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REFEREED PAPER

Towards a National Atlas of the Netherlands as part of the National Spatial Data Infrastructure

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This paper is about different worlds, and how we try to unite them. One of these worlds is the world of National Atlases: collections of complex, high-quality maps presenting a nation to the geographically interested. The second is the world of National Spatial Infrastructures: highly organized, standardized and institutionalized large collections of spatial data and services. In the paper, we describe the two worlds and their fundamental differences and we present the theoretical framework in which these worlds could be united. We introduce a test bed we are using to try out the theoretical framework in a real-life use case. In the architecture of that test bed, we introduce a National Atlas Services layer and describe how we have created an Atlas Map Viewer component, using the Open Web Platform. We conclude by commenting on the results thus far and taking a look into future developments.

Keywords: National Atlas, Spatial Data Infrastructure, Service-Oriented Architecture, web mapping, Open Web Platform

INTRODUCTION

In order to move, as the title of this paper promises, towards a National Atlas of The Netherlands as a part of the National Spatial Data Infrastructure, we actually have to face the question of how to unite two rather different worlds. These worlds are different expressions, or instances, of spatial data, in different technological environments. One of them is the world of National Atlases: collections of complex, high-quality maps presenting a nation to the geographically interested. The second is the world of National Spatial Data Infrastructure: highly organized, standardized and institutionalized large collections of spatial data and services.

These worlds also represent different areas of expertise (Köbben and Graham, 2009). The atlas is where cartographers, with their focus on semiology, usability, graphic communication and aesthetic design, are most at home. Their digital tools are graphic design software and multimedia and visualisation toolkits. The Spatial Data Infrastructures (SDIs) are typically the domain of the (geo-)information scientists and GIS technicians. Their technological habitat has a strong IT focus on multi-user databases, distributed services and powerful client software.

On the other hand, the *users* of these worlds are becoming more and more similar. Most of them routinely use computer programs to access the functionality, of either atlases or SDIs. Nowadays, any standard computer connected to the internet is capable of offering interactive applications with high-quality graphics, for which not so long ago one would have needed professional workstations. The World Wide Web is now the main distribution platform for atlases as well as SDIs. And one has to keep in mind that the end-users of both atlases and SDIs are mostly not aware of, nor interested in the technology behind the products, and indeed they should be able to make sensible use of them without this knowledge. Policy makers have also been promoting the availability and usability for the general public (for SDIs, the INSPIRE initiative is a good example of this). Therefore, generally available end-user applications and websites that show or consume spatial data will become more and more common in the near future, and that data can be part of an SDI as well as an atlas. However, that leaves open the question how to the combination of these two can be realized in a useful and usable manner. That question is the subject of the research we present in this paper.

We will first describe the two worlds and their fundamental differences, in the section on 'Two worlds: National Atlases and Spatial Data Infrastructures'. In the next section, we will present the theoretical framework in which these worlds could be united. Thereafter, we introduce the test bed we currently are using to try out the theoretical framework in a real-life use case. We firstly present our overall architecture (in the section on 'Architecture'), where we introduce a National Atlas Services layer as an integral part of the

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National SDI. Secondly, in the section on 'The atlas viewer prototype', we describe how we have created an Atlas Map Viewer component to connect to this National Atlas Services layer, using the modern Open Web Platform. We finish with conclusions on the results thus far and an outlook into future developments (the section on 'Conclusion and outlook').

TWO WORLDS: NATIONAL ATLASES AND SPATIAL DATA INFRASTRUCTURES

National Atlases, as described by Freitag (1997) and Sieber and Huber (2007), among others, present a synthesis of the spatial data that characterizes a nation. They contain collections of complex, high quality maps, created from combinations of geographical datasets. A very important aspect of atlases in general, and especially of national atlases, is that a considerable effort has been put into making the information *comparable*: the same level of generalisation is applied, data have been collected for similar reference periods, using standard classification methods, class boundaries and legend colours, etc. The main point of bringing all the various types of spatial information together in a national atlas is to make sure that this comparison can be fruitful (Sieber and Huber, 2007).

