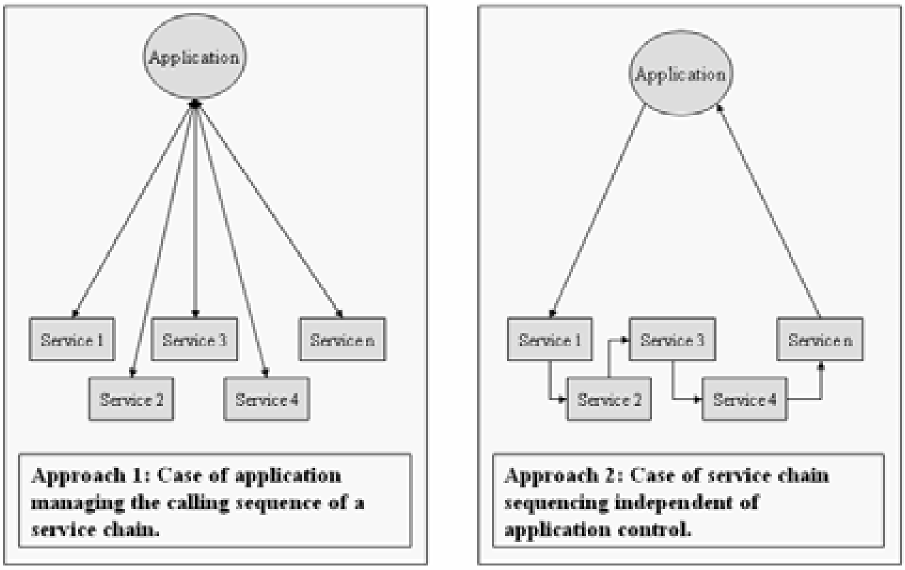


Figure 6. User defined chaining and workflow managed chaining (source Ken Keiser, 2003).

second approach the sequence is decided by the intelligence of the architecture. In this example it is necessary that the intelligence of the chain (metadata of the process) has been recorded.

Standardization: Web Service Architecture Stack

Fortunately, we have to worry less about technical standards; these are available (for a large extend) from the "standard" ICT world. Instead of inventing specific Geo-ICT standards it is important to adapt what happens in this "standard" ICT world and to connect this. In this context it is interesting to see that within the W3C, standards have been developed (and are in development) that support the complete architecture of web services. In this chapter a short overview is given.

Figure 7 illustrates three levels of standardization:

– Messages: how do services talk to each other (Standard: SOAP);
– Descriptions: How to describe services, meta data (Standard: WSDL);
– Processes: How to find services (to integrate them in their chain)? How to define and to use chains of services.

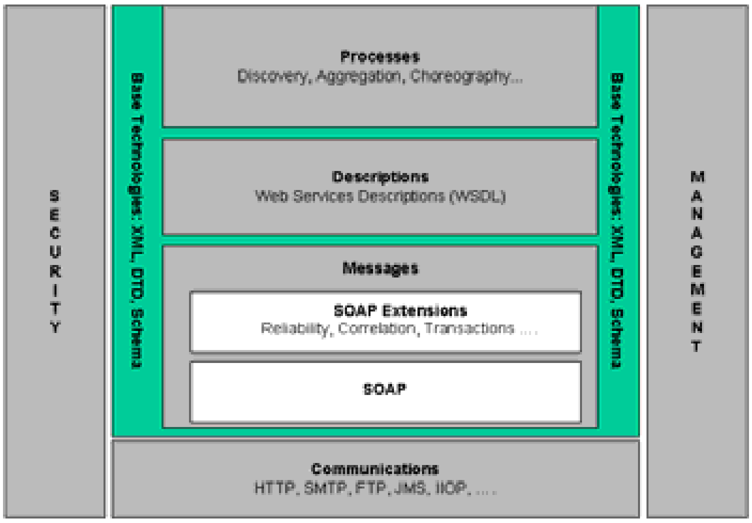


Figure 7. W3C Web service Architecture Stack (source W3C).

It will not astonish you that most of the work has to be done within the domain of the "processes". There are not yet W3C standards available to define and manage service chains. Both IBM and Microsoft are active in this domain with their own industrial standards (WSFL of IBM en XLANG of Microsoft). Besides that the UDDI "standard" is important. UDDI means Universal Description, Discovery and Integration of Web Services and tells where to find data and what is the (platform independent) structure. It is interesting to see how the Open Geospatial Consortium follows the here named W3C and the industrial standards (see table 1).

Operation	**W3C, Industry standards**	**OGC**
Find (Brokering)	UDDI	Registry Services
Describe	WSDL	a.o. GetCapabilities
Bind (Interact)	HTTP SOAP	http (SOAP)
Chaining/orchestrating	WSFL (IBM), XLANG (MS)	

Table 1. W3C and OGC standards (source among other things ITC, 2003).

It can be concluded that not all standards are supported yet. That has also to deal with the fact that OGC was ahead (several times) when the specifications were developed and these standards (e.g. for the "bind" principle e.g. the SOAP protocol) were not yet available and/or not yet in common use. It is good to see that the OGC is ‘synchronizing’ again with the W3C and the industrial standards.

Summary, conclusions, chances for the Geo Information work field

– SOA becomes (very fast) the standard architecture for the Geo Information provision.
– SOA is very suitable to serve the needs from the GIS work field, considering the strong need for integration, considering the “data hunger”(data at the source) and considering the need to use GIS on location in the field.
– Excellent standards have been developed within the “normal” ICT domain: let's pay more attention to these standards and apply them within the Geo-ICT.
– The described developments indicate that more attention can be paid to the semantics instead of technology. So we can ask ourselves: Which services have to be developed to support our domain specific (semantic) standards. The new NEN 3610-2 standard should be applied within the base geo information services. The same is true for the base registrations conform the model “streamlining base data”.
– There should be more attention for the development of a (national) GII based of these concepts. Imagine which possibilities these concepts for the realization of the GII.
– SOA can be seen as the framework for integration, either between or within organizations. Existing initiatives can be recycled. Short: existing initiatives can be packed in a “SOA” wrapper and be made available in this architecture without redefining the base.
– *Free thinking:* It is in particular important to absorb these new concepts and to think of all the things that are possible.

OGC Web Services in action

P. van de Crommert
Geodan IT, the Netherlands
F. Langelaan
Intergraph Benelux, the Netherlands
J. van Winden
ESRI Nederland, the Netherlands

This paper is based on the evolution of Geographic Information Systems towards the web services model. Indeed, this model is rapidly materializing as a result of the advancements in general web service technologies and the focused efforts of the Open GIS Consortium in the areas of service categorization and interoperability of service interfaces. This paper focuses on the use of several complementary and interoperable GIS Web Services to create customized solutions. After this paragraph a GI system integrator (Geodan) and two GI software suppliers (ESRI and Intergraph) will give their respective views on the developments regarding interoperable GIS webservices. (this introduction paragraph is to a large extend copied from Alameh, 2003)

Evolution of GIS

Over the last decade, we have witnessed the evolution of Geographic Information Systems (GIS) from the traditional model of stand-alone systems with geo-data tightly coupled with the systems used to create them, to an increasingly distributed model based on independently-provided, specialized interoperable GIS Web Services (Alameh 2001). This evolution is enabled by the advancements in supporting IT technologies and the growing demand for GIS in a variety of application domains (Figure 1).

