Using Styled Layer Descriptor (SLD) for the dynamic generation of user- and context-adaptive mobile maps – a technical framework

Alexander Zipf

i3mainz - Institute for Spatial Information and Surveying Technology
Department of Geoinformatics and Surveying
University of Applied Sciences FH Mainz
Holzstrasse 36 - 55116 Mainz, Germany
zipf@geoinform.fh-mainz.de
http://www.geoinform.fh-mainz.de/~zipf/

Abstract. The well known OGC Styled Layer Descriptor (SLD) specification allows to specify the design of a map. On the other hand in LBS and UbiGIS maps need to be generated dynamically taking a lot of factors into account which describe the current user, situation and context. We present how to transform such user and context models with a base map represented as SLD resulting in an "adapted" SLD. Further we discuss how to apply these in order to generate SVG-based mobile maps. In order to generate base maps represented as SLD we developed a ArcMap2SLD-generator. This tool allows designing a map using ESRI ArcMap and automatically converting it into a valid SLD-file. This acts as a base for modifications using the mentioned user and context models. Using this SLD as parameter within WMS-requests results in an "adapted map". We explain this approach and discuss potentials and weaknesses.

1 Introduction

The OGC Styled Layer Descriptor (SLD) specification allows specifying the design of a map – in particular a map served by a SLD-WMS. It is getting more and more popular, but still has some weaknesses – especially for use in LBS (e.g. Brinkhoff 2005). On the other hand in LBS or UbiGIS maps need to be generated dynamically taking a lot of factors into account – in particular also attributes describing the current user, the situation and general context [9, 12, 21, 22, 23]. This is being adopted now more and more. An example application would be user-specific focus maps as introduced by [20]. Such a User and Context model can be represented also using XML, e.g. [18, 19] present XML schema for task-oriented mobile maps within a tour guide scenario. See [18] for adaptive mobile GI services based on Ontologies for pedestrian navigation. Now we have the task to use the information represented within these models to parameterize maps. This is done using the Styled Layer Descriptor (SLD) specification. But as this specification still lacks some expressiveness this still leads to problems. We present these after explaining the general idea of the necessary transformations in order to gain a valid SLD from the mentioned user and context models. Further we show how these then can be used in order to generate also SVG-based mobile maps [10] and what problems we encountered with that approach. A further section will introduce our ArcMap2SLD-Generator. This tool is helpful to generate a base map using ESRI ArcMap and then generate a valid SLD-file from that. The generated SLD in turn acts as a base for further modifications through the earlier mentioned user and context models. Using this SLD as parameter within a WMS request results in an "adapted map". We explain this approach and discuss the potentials and weaknesses.

2 User and Context Modelling for adaptive GI Services

Since a few years it has become more and more accepted, that the design of electronic maps – in particular mobile maps - needs to consider a much broader range of influences than conventional maps in order to present just the right information needed in the current situation by the current user of such a map-based system (21, 22, 23). After focusing on technical limitations of mobile devices (storage, processing, interaction, display size, bandwidth etc.) the focus of research in mobile maps shifted recently to cognitive aspects (9, 21), e.g. navigation and wayfinding support [8, 11, 16]. Further examples for adaptive GI applications include e.g. the computation of routes based on context-related criteria [7] or user-aware spatial push of information [24].

In order to actually apply the ideas presented there to an automated system we need to consider three different main aspects:

? What are the indicators influencing the design of a map (which attributed describing the current task, user, situation etc. – we can refer to this as the *User Model* and *Context Model*. They (are sometimes combined) and deliver the structure and possible value domains describing the situation.

? How do these attributes actually influence the design of the map? For answering this we need to components: a.) knowledge about cognitive aspects how to present which information the best way to the user and b.) a mathematical or computational framework for actually applying this within a computerized system – telling how to calculate the values for the weighting the adaptation etc. See [25] for details.

? A technical framework how to apply this in a standards-based open system.

We will only very shortly introduce the state of art for the first two aspects and then will focus on proposing a generic technical framework that makes use of open GI standards only.
In spite of much research the terms context, situation and user model etc. are still quite vague. A range of definitions and proposals exist – mainly originating from work in Ubiquitous Computing, which also has been tried to adopt within the GI community. We do not consider that it is fruitful to argue about "THE RIGHT" model here (if one exists at all), but argue, that we need some interoperable way to transform between the different flavors of application and domain specific classifications. As one example we present a suggestion by [18] adapting ideas from [5 and 6] that was used for some research prototypes.