Furthermore, good atlases not only present a large amount of comparable information, they also try to combine it into a *narrative*, a story about the country that gives a more comprehensive understanding than could be obtained from just the separate maps. In other words, there should be a synergy, making the atlas as a whole more than the sum of its parts.

The National Atlas of the Netherlands

The history of the National Atlas of the Netherlands has been described in various publications (for example, in Kraak *et al.* 2009). The first initiative to produce a National Atlas of the Netherlands was started as early as 1929, but the economic crisis and the decision to first produce a national atlas of Indonesia delayed the plans. Finally, in 1958, the 'Foundation for the Scientific Atlas of the Netherlands' was set up, backed by the Ministry of Education, the Royal Netherlands Geographical Society, the Topographic Survey and several universities. The first edition atlas (published in the years 1963–1978) was a large single book. With hindsight, its attempt to be a narrative of the geographic fabric of the country was not very successful.

A second edition was published by the Foundation in the years 1989–1995 (de Smidt, 1995). This edition was much more clearly centred on the inhabitants of the country, explaining the way the Dutch lived, worked and provided for themselves. It was also broader in scope. The atlas actually consisted of a series of 20 separate booklets, each dealing with a specific aspect of Dutch society (socio-economics, climate, transportation, demographics, etc.): geographical themes that were relevant in explaining how the Netherlands came to be what they are today. The scientific backbone, the set-up and coordination of the atlas, as well as most of the data acquisition, analysing and editing, was done by a varied group of geographers and other scientist from various universities and knowledge institutes specializing in the given subjects. The atlas was produced at a government-sponsored Atlas Bureau, based at the national mapping agency, and was published by the 'Staatsuitgeverij Sdu' (state publishing company).

After this second edition was completed, the government funding was withdrawn, resulting in the Atlas Bureau closing. Since then, the Foundation has been trying to keep the national atlas concept alive. Scanned versions of the maps from the two editions were made available on the National Atlas website (Dutch National Atlas website, 2012). The fact that this site received almost two million hits since mid-2000 seems to show that it answers a genuine user need. But of course the information is now fast getting out of date. A number of initiatives were developed to bring the Atlas back to life, and in the more recent years these have concentrated on a digital implementation rather then a printed edition.

National Atlases in the SDI age

Nowadays, national atlases are still made as printed books, but more and more also in digital mass-consumer environments. Firstly, these were mostly multimedia presentations on CDs, but with the rise of the World Wide Web people started developing interactive atlas websites, as early tests for an online Dutch National Atlas demonstrate (Köbben and Koop, 1997). Until recently, most digital atlases were produced using digital, but still traditional tools: graphic design software and stand-alone visualisation toolkits. And even though these result in products that can be of excellent quality and usability *in themselves*, they are also *on* themselves: they lack the interoperability and connections with the wider digital world outside that we come to expect in this age of SDI.

An SDI is an example of a Service-Oriented Architecture (SOA). Such SOAs differ from traditional software set-ups in that the distributed components fully encapsulate their own functionalities and make them accessible via well specified and standardized interfaces. There are many ways of setting up such SOAs, but by far the most used platform is the World Wide Web and the SOAs implemented on the web are usually called *webservices* (Peng and Tsou, 2003).

The recent development and success of such an SDI in the Netherlands, the 'Nationale GeoData Infrastructuur' (NGDI), has also rekindled interest in the national atlas. With its broad scope, many datasets not originally meant for combining, and users with quite different needs, the NGDI poses many challenges for any implementation that needs a close integration of its component pieces, such as a National Atlas. An SDI in itself, although it will allow mapping the different datasets, does not constitute an atlas, because the maps, and even the data themselves, are incompatible. It thus will not constitute more then the sum of its parts, as a good atlas would.