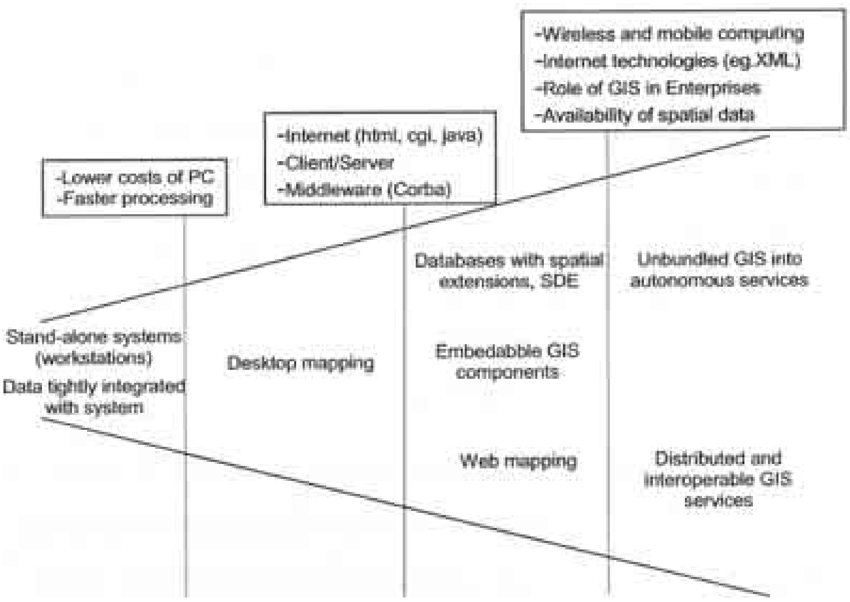


Figure 1. Evolution of GIS.

This gradual on-going transformation is primarily fueled by the growing role of GIS in today's organizations, the increasing availability of spatial data and its inherent conduciveness to reuse, the relative maturity of web and distributed computing technologies, and the key role of GIS in a promising location-based services market (Figure 2).

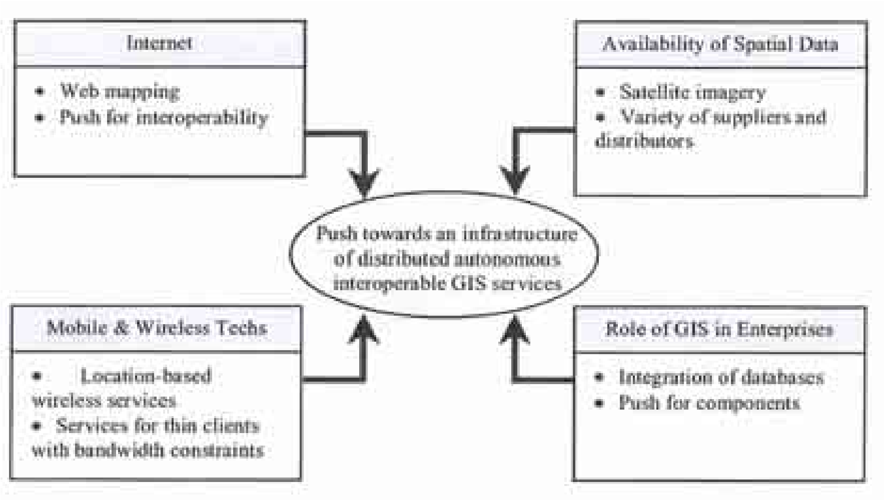


Figure 2. Key drivers of GIS Web Services Architecture.

The service-based model is rapidly materializing as a result of the advancements in general web service technologies and the focused efforts of the Open GIS Consortium (OGC) in the areas of service categorization and interoperability of service interfaces (Buehler and McKee 1998). Soon, it will be possible to dynamically assemble applications from multiple network-enabled GIS services for use in a variety of client applications. This dynamic assembly of services is the motivation behind studying service chaining in this paper. Service chaining is the process of combining or pipelining results from several complementary GIS Web Services to create customized applications.

What are OGC Web Services?

A simplified view of the GIS Web Services Architecture is presented in Figure 3. This figure shows a variety of GIS Web Services being chained and accessed via standardized interfaces by a range of clients.

Web services are self-contained, self-describing, modular applications that can be published, located, and dynamically invoked across the web (ISO 2001). Web services provide access to sets of operations accessible through one or more standardized interfaces. In the process, services may use other external services and operations. Services can be grouped into five basic categories:

Data services (such as the OGC Web Mapping, Web Coverage and Web Feature services) offer customized data to users (OGC 2002). These services are tightly coupled with specific data sets.

Processing services are not associated with specific datasets. Instead they provide operations for processing or transforming data in a manner determined by userspecified parameters (Alameh 2001). Such services can provide generic processing functions such as projection/-coordinate conversion, rasterization/vectorization, map overlay, imagery manipulation, or feature detection and imagery classification.

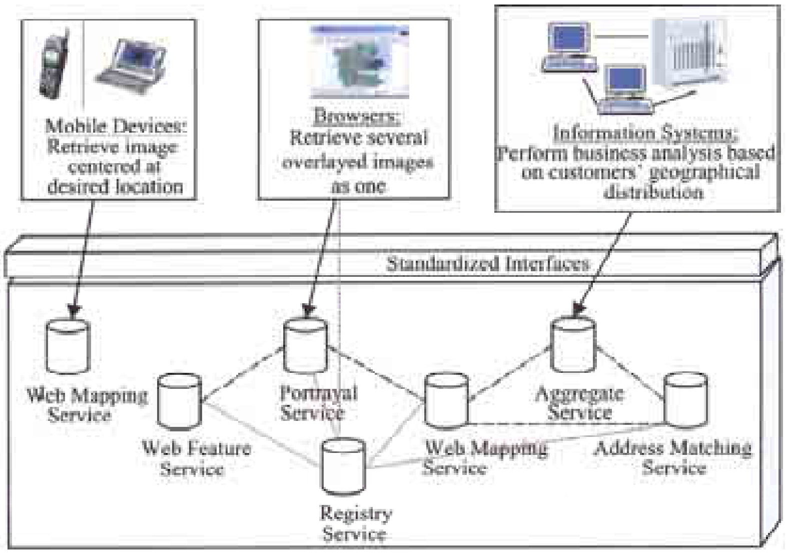


Figure 3. Simplified View of GIS Web Services Architecture.

Registry/catalog services are used to classify, register, describe, search, maintain and access information about Web services (OGC 2002). Types of registries are differentiated by their role such as registries for cataloguing data types, online data instances, service types and online service instances.