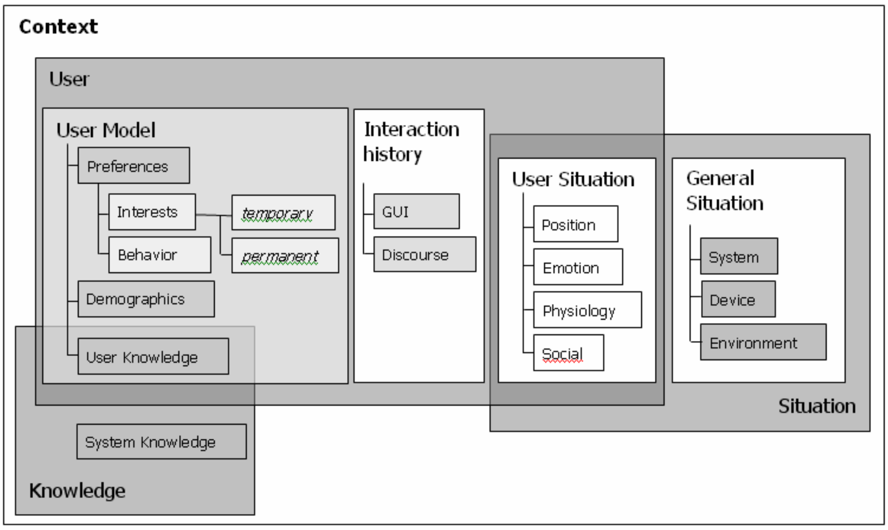

Fig. 1. Integrated User and Context model [18]

For further discussions of these topics see [4, 5, 6]. As such models are nowadays typically expressed using XML we can expect that there will be ways to transform these into the actually needed representation (or even a standard ontology, once a widely accepted one appears) quite easily (e.g. using XSLT). What we have to note here is that we do need not only theoretical construct, but really a formal representation of the relevant concepts, their value domains and relationships, e.g. using the OWL language. OWL allows to define and instantiate *ontologies*, which are explicit formal descriptions of concepts or classes in a domain of discourse, which express a shared specification of a conceptualization. OWL thus provides the possibility of expressing information associated with people, events, devices, places, time, and space etc. Moreover, it provides means for sharing such context knowledge, thereby minimizing the cost of sensing.

3 Applying User Modeling for Adaptive GI Services

As an important example we focus now on how to model the user within such an adaptive map-based system. [18] propose an ontology-based approach for their own realizations of adaptive GI services that employs different machine learning methods based on stereotype reasoning, domain inference etc. [3] in order to calculate dynamic user properties as for example the current interest of the user in specific types of objects. They present a XML schema (see figure 1) for a user model that consists of basic user properties (UserID, name, preferred language etc.).