THE TWO WORLDS UNITED: WEB MAPPING IN A SERVICE-ORIENTED ENVIRONMENT

To look into this problem, a study, described in detail in Kraak *et al.* (2009) was conducted to investigate the

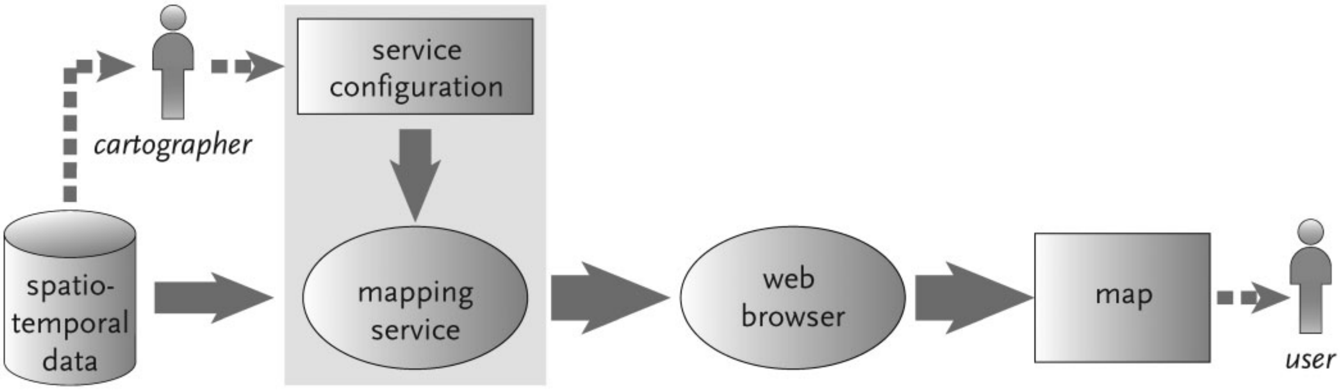

Figure 1. General principle of current practice in dissemination of maps in a Service-Oriented Environment (from Köbben *et al.* 2012)

feasibility of creating an up-to-date, cartographically sound, national atlas, within the technological environment of an SDI. The objective was to create an architectural framework for a national atlas as an integral part of the SDI, and to build a proof-of-concept prototype. Such an atlas would benefit from the up-to-date data in the SDI, and the SDI would benefit from having integrated visual summaries of the available spatial data, in well-designed, comparable maps. As such, a national atlas would provide an alternative, interactive and dynamic way to access the SDI (Kraak *et al.* 2009).

The general principle of disseminating maps in a web services environment is depicted in Figure 1. This general set-up is being used in many of today's web mapping solutions, with considerable variation in the choice of technology for the mapping service and the subsequent map formats. This choice to a large extent defines the possibilities of the system as a whole to achieve what we call the *direct* and *automatic* production of maps.

By 'direct' we mean that the maps are generated on-the-fly from the data. This is necessary because the map generation should fit in an interoperable SDI, and it guarantees the maps are always up-to-date. To achieve this directness, the visualisation functionality should be loosely coupled to the other parts of the system. The Open Geospatial Consortium's (OGC) Open Web Services (OGC, 2010), a set of specifications that includes among others the well-know Web Map Service standard, are especially useful for this. Such web services are designed to take their input from a variety of distributed sources and generate output meant for Internet dissemination.

The link between data and visualisation is determined by the appropriate service configuration. The actual implementation of this service configuration can vary considerable. In many real-world cases, this configuration is rigid, for example, the well-known Google Maps and Bing Map services consist of pre-rendered map tiles using a fixed styling that cannot be influenced by the user and is independent of the actual objects mapped or their attributes. Other systems, such as implementations of the OGC WMS standard, offer the possibility to switch between a limited number of pre-made styles per data layer. In more sophisticated solutions, the end-user might get direct access to the configuration setting and can thus influence many aspects of the map rendering. Note, however, that in all these set-ups, the cartographic decisions as to what type of map to use for different data types, attributes and instances, have to be made by a human (the cartographer in Figure 1). In that sense, the term 'automatic' we used before only means that the maps will be generated from the data by the system 'working by itself with little or no direct human control' (which is how automatic is defined in Fowler *et al.*, 1976). But this automated instance still has to be set up 'manually' beforehand. Whenever there are changes in the data that require fundamental changes in the map, the service configuration has to be rebuilt.