Portrayal services are services through which requested data (maps) are being transmitted to the requester. Amongst others we mention the Map Portrayal Service. Portrayal services are registered automatically through Registry Services.

Application Services are services that are used to build user interface (webapplications) through which all other webservices are offered to endusers. An Application Services always first 'finds' available portrayal-, data- and/or processing services and them 'binds' them in the webapplication and presents them via the user interface.

These five basic services are jointed in a so called OWS service framework in figure 4.

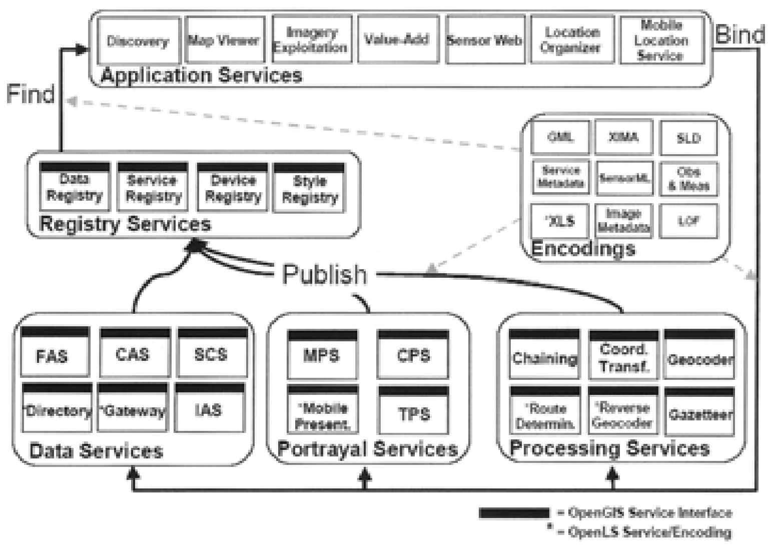


Figure 4. OWS Service Framework.

Service Chaining of Interoperable Geographic Information Web Services

Once GIS Web Services are deployed, client applications can be built more flexibly by mixing and matching available services. Figure 3 shows a variety of clients that can be directly linked to the key distribution drivers presented in Figure 2. The clients featured cover a range of possible applications: thin clients such as web browsers, newly emerging clients such as hand-held devices as well as the traditional information and GIS systems.

Each client application is created by using multiple GIS and non-GIS Web Services. Service chaining is an integral part of developing customized client applications in such an environment. Figure 5 shows a simple service chaining example where several GIS coverages are fetched from Web Coverage Services (WCS), mosaicked and portrayed using a Coverage Portrayal Service (CPS). The resultant coverage is then reprojected to another Spatial Reference System (SRS) using a processing service. The coverage along with feature data extracted from a Web Feature Service (WFS) are then overlayed and portrayed as a finished image to the client. For more information on WCS, CPS and WFS, refer to the OGC webpage (OGC 2002).

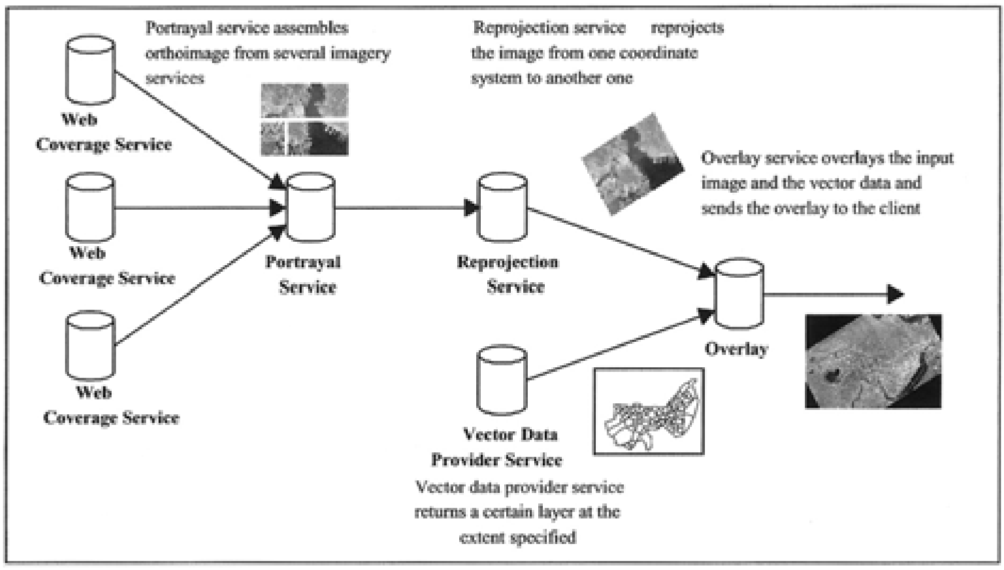


Figure 5. A Simple Service Chaining Example.

There are several alternatives for efficient and practical dialogs that occur among the individual services being chained as well as between the services and the calling client. There are 3 main service chaining methods identified (Alameh, 2003):

- Client-Coordinated Service Chaining
- Static Chaining using Aggregate Services
- Workflow-Managed Service Chaining with Mediating Services

We refer to Alameh 2003 for more detailed information on these chaining methods.

Geodan’s Open GeoSpatial and Open Source GIS Strategy

Geodan joined as an OGC member as the first Dutch GIS consulting company in 1998. As Geodan always operates on the forefront of GIS developments they started to use OGC compliant Open Source GIS software in the beginning of this century.
The Open Source Software (OSS) phenomenon is not a new one. However, Open Source GIS has received a lot of attention recently, as it offers a growing number of interesting possibilities in the field of GIS webservices. Geodan has knowledge of and experience in the field of Open Source GIS, which allows for the thorough implementation of Open Source GIS technology in an organisation. The desired services can be customised. The combination of Open Source with OGC/ISO webservices architecture is how we see future GIS’s evolving in the next decade or so. Geodan strongly believes in the future of OGC webservices as an irreversible process which will also reflect on the suppliers of current ‘closed’ GIS software.

The source code of Open Source software is freely available. The so-called licence models have been developed to regulate the intellectual property and use of the software and source code. These licence models describe who can access, use, upgrade, complete and distribute the source code. Consequently, software developers can use the source code and adapt it, thus providing for natural evolution of the software. The Open Source community assumes this results in better software.
With Open Source, the software user can verify the exact operation. The life of the software is lengthened for two reasons:

– As the program code is available, the software can be adapted in the future, also by other suppliers.
– The relatively large group of software developers can build in the newest standards and insights in the software.

A much heard drawback of Open Source software is that the products are delivered without any type of support. This is based on a misunderstanding. Just like for Linux, it is very well possible to enter into a Service Level Agreement.

Geodan, Open Source and OpenGIS

The freely available source code of Open Source software fits of the OpenGIS consortium: 'A world in which everyone benefits from geographic information and services made available across any network, application or platform.’ In addition, most Open Source GIS software has been developed according to OpenGIS standards.