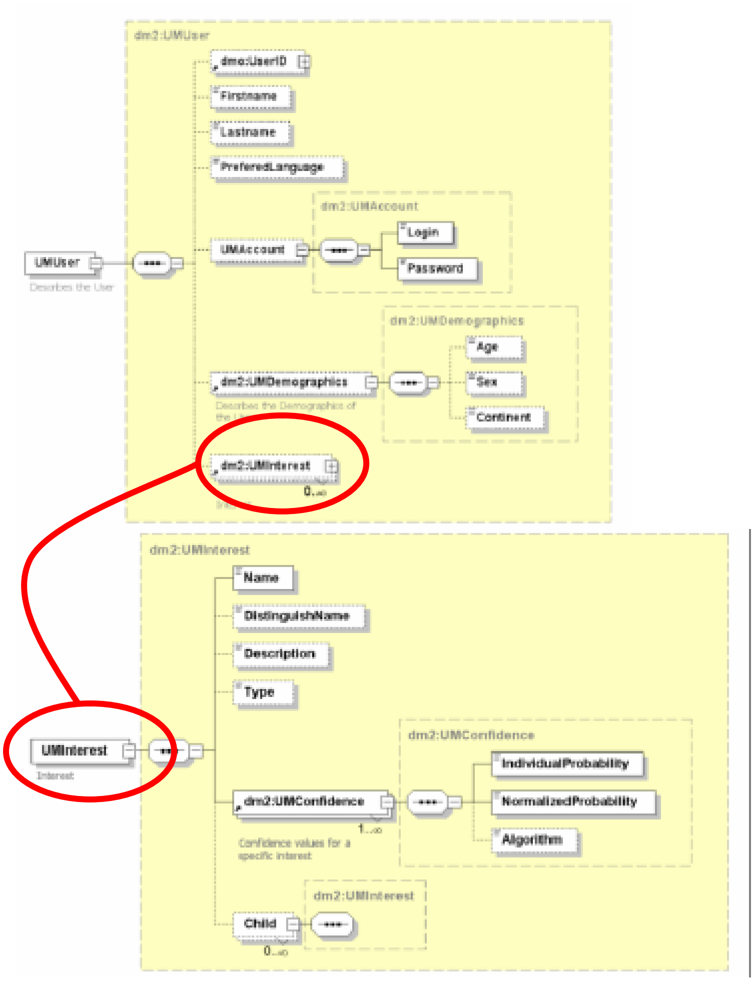

Fig. 2. User Model User XML Schema & UMInterest including confidence elements [18]

It also includes demographic attributes and account data. But the most important property is the different *interests* of the user modelled as "*UMInterest*". This is described by name, description and further type definition. Within the *UMConfidence* property the probabilities (individual and normalized over all users) calculated by a software module, that calculates individual user preferences and their probabilities dynamically from the different data sources are stored as well as the algorithm used for this. This gives a measure for the validity of the calculated interest values. Storing this explicitly allows taking them into account when applying the interest values for adapting a service offered to the user.

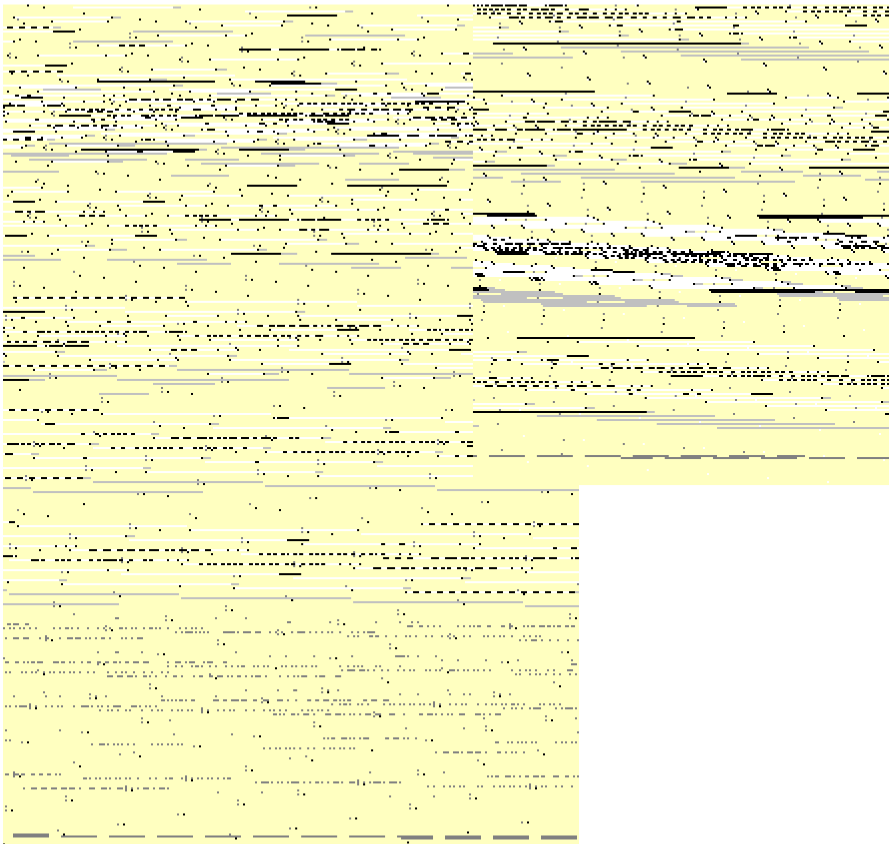

Fig. 3. Extract of XML schema of the "MapTask" model (see [18] extending work by [12]).

One of the dominant factors for adaptation is the task the user wants to perform - what does the user wants to do at all. As all parameters relevant for adaptation the relevant factors need to be represented formally within the system. Therefore we present shortly an example of an ontology for tasks the user wants to perform with a mobile map. The idea is that user activities can be described in an ontology. See figure 3 for a recent example of a task ontology that has been newly developed by [18] based on the ideas of [12].