The challenge to enable *fully-automated* set-up of the service configuration, with cartographic design decisions included, remains an interesting research subject, which we will briefly revisit in the section on 'Conclusion and outlook'.

THE TEST BED: THE DUTCH NATIONAL ATLAS AS INTEGRAL PART OF THE NATIONAL SDI

In an SDI such as the Dutch NGDI, many of web services as described in the previous section come together. As we noticed earlier, this poses challenges if we want to combine them in cartographically sound maps, and especially if these maps are to be part of an atlas. In many existing web mapping set-ups, the maps are delivered to the end-user as raster images from Web Map Services. Although such map layers can technically be combined in a compound map, this is not a desirable solution for an atlas system, as the portrayals of they layers cannot be influenced, and therefore, cannot be matched.

Architecture

The architecture that we developed for our proof-of-concept prototype had to overcome the matching problems mentioned before. To achieve that, the proposed National Atlas prototype consumes *data* services instead of *portrayal* services. As can be seen in the architecture diagram in Figure 2, we consume data from Web Feature Services (WFS), and combine and portray that data using a client-side data integration and mapping component (described in more detail in the section on 'The atlas viewer prototype').

In the first incarnation of our prototype, the result of the first phase of the project ending in 2009 (Kraak *et al.*,

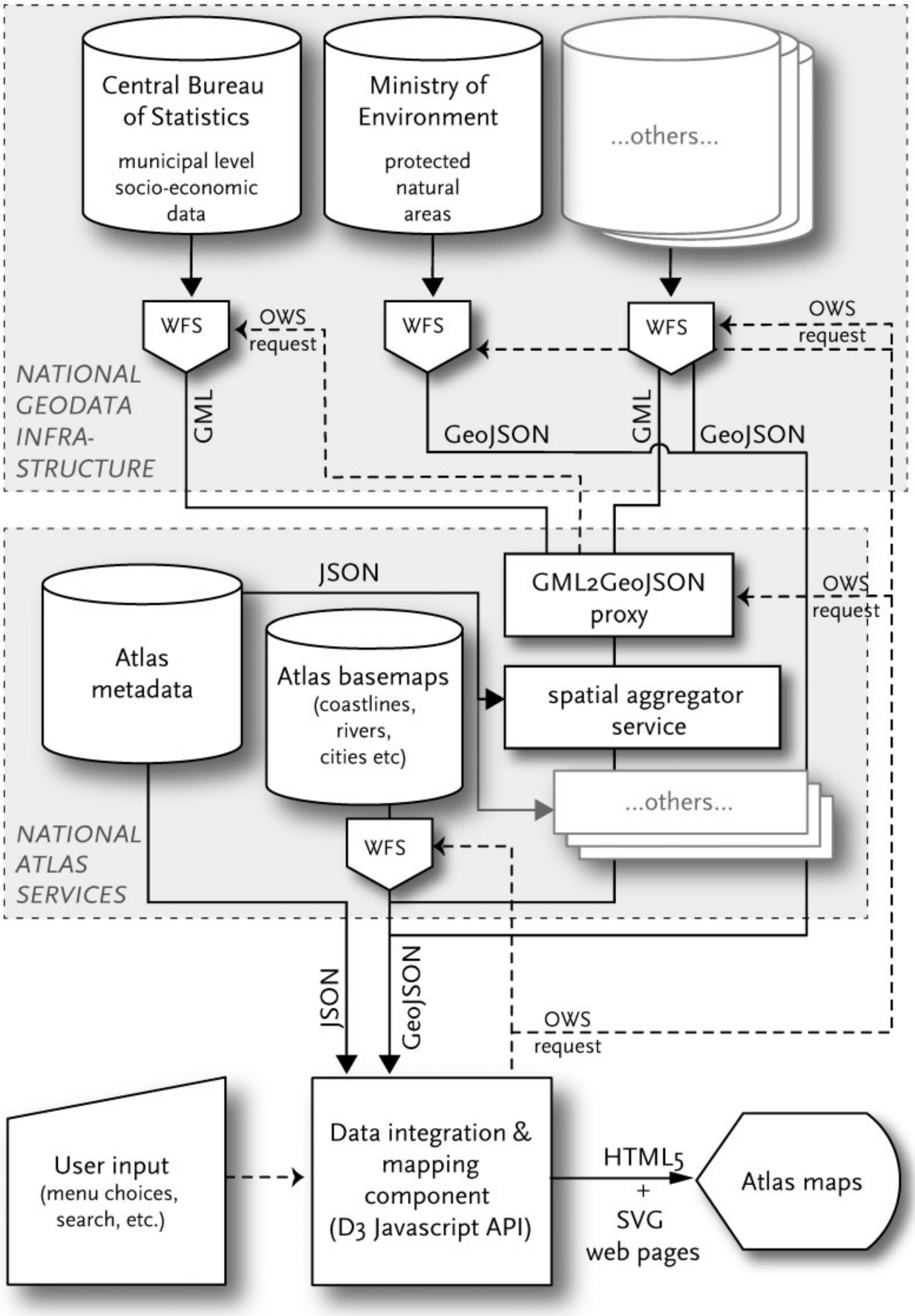

Figure 2. Proposed set-up of combining the SOA environment of the NGDI with the National Atlas services and the National Atlas map viewer on the Open Web Platform

2009), the client-side mapping application directly consumed the WFS output, in most cases, a Geography Markup Language (GML) data stream. This client-side application also included a set of atlas metadata: design templates, classification schemes and the other components needed to set the service configuration mentioned earlier in the section on 'The two worlds united: web mapping in a service-oriented environment'.

This approach had several drawbacks. GML is a versatile and powerful language, but also a complicated one. At that time we used a limited set of services configured by ourselves (for various reasons described in Kraak *et al.