Geodan attentively follows developments in the field of Open Source software in relation with OpenGIS standards. In this sense, Geodan obviously focuses on stability, compatibility with open standards, quality of the open standards, future stability and sample implementations. Open Source enables Geodan to join forces with a broad community of developers and experts and therefore to provide even better services to its customers.

Five clear reasons explain why OSS receives attention for geo-ICT just now:

– The Vendrik motion that was unanimously carried in the Lower Chamber in 2002 calls on the Dutch government to assure that by 2006 all information systems in the public sector operate on an open standards basis and to focus ambitious policymaking in the field of Open Source software. Through establishment of the Open Standards and Open Source Software

(OSOSS) program, the Dutch government wishes to encourage developments in the field of Open Source.

- The Open Source software for geographic applications has grown up. Components such as webmapping servers, catalog servers and web feature servers are no longer inferior to the traditional alternatives in terms of performance, stability and possibilities.
- Geodan and others provide reliable support and Service Level Agreements for Open Source software.
- Using Open Source and open standards avoids dependency on a single provider and offers the flexibility to connect to other information systems in the future.
- Modern information architectures have been developed according to the multi-tiered principle, using web services. With this architecture, it is possible to consistently use software from different providers and to make the best choice for every component.

Geodan's OGC webservices in action

Some of the more recent implementations of OGC webservices (some in combination with Open Source GIS software) are:

- Geoservices, RWS-AGI, Mapserver and Chameleon in combination with Geodan's Mapserver, ArcIMS services and IONIC Red Spider
- Crossborder GDI NL-NRW pilot. Combining crossborder webservices as seen in figure 6 (Bregt, 2004)
- GBKN online, The Large Scale Basemap of the Netherlands available as a OGC webservices
- KLIC-Net, A call-before-you-dig OGC webservices based application combining several other data services
- EduGIS, and educational webportal that combines many Dutch datasets through OGC webservices in the form of highschool Geography tutorials/exercises
- KRW-portal, RIZA, The Dutch Water Framework Directive portal that uses OGC webservices.

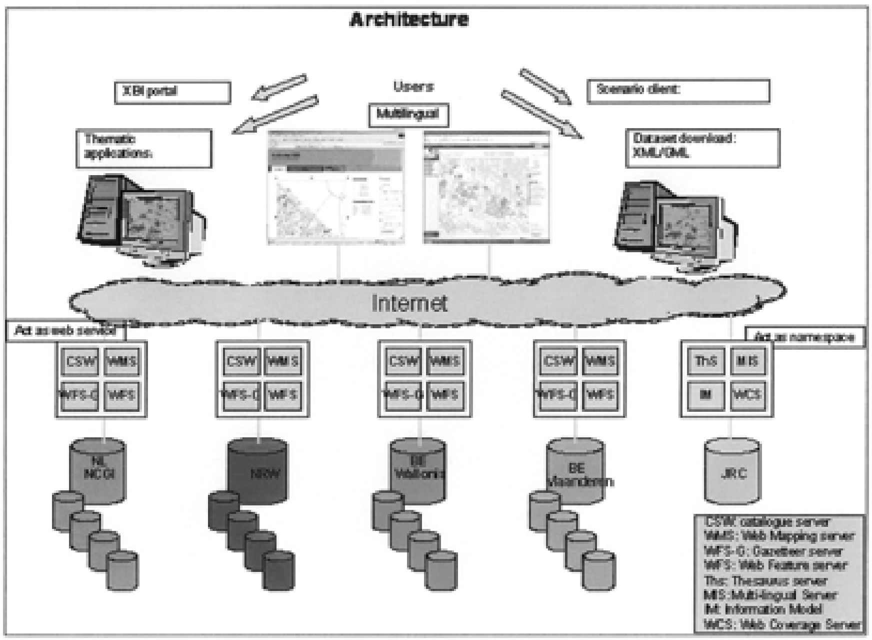


Figure 6. OGC web services used in cross border GDI to solve 'borderless' challenges.

ESRI’s Support of OGC Specifications (ESRI, 2004)

ESRI has a long history of building open and interoperable commercial off-the-shelf software products going back over 25 years. We have always been, and continue to be, keen advocates of the need for open access to geographic data and software functionality using widely adopted, practical standards. Our current products have appropriate open application programming interfaces and support key data interchange formats and Web services standards for ensuring relevant geographic information system (GIS) and information technology (IT) interoperability between systems over wired and/or wireless networks. We provide the largest number of products in the market today with interoperability and open standards support, and have extensive software development plans that include support for all future mainstream interoperability standards.

ESRI's perspective on interoperability extends beyond just the capacity to adequately manage geospatial data interchange. There are a number of major technology trends and advancements that are driving much of the general IT and computing marketplaces. Several of these are having perhaps the greatest influence on the direction of the GIS/geospatial market. These include Web-based services and Internet computing environments, server based architectures and computing, advancements in middleware and Web tier based technology and solutions (such as Web servers, application servers, etc.), wireless advancements and technologies, and the general area of Enterprise computing and deployment environments. ESRI is actively working in all of these areas and leads in new advancements and developments while also cooperating with, adhering to, and partnering with industry leaders such as Microsoft, IBM, Sun, SAP, SAS, BEA, Oracle, and others.

In the last decade, ESRI launched a major initiative to re-architect its GIS product line to adhere to important, emerging IT and GIS standards. The resulting product, ArcGIS, is a scalable and modular family of software comprising a complete GIS. ArcGIS is founded upon key interoperability and Web computing concepts and is in use today by tens of thousands of organizations that rely on GIS and IT interoperability.

ArcGIS was engineered from first principles to support a number of key GIS interoperability trends including:

- GIS compliance with IT standards
- GIS data management and information interchange
- Emerging Web services
- GIS Portals and Spatial Data Infrastructures (SDIs)
- GIS methods for interoperability

Now, ArcGIS enables users to incorporate GIS into any application, on a multitude of computing and mobile devices, all of which can access and use geographic information in almost any format, from numerous databases, and in integrated Web services. 1-1 July 2004
GIS can be deployed and used in a number of alternative scenarios that range from traditional GIS use to emerging Web services frameworks and wireless environments to GIS integration within enterprise systems. ArcGIS is engineered to support each of these settings.

While ESRI's approach to Interoperability fully encompasses OGC specifications and standards, it also includes the more comprehensive world of general IT standards such as those related to International Organization for Standardization (ISO), W3C, INCITS/ANSI, CEN and many other standards bodies as well as the leading de facto industry standards. This includes adherence to and leadership work in areas such as XML, SOAP, SQL, etc. Our goal is to support appropriate specifications as they become finalized and to participate in the development of GIS standards via ESRI's participation in ISO and OGC.

ESRI participates in OGC as a member of the Planning Committee and Technical Committee. ESRI also has a staff person who is a member of the OGC Board of Directors. Additionally, ESRI participates in OGC projects as appropriate depending on a number of factors such as resource availability and allocation, technical issues and requirements, current number of other active OGC initiatives that we are involved with at any given time, partners/colleagues that are participating, etc. It is our intended goal to support all practical OGC standards for which there is a significant demand in our current and prospective user community and as they evolve and grow with the market.