4 A technical framework to generate user-adapted SLDs

The OGC Styled Layer Descriptor Specification [26] defines an XML Schema to describe the appearance of the layers a map. The general model (simplified version) is depicted as UML class diagram in figure 4. A SLD document is a XML file that can be validated against this model. SLDs are getting more popular in Web Mapping applications with the growing availability for SLD support in WMS. But until recently these SLDs are more or less hand-made or application specific. But as SLDs provide the means to specify the look of map in a domain and vendor-neutral way it is a good choice for a formal representation of maps in general.

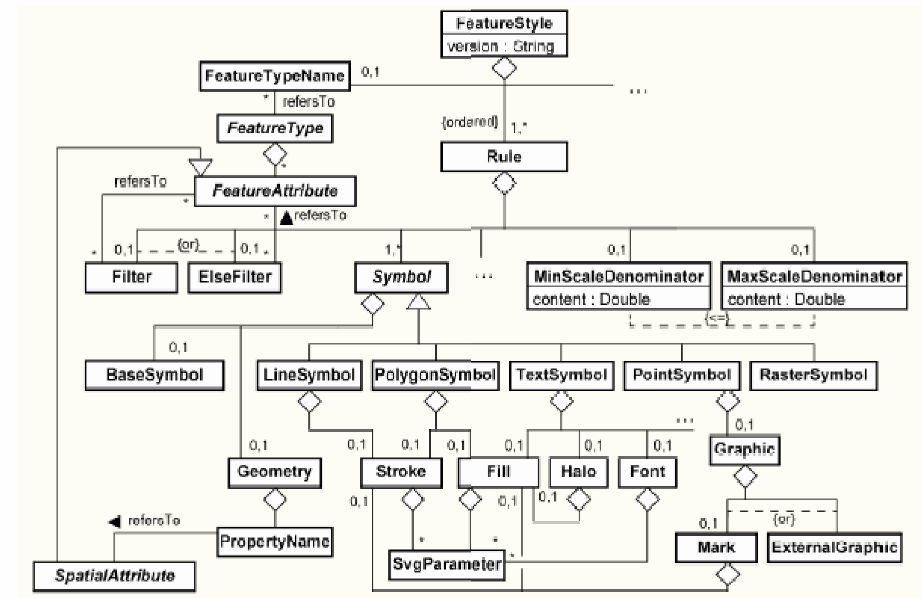

Fig. 4. Simplified Data Model of SLD according to (OGC 2003).

The question is now how to go beyond these hand-made SLDs and generate these in an automated way (using Open Standards predominantly). This is a technical question and can be solved easily. An example is given in section 4 where a SLD generator for ESRI ArcMap maps is presented. A more general way is to use different data sources (e.g. OGC Catalogs or WFS and their metadata – all of which are XML-based) in order to generate the XML-based SLD files from these using XSL Transformations. A similar approach has often been used for converting e.g. GML to SVG (this would be only the right side (Case A) of figure 5 with a static gml2svg transformation script). But in both examples we would have to hard-code the styling information within the XSLT script. This is not desirable, as styling information should be separated from code. Therefore [10] present an innovative approach where also the transformation scripts are being dynamically generated using standards-based data sources like information e.g. from OGC WFS *DescribeFeatures* and *GetCapabilities* requests. But while in this approach even two XSL Transformations are generated dynamically, still the SLD is a static file (figure 5, left oval). Therefore we want to extend this approach by also eliminating the need to build this SLD by hand. Further we want to extend the approach and include user and context specific elements to generate adapted maps. In the following first a short introduction to the original transformation cascade is given and then of the extended approach to include user- and context parameters.

4.1 Generic transformations in order to produce maps

For a generic application the gml2svg transformation script cannot be a static document because both the structure of the GML data as well the styling of the presentation depend on the specific application. Therefore the script must be computed dynamically. As the presentation information is contained in an SLD document it is possible to generate the gml2svg script in another XSL transformation from the SLD document.