*, 2009). Therefore, it was feasible to have the client-side component parsing the GML data. However, in the current implementation, we can and want to use a very wide range of existing data services, and therefore, can expect GML data of different versions and with a large variation in GML application schemata. We decided not to try parsing this client-side, but instead feed the mapping component with GeoJSON data. This geographic extension of the JavaScript Object Notation format (GeoJSON website, 2012) is light-weight and optimized for use in client-side web applications. Although some services in the NGDI do actually supply data in GeoJSON format, most only support GML output. We therefore introduced in our set-up a conversion component in an intermediate National Atlas services layer, depicted as the GML2GeoJSON proxy in Figure 2.

We foresee the implementation of more National Atlas services, such as a spatial aggregator service, which for example would perform the generalization of socio-economic data at the municipal level into higher level provincial data.

Another component in this National Atlas services layer is the Atlas base map service. This serves data for several map layers that are used repeatedly, such as coastlines and major cities. This enables us to provide a common look and feel to the maps. Note that this is implemented as a standard WFS, and as such is a fully independent stand-alone web service node. It could therefore be considered as part of the NGDI layer just as well.

The NGDI layer includes a broad range of possible data services. The two services specifically mentioned in Figure 2 are the ones we use in the prototype at the time of writing. Which services are actually used by the atlas is determined by the settings in the Atlas metadata.

This Atlas metadata is in fact the *service configuration* component as discussed in the previous section. The metadata is now included in the National Atlas services layer, whereas in the previous prototype, it was part of the client layer. This change makes it possible to loosely couple the metadata with the mapping component, as opposed to the tight coupling in the earlier prototype. It also makes the atlas metadata available for a wider audience. For reasons elaborated in the section on ‘The two worlds united: web mapping in a service-oriented environment’, many of the metadata settings have to be edited ‘by hand’. Because of this, the National Atlas cannot function without some editorial staff. They are responsible for the cartographic quality of the atlas, and for example, should also keep track of new geospatial information being made available by national providers, as well as taking account of the changing needs and interests of the general public, schools and professionals (Kraak *et al.*, 2009). Several researchers have been looking into automated components to support these editorial tasks, for example, Zumbulidze (2010) has investigated updating mechanisms, and Chanthong *et al.* (2012) proposed business processes to securely manage the administration.