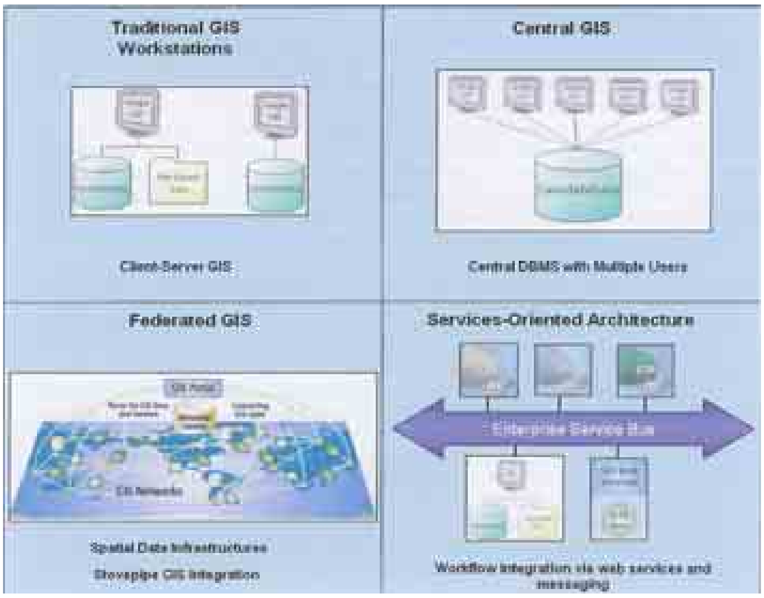


Figure 7. GIS Deployment Scenarios (ESRI, 2004).

We approach each OGC (and the other international standards and specification organizations that we are involved with such as ISO, W3C, etc.) project with a unique perspective driven by what is best for our user community and the state of our software development efforts. In many cases, the work being done for an OGC project is adequately supported by or compatible with our technical product development efforts, so a great deal of work by us is not warranted. Our goal is always to maximize our support for OGC and other standards bodies work while at the same time maximizing our development resources and coordinating synchronization issues with our commercial off-the-shelf (COTS) release cycles so that we can provide the optimum level of functionality and open specification support for our users and the market in general. Given the evolutionary nature of OGC standards, we often offer support for OGC specifications as download options for our users, giving them the freedom of choice in their implementation of OGC specifications.

In addition to OGC standardization activities for geospatial technologies, ESRI also works indirectly with wireless industry standardization organizations. The Open Mobile Alliance (OMA) and the Parlay Group are two independent wireless industry standards organizations that have defined application programming interfaces specific to mobile location queries to public cellular networks. The OMA Mobile Location Protocol and the Parlay Group's Parlay X Web services are the two standards available on the market today. ESRI application server partners such as

IBM support these standards, and ESRI is actively involved in developing business with cellular network providers offering mobile location Web services queries. ESRI's cellular network service provider partners include Bell Mobility, NEXTEL Communications, and Sprint PCS. ESRI's work includes the aggregation of our partners' mobile phone location APIs, which in turn allows joint delivery of end to end geospatial wireless solutions to business and enterprise developers. ESRI's work also includes the development of ESRI GIS Portlets to support IBM WebSphere Portal for customers requiring J2EE-compliant IT infrastructure.

Portlets provide a standard for building GIS-powered Web/wireless portals. ESRI's portlet development effort will provide a toolset for building an integrated complete solution (supported by major players in their respective industries) and implemented on wireless network services standards, J2EE application server portals, and geospatial industry standards.

The main foci of our standards and interoperability work in our products and immediate development work center around:

– Openly published formats of native data structures including shapefiles and geodatabase (XML) and APIs (ArcSDE -C, Java and .NET; ArcIMS–ArcXML)
– Support for over 140 GIS file formats by direct read and conversion
– Extensive use of IT standards including SQL, SOAP/XML Web services, .NET and Java programming frameworks, Python open source scripting language
– Core client and server support for OGC simple features, Web Map Server (WMS), Web Feature Server (WFS), Geographic Markup Language (GML), catalog services, and in the future Web Coverage Services (WCS)
– Development of support for new standards as these come in mainstream use
– Open access to metadata in US Federal Geographic Data Committee (FGDC) and ISO formats including out of the box collection, management, storage, and searching of ISO 19115 metadata. Metadata is stored in XML format in files and databases.
– Ongoing development of an open portal system for implementing SDI portals at local, regional, national and international level. This includes core support for relevant OGC (Z39.50 and CS-W) and other industry standard data and formats.

Intergraph’s support of OGC Specifications (Intergraph, 2004)

As geographic information systems (GIS) move increasingly into mainstream information technology (IT), embracing open standards becomes more and more important. With Spatial Data Infrastructure projects high on local, regional, and national government agenda, open technology will be a key factor in building a solid, interoperable infrastructure management system. As a founding member of the OpenGIS Consortium (OGC) and the only GIS vendor at the strategic membership level, Intergraph has always been committed to open standards. This paper outlines the concept of interoperability, discusses ongoing customer projects leveraging open technology, summarizes the benefits for individual organizations and the economy, and charts Intergraph’s vision for the future.

Intergraph’s Position on Open Interoperability

Data sharing and interoperability have been components of the Intergraph vision from the inception of GeoMedia. Intergraph’s products were built with open interoperability principles in mind. The WMS, WFS, and GML data servers as well as other open functionalities have been complementary additions to the product architecture.

Intergraph is a strategic member of the OGC – the Consortium's highest level of membership. As a founding member and the only mapping and GIS software provider at the strategic level, Intergraph takes an undeniable lead in supporting interoperable solutions that "geo-enable" mainstream IT and the Web. Intergraph's long-standing support of OGC, coupled with the top membership level, affirms its strong commitment to open geospatial interoperability.
As a strategic member, Intergraph provides significant resources above and beyond those provided by principal members. Special functions include taking an active role in setting the direction of OGC technology specification activities and facilitating the use and acceptance of its technology in markets of strategic value to the OGC and its member organizations. In addition to the responsibilities of strategic membership, Intergraph has entered into an agreement to work closely with the Consortium's members and staff to create special programs designed to enhance effectiveness in selected areas of OGC operation.
Intergraph dedicates a staff resource to the OGC, focusing on advancing interoperability in the area of Critical Infrastructure Protection. Additionally, Intergraph engages in strategic planning as a member of both the OGC Planning Committee and the OGC Strategic Advisory Committee. The company also participates in OGC Technical Committee programs to collaboratively define and approve spatial interface specifications that support interoperability.

Open Interoperability in Action

On 3rd Septermber 2003 Intergraph Benelux BV demonstrate it's Web Feature Server live in the Netherlands for the first time for an audience of about 450 visitors attending an Open GIS seminar. With this working demonstration of a live WFS, Intergraph underlined its leading position as innovator of GeoSpatial technology. A number of organizations around the world have begun to implement open standard solutions.