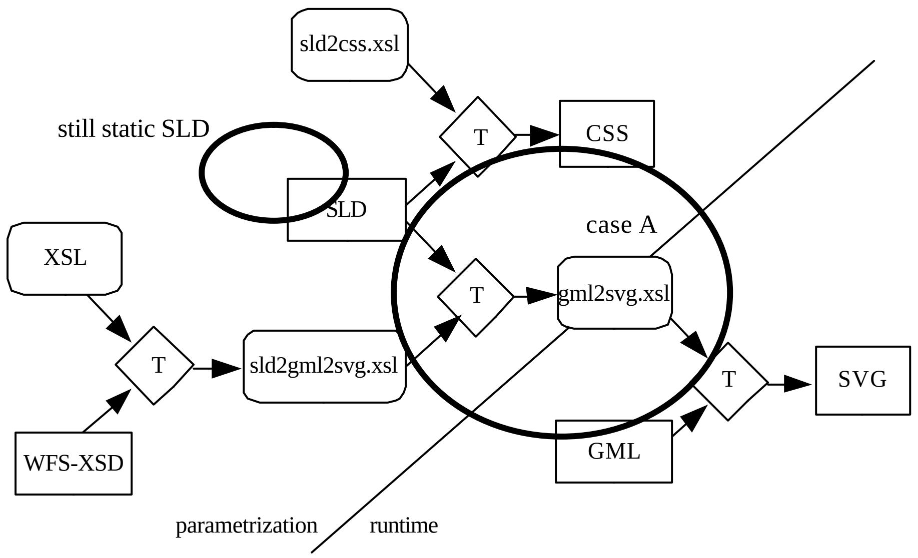

Fig. 5. Complete transformation cascade for a generic application-parameterized generation of SVG from GML data with styling information from an SLD document [10]. T stands for executing a XSL Transformation.

Figure 5 shows the three XSL transformations differentiating between 'runtime transformation' being executed after a specific query and 'parameterization transformation' which can be executed earlier. It shows the complete transformation cascade that needs be executed in order to display geodata from a WFS as an SVG document based on an XML schema from the WFS and an application-specific SLD document in a completely generic way.

4.2 Generating user adaptive SLDs

In the following we want to extend this approach by also generating the still static SLD document also dynamically - taking user and context information into account. Here come the user and context models introduced earlier into play: First we need a base map, or more precisely a base SLD describing the not-adapted map. This can be generated from desktop GIS like ArcMap as explained later or from another SLD generator tool that certainly will appear soon. But certainly somewhere we need basic signature rules in some format for the first step. So let’s take the mentioned base SLD: we then have the task to combine this base SLD with the user and context model. This can be achieved by generating a XSL transformation script from both the user and context model that transforms the base SLD into an adapted SLD. This generation of the transform script includes the knowledge of how to adapt a base SLD according to specific user and context values.

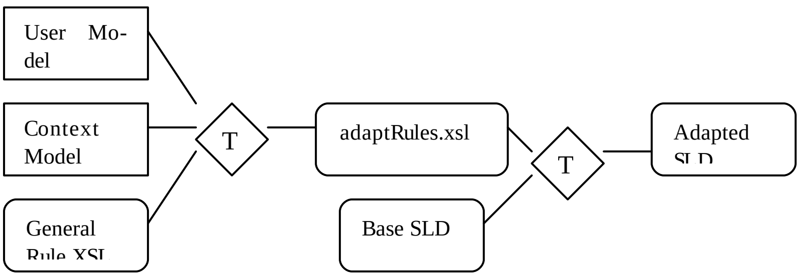

Fig. 6. Extension of the transformation cascade in order to generated an adapted SLD from User and Context Models and general rules how to apply these (specified in XSL).

This approach leads to the incorporation of the adaptation knowledge into “hard coded” rules that generate the XSL. This is a situation that should also be improved. This means instead of writing the rules into the code it would be wishful to have some declarative language or representation that describes the adaptation rules in a language independent way. As such a declarative rule representation is not yet available we propose the future definition of such a rule base. The following figure shows the approach. The resulting “*Adapted SLD*” then can act as input for the transformation cascade introduced by [10].

5 Visual generation of SLD-Files with Desktop GIS

Our application that generates the base SLD from existing maps in commercial Desktop GIS is introduced briefly. On the top left corner of the figure 7 one can see a screenshot of the ArcObjects application that analyses all layers and their according renderer types and symbol definitions within an ESRI ArcMap map and transforms these into an SLD document that can act as input for an SLD WMS (e.g. UMN, degree, ArcIMS). We propose to use this base map SLD as a base for further modifications according to the user and context models introduced. The results of applying the generated SLD file to a WMS can be seen in figure 8, which compares the map to the original ArcMap display. One can recognize from figure 8 that it is still not possible to achieve 100% the same look using the WMS on the one hand and the original ArcMap map on the other, but a very good compromise can be achieved.