The atlas viewer prototype

To implement the loosely coupled visualization functionality described in the section on ‘The two worlds united: web mapping in a service-oriented environment’, we looked for a technological solution that would offer flexibility, high-quality graphics as well as standards compliance.

Following the current developments of web technology, a logical step was to look for map viewer components based on the Open Web Platform. The primary goal of the Open Web Platform is to create a comprehensive range of advanced, open Web standards (W3C, 2012), enabling us to create standards compliant web applications without the need for proprietary technology. There are several frameworks that enable the Open Web Platform in modern browsers, mostly implemented as client-side Javascript libraries.

We tested various possible set-ups of the map viewer component, and based on these tests decided to use the D3 library (Bostock *et al.*, 2011; D3 website, 2012). D3.js is a JavaScript library for manipulating web pages programmatically, through their Document Object Model (DOM). It allows you to bind arbitrary data to the DOM, and then apply data-driven transformations to it, using the full capabilities of modern web standards such as CSS3, HTML5 and SVG. We found D3 to be fast and efficient, even when using large datasets. Its code structure, based on the popular Javascript framework jQuery, allows for dynamic behaviours of the objects, thus enabling maps with interaction and animation. The resulting map viewer offers high-quality interactive map views of data from the NGDI. The viewer is still actively being developed. The most recent stable version can be always be tested at the website (Dutch National Atlas website, 2012), and a screen dump is provided in Figure 3.

CONCLUSION AND OUTLOOK

The study we mentioned in the beginning of the section on ‘Two worlds: National Atlases and Spatial Data Infrastructures’ was funded by a research grant that ended in 2009. Since then, we have been continuing the development of the National Atlas prototype as an informal project to be worked on if time permits, and the progress has therefore been slow and limited in scope. We feel however, that the current set-up and proof-of-concept prototype, as described in this paper, demonstrates that high-quality atlas mapping using services from a national SDI is feasible, and provides many advantages in up-to-dateness, flexibility, extensibility as well as interoperability and adherence to standards.

We hope to further enhance the system, and gradually expand the amount of data mapped. Furthermore, we also consider the National Atlas in the NGDI as an excellent testing ground for more fundamental cartographic research questions.

One of those research questions is the further automation of setting service configuration parameters, with cartographic design decision included, as mentioned in the section on ‘The two worlds united: web mapping in a service-oriented environment’. In order to achieve that, the system should independently create the service configuration based on properties of the data, on the intended user and/or usage of the map and of course on knowledge of the cartographic process. Most of these inputs seem to be available. The cartographic grammar provides us with relatively simple rules for the most common map types, and the amount of possible users and their tasks should also be relatively limited. And although meta-data availability is still rather fragmented and limited, the place where typically the collection and dissemination of meta-data is properly