City of Copenhagen, Denmark

The City of Copenhagen, Denmark, uses a Web solution built using GeoMedia WebMap Publisher that enables the Web sites to integrate data and maps from different departments. In addition, the solution automatically secures coherence between all Web sites and servers (test sites, intranet sites, Internet sites, and OpenGIS WMS servers), which enables the city to handle all administration tasks centrally and boasts nearly 100 percent uptime.
Departments within the city still make and control their own maps, and any change is reflected immediately on the Web site. The City of Copenhagen has both test and enterprise sites in addition to its own OpenGIS WMS server. Test sites are used by different departments for testing new maps and setups while enterprise sites are used by the entire organization to supply customers with advanced maps and relevant functionality. The WMS server delivers maps for integration with other systems both internally and externally. The Web solution provides the city with the ability to automatically synchronize the different maps on Web sites and the WMS server, enabling central administration of the city's GIS publications. For example, the city can update the enterprise Web sites and WMS server when changes to a test site have been approved, ensuring not only a quick synchronization but also thorough testing before launch. This facilitates a stable system with an excellent uptime – even on Copenhagen's frequently changing and ever-expanding Web sites and servers.

Portuguese Geological Survey

The Instituto Geológico e Mineiro (Portuguese Geological Survey) has completed the first phase of a project to build a system that will publish geoscientific information on the Web – the e-Geo project. Recent developments in Web-mapping technology and interoperability standards

were explored and tested, and new XML-based formats such as GML and Scalable Vector Graphics (SVG) were chosen for geographic information description and representation. The organization chose OpenGIS specifications for Web services such as WMS and WFS to enable an interoperable geospatial Web server. The e-Geo Web Server is a GeoMedia WebMap 5.0-based server that publishes data in GML and produces ActiveCGM maps – with plans to upgrade the server to GeoMedia WebMap 5.1.
Data is extracted from an SQL database that holds information on geological mapping, locations of study areas, and ceramic minerals locations. More datasets are expected to be included in future phases of the project in 2003-2004. Contents of the e-Geo Server will be accessible from a standard Web browser using a WFS-compliant Web application.

The National Coordinating Agency for Surveys and Mapping, Indonesia

The National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL) of Indonesia is conducting tasks in the field of survey and mapping in line with existing government regulations. Tasks include monitoring and guiding national surveys and mapping. The agency also provides general administration in the fields of planning, organizational management, personnel, finances, archiving, and internal affairs. The goal of the current project is to build a national spatial data infrastructure to provide a reliable database for existing fundamental data sets (e.g., primary reference, natural resources and environmental information, administration boundary, build environment, socio/economy) for the development of the nation.
The organization has been working on the project, the Integrated Spatial Data and Information Management System (ISDIMS), since 2001. This system is designed to provide and manage spatial data and information according to common standards and to provide public access. BAKOSURTANAL is working very closely with producers of spatial data, within both government institutions and the private sector as well as from universities and the military.
BAKOSURTANAL's mission is to use components and national capabilities in survey and mapping to build up a National Spatial Data Infrastructure (NSDI) in the field of survey and mapping. The GIS development, supported by the Intergraph Open Interoperability Grant, should be applied on a national, provincial, district, and city level to create synergy. The system should provide public access to information services on the Internet and intranet. The first small-scale model is scheduled for completion in October 2003.

"IDE-E: Advances for an INSPIRE-based National Spatial Data Infrastructure in Spain the Feasibility of GeoMedia Software Components"

The GeoMedia and AGILE award-winning project, "IDE-E: Advances for an INSPIRE-based National Spatial Data Infrastructure in Spain the Feasibility of GeoMedia Software Components," was developed with the goal of technological advancement toward the construction of a spatial data infrastructure (SDI) in Spain. The SDI would be a critical tool in facilitating the exploitation of key public sector information for an extensive list of applications, contributing not only to economic development but also to environmental management.
The project stems from the European Commission's (EC) previous launch of INSPIRE, Infrastructure for Spatial InfoRmation in Europe, an initiative to create European legislation to guide national and regional SDI development. The INSPIRE initiative includes core geographic data, metadata, catalogue services, and other geospatial services such as Web map services, Web feature services, Web coverage services, gazetteer, and more. With a fundamental emphasis in standards and interoperability, the initiative will facilitate public access to geographic information and support the needs of partnering organizations, initially from the environmental sector.
A major boost for Spain SDI, the project will focus on SDI node creation methodologies, the study of adequate SDI software architectures, and develop software technology for some services (software components based on OGC standards). Additionally, it will test the feasibility of

technological interoperability with other COTS with emerging OGC standard-based interfaces, such as GeoMedia products.
The ultimate goal is to enable the seamless integration of a number of disparate data formats and services, thereby promoting interoperable geoprocessing. The project is lead by Professor Pedro R. Muro-Medrano, University of Zaragoza, a Team GeoMedia Registered Research Laboratory member. An initial report on the results of this project will be available in April 2004.

How to Take Advantage of Open Interoperability

Intergraph provides a range of software, tools, and programs to make it easy for both customers and non-customers to take advantage of the benefits of open interoperability.
Intergraph's Open Interoperability Grant Program is designed to stimulate the use of open interoperability standards through the support of organizations desiring to build Web services using OGC standards as well as organizations wishing to publish their data in XML/GML (file) format.
While the grant program targets governmental and commercial organizations, Intergraph's Team GeoMedia Registered Research Laboratory program provides a comprehensive software and support offering, including the latest interoperability components, to academic institutions and non-commercial research groups. There is no financial charge for joining the program. Instead, the submission of two research papers per year is required.

Intergraph's Conclusion

As the global economy moves into "now" time, data access and interoperability can be key competitive differentiators. The future of GIS is open, interoperable standards .
Open interoperability has not been an easy technical challenge, but Intergraph has remained committed to open interoperability from the beginning and has consistently met the challenge. eloquently highlights the scale of the technical task in the development of open standards, GIS interoperability: a dream for users and a nightmare for system developers.
The critical first wave of hard work has been completed and users are already reaping the benefits. The dream is becoming the reality.

Final remarks and Conclusions (Alameh, 2003)

It is becoming increasingly evident that there is a growing need for a GIS Web Services architecture (Abel D, Ooi B, Tan K, and Tan S 1998). This architecture will be especially beneficial for scientific research and engineering modeling as well as state and federal government settings, where tightly coupled hierarchical systems are unlikely to provide the desired breadth and flexibility. The web services model allows users in these settings to freely combine services to create customized solutions with minimal programming, integration and maintenance efforts. Such a model will also be a key enabler of GIS to extend beyond its traditional boundaries of mapping to embrace a broader community of users and wider scope of services. Critical to the success and sustainability of the distributed Web Services architecture is the issue of service chaining.

