

## USING WEB MAP SERVICE (WMS) WITH STYLED LAYER DESCRIPTOR (SLD) FOR CREATING DYNAMIC AND USER-ORIENTED MAPS

*BURDZIEJ J.*

*Nicolaus Copernicus University, TORUN, POLAND*

### BACKGROUND AND OBJECTIVES

Recent years has shown the increased use of Web Map Services (WMS) for publishing maps in the web environment. The basic idea behind WMS standard is to provide a simple web interface for requesting georeferenced map images (OGC, 2010). Each WMS request defines map layers to be processed and geographic boundaries for which the map will be rendered. Web Map Service, as opposed to the Web Feature Service (WFS), serves raster map images instead of raw vector data in order to enhance web map performance.

Maps exposed as WMS services can be symbolized using the Styled Layer Descriptor (SLD), an XML-based markup language, which enables to create advanced rules for cartographic visualization of geospatial data. SLD schema can be used for symbolizing point, line, polygon as well as raster layers, for labeling features and creating scale dependent styles. It can also be used with filters in order to define custom classes and categories for creating thematic maps.

These two open standards, officially released by the Open Geospatial Consortium (OGC), are nowadays defining the foundations for modern web mapping. Many different kinds of Internet maps act as WMS clients, displaying thematic WMS layers. Also a growing number of desktop applications, both open source and proprietary, can now connect to WMS servers and display WMS layers along with other geospatial data, such as vector objects or raster images stored locally on desktop computers. Additionally, there are more and more applications that can publish maps as WMS services. This increasing availability of tools results in a growing number of WMS services being published by different government institutions, offices and private companies.

The SLD schema gives cartographers a wide range of tools for controlling visual representation of WMS maps. These style definitions are usually stored on the server along with raw data being exposed as Web Map Service. However, the style definition can also be sent by the client (e.g. map user) with each WMS request, resulting in a customized map representation. These possibilities open a great potential for designing interactive Internet maps using widely adopted open standards.

The main aim of this paper is to inspect how a combination of Web Map Service (WMS) and Styled Layer Descriptor (SLD) standards with PHP script can be used for creating dynamic and user-oriented web maps. Such interactive approach can be used in many different web scenarios, e.g. for creating thematic maps based on user-specified class ranges. In this project, WMS and SLD standards are applied to a web environment using well known open source mapping libraries, i.e. OpenLayers and GeoExt. This solution gives a great flexibility in terms of cartographic representations for interactive web maps and ensures high level of interoperability. It combines advantages of open standards with dynamic and interactive functionality provided by JavaScript and PHP technologies. Finally, a sample web map application, where users can define custom parameters and create custom thematic maps using dynamically generated SLD definitions, is described.

### APPROACH AND METHODS

#### *Styled Layer Descriptor*

Styled Layer Descriptor (SLD) is an OGC standard, released as version 1.0 in 2002. It is an XML-based schema that allows advanced symbolization of map layers and is typically applied to WMS layers (OGC, 2002; OGC, 2007; Zipf, 2005). Map symbology is defined in <Rule> elements, which describe how a certain set of objects will be depicted on the map. Rules can have a name and a title, optional filter element (OGC, 2005), scale denominators and different types of symbolizers for points, lines, polygons, labels and raster images. The following example of an SLD style would apply a red circle symbol to a layer named "Cities".

```
<?xml version="1.0" encoding="ISO-8859-1"?>
```

```
<StyledLayerDescriptor version="1.0.0">
```

```
...
```

```
<NamedLayer>
```

```

<Name>Cities</Name>
<UserStyle>
<Title>Simple point style</Title>
<FeatureTypeStyle>
<Rule>
<Name>Small Town</Name>
<Title>1 to 50000</Title>
<ogc:Filter>
<ogc:PropertyIsLessThan>
<ogc:PropertyName>POPULATION</ogc:PropertyName>
<ogc:Literal>50000</ogc:Literal>
</ogc:PropertyIsLessThan>
</ogc:Filter>
<MinScaleDenominator>10000000</MinScaleDenominator>
<MaxScaleDenominator>100000000</MaxScaleDenominator>
<PointSymbolizer>
<Graphic>
<Mark>
<WellKnownName>circle</WellKnownName>
<Fill>
<CssParameter name="fill">#FF0000</CssParameter>
</Fill>
</Mark>
<Size>8</Size>
</Graphic>
</PointSymbolizer>
</Rule>
</FeatureTypeStyle>
</UserStyle>
</NamedLayer>
</StyledLayerDescriptor>

```

Assuming “*Cities*” layer has an attribute called POPULATION, the above SLD style would select only those cities that have a population less than 50000. Additionally, *MinScaleDenominator* and *MaxScaleDenominator* elements would define that this rule should be applied for map scales between 1:10M and 1:100M. Other rules may be designed for other scale ranges, and different rules may be applied to cities with population higher than 50000.