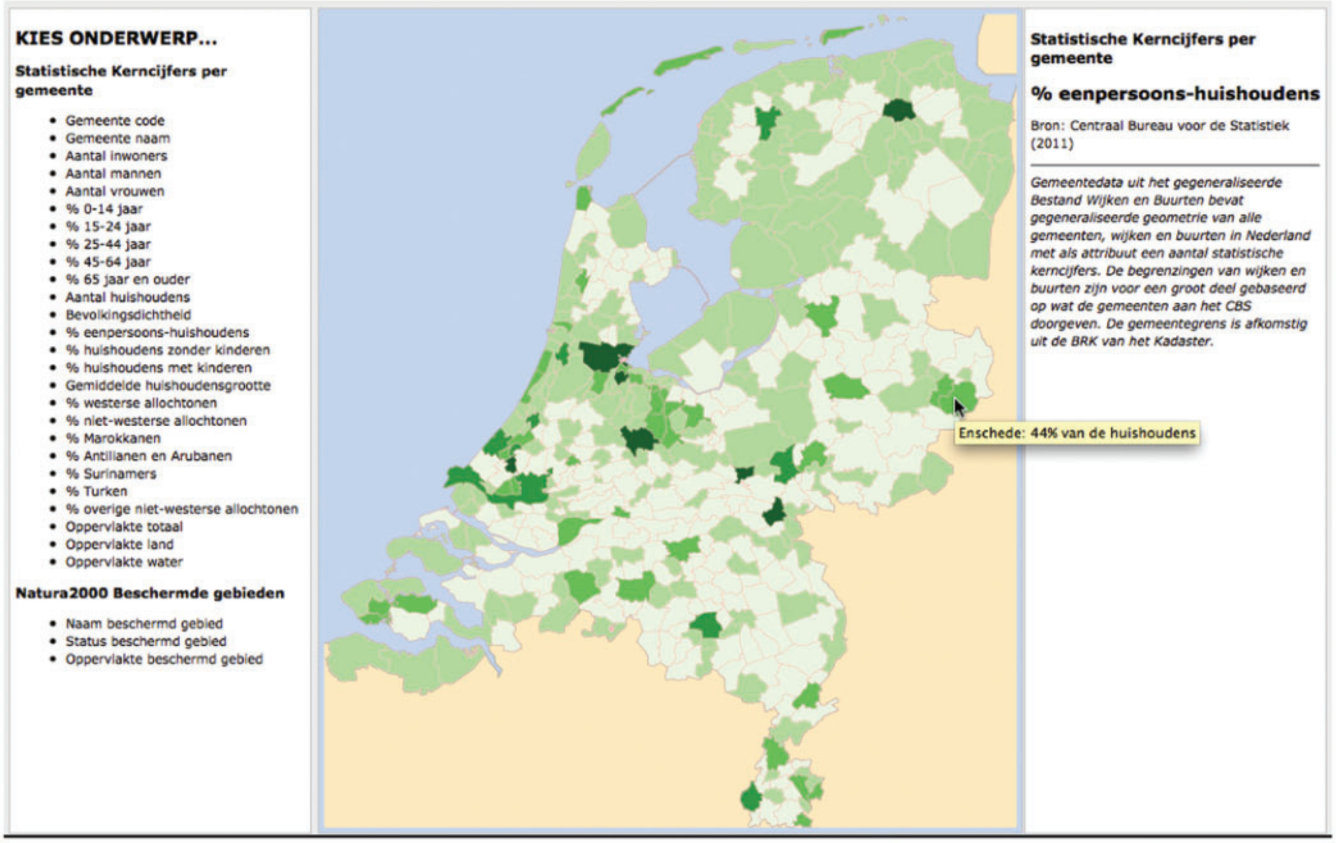

Figure 3. A screen dump of the National Atlas viewer prototype. The D3 library was used to interactively map the percentage of single-person households per municipality (from a Central Bureau of Statistics Web Feature Service) as a choropleth map, using HTML5 and SVG