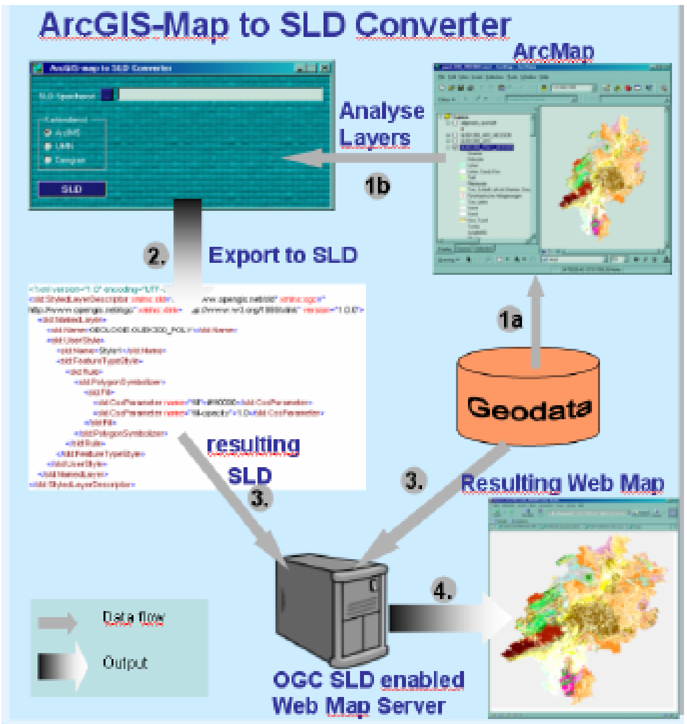

Fig. 7. Process of designing a map in ArcMap and exporting it to a SLD document, that can be used to configure WMS servers or to issue user-specific requests to SLD Web Map Services.

Some map server currently still offer even less support then the ones we used for all the parameters defined in SLD and therefore result in maps looking more differently. It is hopefully only a matter of time until this varying support of the SLD has reached a more stable situation and the different render engines produce very similar maps from the same SLD configuration. In order to achieve this also the SLD specification needs further extensions in order to clarify how to represent a range of symbolization issues.

6 Summary and Outlook

In this paper we have presented several novel ideas for generating adaptive GI services for mobile applications using dynamic personalization as well as context factors. Possibilities for future enhancements include first of all a more specific definition of the rules how to adapt the SLD in what way for specific parameters. It is an innovative approach of applying adaptation techniques like learning of user models in the domain of geographic information services that opens a new area of research within GIScience. A lot of further work is necessary to develop a solid theory for this kind of adaptation to GI services. While we have shown that it is possible to adapt GI services dynamically to context and user properties in general - how to actually do this (what parameters to choose, how to weight them and what types of adaptation to realize) the best way in order to achieve optimal results - is yet open. This requires further empirical tests, evaluations as well as theoretical work.

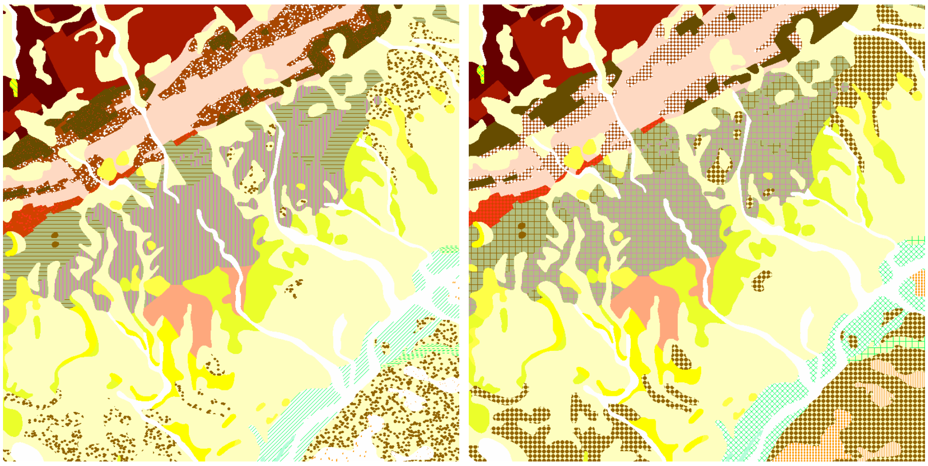

Fig. 8. Comparison of the resulting map from the dynamically generated SLD description renderend by UMN Mapserver by SLD (right side) and the original map in ArcMap (left side).

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