Enabled by the advancements in web services in general, and by the on-going work of subgroups within OGC, the GIS Web Services architecture is rapidly manifesting itself. Various groups within OGC are working on service categorization (data, processing and registry services), encodings (SLD, GML), and service chaining (WMS/SLD/CPS, which is setting a

precedent for service chaining in the web services environment). Within this work, general web services technologies have been critical: examples include WSDL for service description, UDDI for service discovery, SOAP for passing XML-encoded data, and IBM WSFL and MS XLANG for web service composition and process languages for orchestrating web services (OWS1 2002).
The next section provides some insights on how the GIS marketplace may be changing in the near future as a result of such advancements.

A Changing GIS MarketPlace

The unbundling of GIS systems into independently-provided interoperable components, and the delivery of subsets of GIS data to users on demand will lead to significant changes in the GIS marketplace. Figure 8 outlines a potential value chain for the future GIS marketplace.

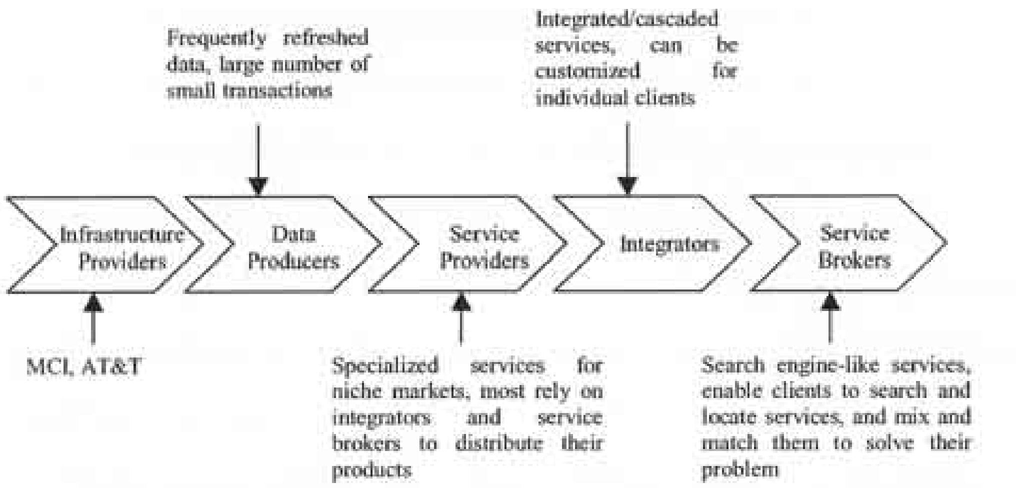


Figure 8. Potential Value Chain for the Future GIS Marketplace.

In this new distributed environment, the private sector as well as the public sector at the local, state and federal levels will all likely contribute in establishing and maintaining a national GIS infrastructure. The different players in the value chain will share different responsibilities according to their expertise. For instance, governmental agencies are well positioned to offer and maintain public data covering their areas of jurisdiction. National agencies such as RWS and TDK can provide shared access to their data via interoperable interfaces. In the private arena, satellite imagery providers are likely to follow an e-commerce model for providing users with on-demand access to their huge repositories of data.

With the unbundling of GIS, it will not be necessary for players to build comprehensive systems in order to gain a share of the market. The new environment will open the door to small niche players to enter this market with application specific offerings that leverage their understanding of particular industries or processes. In this paper, we saw that the need for mediating services to coordinate service chaining will provide huge market entry opportunities for these new players. New opportunities may be available for some service providers to target niche markets in the cases when the backend services are expensive, when service chaining requires specific domain expertise, or when the data provided is sensitive to local context and subcultures. Nonetheless, these opportunities will be limited by the availability of data/service repositories and catalogs in the market. Such players are likely to wait for enough services to become available on the market, and select partners from the players that provide them.

Finally, in terms of the reaction of traditional GIS systems providers in the face of the new competition, we expect them to adapt their business models by offering access to components of their systems through portal-like applications. Of course, the path to realizing the potential changes described in this section requires standards for data and metadata exchange in addition to well-defined simple service interfaces, both current key research topics within the GIS community.

References

Abel, D, B. Ooi, K. Tan K and S. Tan, 1998, Towards *integrated geographical information processing.*International Journal of Geographical Information Science 12(4): 353-371.

Alameh, N., 2001, *Scalable and Extensible Infrastructures for Distributing Interoperable Geographic Information Services on the Internet.* PhD Dissertation Submitted to MIT Libraries.

Alameh, N., 2003, *Service Chaining of Interoperable Geographic Information Web Services*, Global Science & Technology

Bregt, A., J. Crompvoets, H.J. Scholten and P. van de Crommert, 2004, *The Dutch National Spatial Data Infrastructure: past, present and future.*

Buehler, K. and L. McKee, 1998, *The OpenGIS Guide: Introduction to Interoperable Geoprocessing and the OpenGIS Specification.* Waltham, MA, OpenGIS Consortium.

ESRI, July 2004, *Interoperability: ESRI's Support of OGC Specification*, White Paper.

Intergraph, July 2004, *Open Interoperability: From Conception to Realization*, White Paper.

ISO 2001 *ISO/TC 211 Geographic Information/Geomatics*.
http://www.statkart.no/isotc211/

OGC 2002 OGC *Web Services Initiative 1 (OWS1) Baseline Documents Page* WWW document, http://ip.opengis.org/ows1/docIndex.html.

Henri Aalders ‘in action’

B.M.J. Possel
The board of the Surveying Union Snellius (Landmeetkundig Gezelschap Snellius),
the Netherlands

Survey camp

A survey camp is a typical thing related to the study Geodesy in Delft. Each year during the first 2 or 3 years of the study students go somewhere in the Netherlands and measure for 2 weeks. The measurements are used for instance by the municipality, and sometimes they are just to practice measuring. Since 1988 Henri was a supervisor during these camps, and since 1999 he was chairman of the survey camp supervising committee. In 2002 Henri celebrated his 3rd lustrum as survey camp supervisor in a small town called Teteringen, together with Joop Gravesteijn and Hans Garlich. That next year was the last survey camp in its original form, and so it coincided with the last year with Henri as supervisor, and that after 16 years!

Something he always found important during these camps was that students arrived on time in the morning. He could regularly be found at the door where he made notes of everybody who arrived to late, and always said that sanctions would follow. It reached its peak when in 2003 he desperately started pulling students out of their beds because they were still sleeping. Although on the other hand during camp in 1995 in Noorbeek he treated the whole group to ice creams, something he did more often, probably because he himself likes an ice cream (or 2) ….

Henri Aalders ‘in action’ at the start of surveying camp 1999 in Nijhuzum.

Teaching

Not only was Henri involved with survey camps he also taught courses like: ‘Informatica’ and ‘Gis data-structuren’. He never became a professor at the Technical University of Delft, but he is also related to the Katholieke Universiteit Leuven were he is a professor at the faculty of applied sciences.

Henri's involvement was not only with things related to studying, he also regularly took part in activities outside of the obligatory curriculum. He was for example present at the anniversary party in honour of 60th year jubilee of L.G. Snellius.