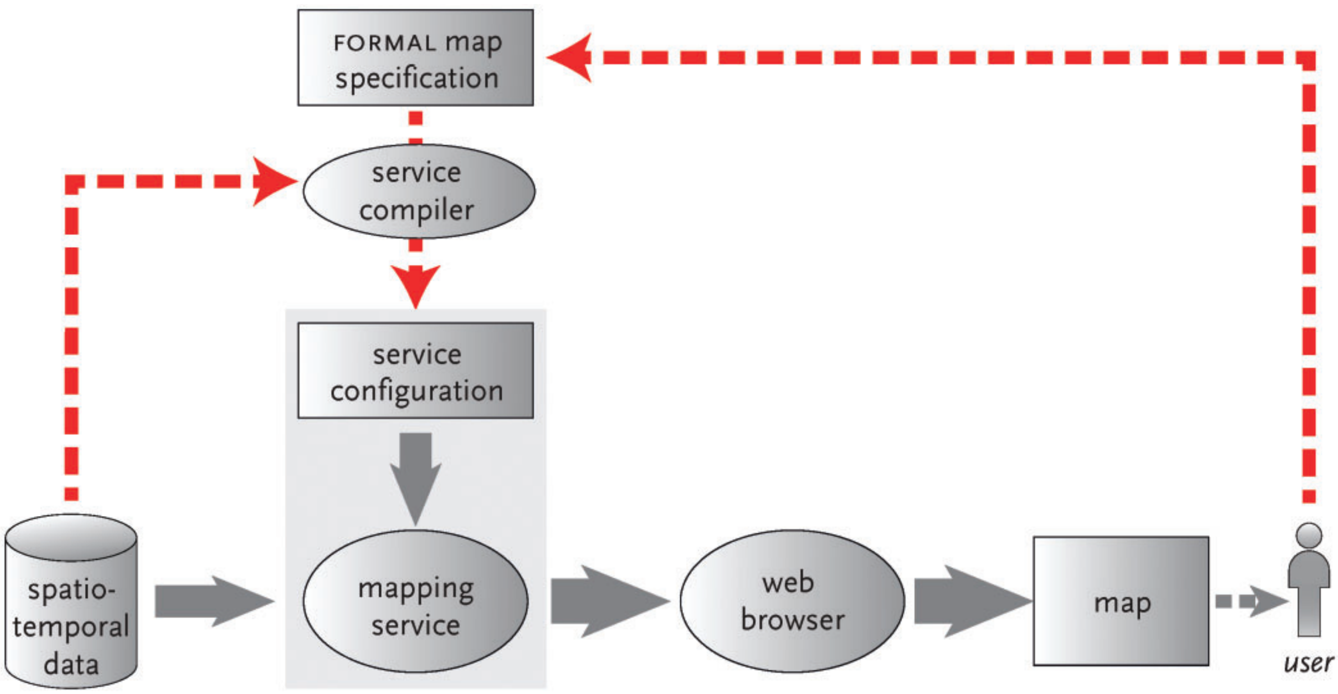

Figure 4. Possible set-up of dissemination of maps in a Service Oriented environment with a fully automated service configuration

taken care of is in institutional SDIs. What is still missing is the link between these inputs: A description of what map type needs to be created if a particular user with particular user requirements wants to map data with particular properties. Furthermore, this description needs to be in a format that can be used by an application to read and reason with the knowledge. There appear to be several approaches for this problem, a promising one being the use of a formal map specification language in a set-up as shown in Figure 4.

The role of the cartographer in Figure 1 would be taken over by a service compiler. This component creates a service configuration on-the-fly, based on the spatio-temporal data and the formal map specification. This would be expressed in a formal language (in the computer science sense, as explained, e.g. in van Lamsweerde, 2000; Nelson *et al.*, 2001) that defines an outcome in a controlled and consistent manner, using a formal, declarative language with degrees of freedom. These degrees of freedom, e.g. ranges of acceptable values, could be influenced by user requirements or preferences, as depicted by the dashed arrow in the upper-right part of Figure 4.

Further exploration of this set-up remains an interesting future research challenge, and we are confident that for this and other such challenges our prototype National Atlas as part of the National Spatial Data Infrastructure will prove a useful test bed.

BIOGRAPHICAL NOTES

Barend Köbben holds an MSc in Geography, specializing in Cartography, from Utrecht University in The Netherlands. He works at the International Institute for Geo-information Sciences and Earth Observation (ITC), an international school providing courses on GIS and Remote Sensing to students from all around the world. Since 1 January 2010, ITC is a Faculty of the University of Twente. Here he is at present Senior Lecturer in GIS and cartographic visualisation in the Department of Geo-Information Processing. His teaching subjects include Cartographic Theory, WebCartography and WebGIS, Geowebservices and web application building. He is involved in teaching short courses and workshops in Open Source GIS & WebMapping, promoting the use of the Open Source geospatial applications and data. His main research interests are automated mapping in a services environment, animated vector map services (using the RIMapper WMS Open Source platform he developed, and the SDIlight concept). He was involved in various consultancy projects in The Netherlands, India, Iran, Italy, Malaysia, South Africa, Thailand and Zambia. Barend Köbben is Map Editor and member of the Editorial Board of Geografie, Charter Member of OSGEO, the Open Source Geospatial Foundation and member of the ICA Commission on Open Source Geospatial Technologies.

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