Henri Aalders at the anniversary party of L.G. Snellius.

Thanks

On behalf of all the former geodesy students and all the current geodesy students we would like to thank Henri for all the efforts he has put into everything during the past years. In particular all the survey camps, courses and practical exercises he has helped with, given or has partaken in.

But there will always be one thing that all the students who know Henri will always remember, and that is the quote, which only can be quoted in Dutch: "Toen ik nog bij het Kadaster zat…”

Laudatio

M.J.M. Bogaerts
Emeritus professor Delft University of Technology, the Netherlands

Land Information and Cartography

In 1988 I invited Henri Aalders to come to the TU-Delft to strengthen the academic team "Land Information and Cartography" as associate professor. To understand the reason for this invitation I will give a brief overview of the development of this team.

In 1974 the curriculum of geodetic engineering was changed drastically. The board of the faculty of Geodesy realized that the society was asking for more information about the land, the sea and the outer space. Nowadays we would say more need for geo-information. One of the results of this reprogramming was the founding of a new academic chair in land information. In 1976 I was nominated for this chair.

To set up a teaching program and a research program for a new chair is rather time-consuming. Furthermore after two years I was chosen as dean of the faculty. If this was not enough, the vacant chair of cartography was combined with that of land information.

A task as dean and leader of two academic chairs could only be carried out with the help of an experienced and devoted staff. An additional problem was the democracy in the higher education and at that time resulted in endless meetings, where in my function I had to be present.

Associate professor

Therefore I was looking for a heavy-weight scientist with sufficient experience and authority in the field of land information and cartography to replace me in a number of duties. The profile of associate professors at the TU-Delft is to be excellent in education and research and to have the disposal over sufficient management capacities.

I knew only one person who met these requirements. Henri Aalders started his career as deputy-head of the department of photogrammetry at the "Meetkundige Dienst van de Rijkswaterstaat". Then he became lecturer at the department of cartography at the ITC. Later he became Head of the Research Department of the Dutch Cadastre.

However there were some restrictions, because a PhD-title was requested for the rank of associate professor. A good thing was that his scientific achievements were judged on the level of PhD.

Scientific interest

From the program of this symposium we see the scientific interest of Henri. It is in the first place oriented on standardization and classification of geo information.
Without standardization there is no communication possible. Classification is an essential part of language. I can communicate with my grandchildren, because they learn very early that a large category of different animals must be called dog, or to say chair for the many objects they

can sit on. In the same way, classifying of geo information is necessary to make communication possible between the thousands existing geo information systems. Already with the introduction of the computer in land information the necessity of standardizing and classifying was evident. Especially municipalities with a large diversity in large and small information systems started to tackle this problem already in the sixties. They developed SOAG, a cooperative organization for the automation in Dutch municipalities.

In SOAG the land information got a prominent place. The computer centers of Amsterdam and Rotterdam got the task to develop systems respectively for land and buildings and for topography and utilities. Within this framework a very good classification system for land information was developed in the sixties.

In the beginning of the seventies the concept of the SOAG did not answer the needs anymore. The cooperation was disbanded and the first large classification system was put to the grave. However the knowledge was still there and the experts continued their research, coordinated by the Study Center for Land Information. The result was adopted by the BOCO, an intergovernmental organization for automation. This BOCO-classification was adopted by the national council for land information (RAVI). The final result was the Terrain Model Land Information. From his position at the TU-Delft, Henri played an important role in the development.

Henri was also active in the European developments in the field of standardization. The acknowledgement for this was the appointment as chairman of CEN/287. In fact I am derogating Henri's merits by only writing about standardization and classification. His field of interest was much broader. It is impossible to give a complete overview in this laudatio.

I should like to confine myself to one sentence from his profile:

The combination of his background in geodesy, photogrammetry, cartography, cadastre, GIS technology, design of large databases and the experience in setting up and management of large geo nformation projects give him specific expertise in this fields.

Professor Aalders in front of the main building of the Katholieke Universiteit Leuven.

Henri Aalders as teacher

Henri Aalders is simply a good teacher. This quality is also known in foreign universities. He gave guest-lectures in Warsaw, Olstzyn, Wroclaw, Kishinev and in Brno. His subjects were different themes of GIS-technology. He spent his sabbatical in the Department of Geomatics of the University of Melbourne.

In 1994 I was approached by the board of the Katholieke Universiteit Leuven. They were looking for a successor of the well-known professor Van Twembeke, who was going to retire.

For me there was no doubt that Henri was the right person. His broad knowledge of geodesy and geo information made him the right person for this prestigious position. So professor Aalders gives lectures in geodesy, land surveying, photogrammetry and GIS at the KU Leuven. He will continue these activities after his retirement in Delft.

Henri Aalders as scientist

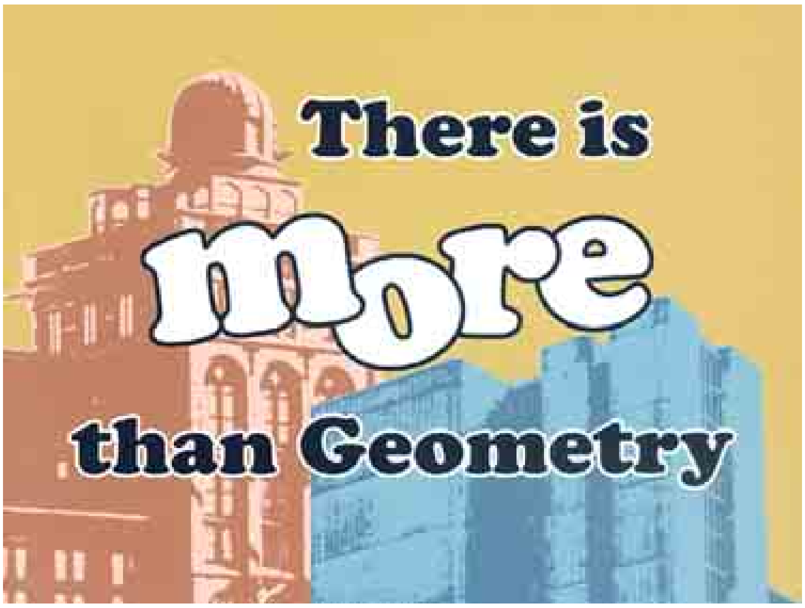
Henri will understand me if I compare scientists with musicians. He is an enthusiastic singer in the choir ‘In Honorem Dei’ There are many kinds of musicians. There are composers, conductors, soloists, orchestral members, choir singers, etc.

The same specialism we see in science: scholarly recluse, scientific managers, inventors, etc. In music Henri is a team player: in science I would characterize him more as soloist with so many national and international appearances. But above all he is a teacher who wants to transfer his knowledge to young people.

In Honorem Dei.

Anyway Henri has played an important role in the young history of geo information.

Henri also played an important role with my own farewell. I am glad that with this laudatio I could do something back. The motto that he has given for my farewell counts also for him.



Henri: thank you very much.