### WEB MAP SERVICE

The Web Map Service (WMS) 1.0 standard was released by the Open Geospatial Consortium (OGC) in April 2000 and it soon became one of the most common ways for serving map images over the Internet. It uses HTTP interface for requesting map images (OGC, 2002a). A simple WMS request, which has a form of an URL address (decoded), is shown below:

```

http://server.com/WMS?
VERSION=1.1.0&
REQUEST=GetMap&
SRS=EPSG:4326&
BBOX=0.0,0.0,1.0,1.0&
LAYERS=Cities&
STYLES=PointStyle&
WIDTH=500&
HEIGHT=500&
FORMAT=image/png

```

The *GetMap* request is a specific type of request used for fetching map images. It consists of several parameters: URL of the WMS server, request type, spatial reference system, the bounding box, i.e. the area for which the map image is requested, a list of requested layers (*Cities*) with relevant styles (*PointStyle*), a width and height of the map image and output image format.

*STYLES* parameter indicates which predefined styles will be applied to each of the WMS layers. Sending WMS requests with different styles will result in different maps being rendered (OGC, 2007). However, this solution is limited to the list of predefined named styles stored on the server, thus its usefulness for creating dynamically styled user maps is rather limited. Alternatively, *GetMap* request may be used with *SLD* parameter, which points to the external SLD file.

```
http://server.com/WMS?  
VERSION=1.1.0&  
REQUEST=GetMap&  
SRS=EPSG:4326&  
BBOX=0.0,0.0,1.0,1.0&  
LAYERS=Cities&  
SLD=http://otherserver.com/customSLD.xml&  
WIDTH=500&  
HEIGHT=500&  
FORMAT=PNG
```

The advantage is that custom styles can be published on some external servers and may be used for rendering WMS layers. Different sets of SLD styles may be created and map users may be allowed to choose from this set of styles. This approach adds some dynamic interaction for map users, although it is still limited to the predefined styles, represented by individual SLD files. As every user may have different needs, this would result in the infinite number of style definitions that would need to be predefined, which obviously is impossible.

The third option for styling WMS layers is to use *SLD\_BODY* parameter. With this parameter the literal SLD definition, created dynamically on the client-side, may be sent directly to the WMS server.

```
http://server.com/WMS?  
VERSION=1.1.0&  
REQUEST=GetMap&  
SRS=EPSG:4326&  
BBOX=0.0,0.0,1.0,1.0&  
LAYERS=Cities&  
SLD_BODY=&<?xml          version="1.0"          encoding="UTF-?"><StyledLayerDescriptor  
version="1.0.0"><NamedLayer><Name>Cities</Name><UserStyle><Title>Simple          point  
style</Title><FeatureTypeStyle><Rule><Name>Cities</Name><PointSymbolizer><Graphic><Mark  
><WellKnownName>circle</WellKnownName><Fill><CssParameter  
name="fill">#FF0000</CssParameter></Fill></Mark><Size>8</Size></Graphic></PointSymbolizer  
></Rule></FeatureTypeStyle></UserStyle></NamedLayer></StyledLayerDescriptor>  
WIDTH=500&  
HEIGHT=500&  
FORMAT=PNG
```

The *SLD\_BODY* parameter in WMS *GetMap* request offers the most convenient way for creating dynamic maps with user-defined styles. However, its usefulness is significantly limited by the problems caused by the excessively long URL requests, resulting from complex SLD definitions. As some web browsers may have problems with these long URLs (Microsoft, 2010; W3C, 1999), it is recommended to use *GetMap* request with HTTP POST method encoded in XML. However, there is still a lack of vendor support for this method (OGC, 2002).

In this paper an alternative method is proposed, which allows flexibility of the *SLD\_BODY* method and, in the same time, eliminates the limitation for long URLs. The proposed method is based on the simple WMS request with *SLD* parameter, which points to the external SLD definition. However, instead of a static SLD file, a PHP script is used. It can fetch some additional attributes from the URL (e.g. user-defined class ranges), and use them for building custom and unique SLD definition.

```
http://server.com/WMS?
```

*VERSION=1.1.0&*  
*REQUEST=GetMap&*  
*SRS=EPSG:4326&*  
*BBOX=0.0,0.0,1.0,1.0&*  
*LAYERS=Cities&*  
*SLD=http://server.com/sld.php?pop="10000"&*  
*WIDTH=500&*  
*HEIGHT=500&*  
*FORMAT=PNG*

The above SLD link redirects the request to the PHP script and sends an additional parameter, in this case *pop="10000"*. The PHP script can fetch the population value from the URL with *\$\_GET["pop"]* function and place it in a proper filter element of the SLD definition.

The PHP script would then return a valid SLD schema, customized by the population value sent by the client, which can be used for styling WMS layer. The advantage is that an URL provided in *SLD* parameter does not include a full SLD body. Instead, it only contains a link to the PHP script with some additional parameters for building SLD definition. Thus, it would not exceed the URL length limit, even with highly complex styles, while maintaining a high level of flexibility for user control over the map style.

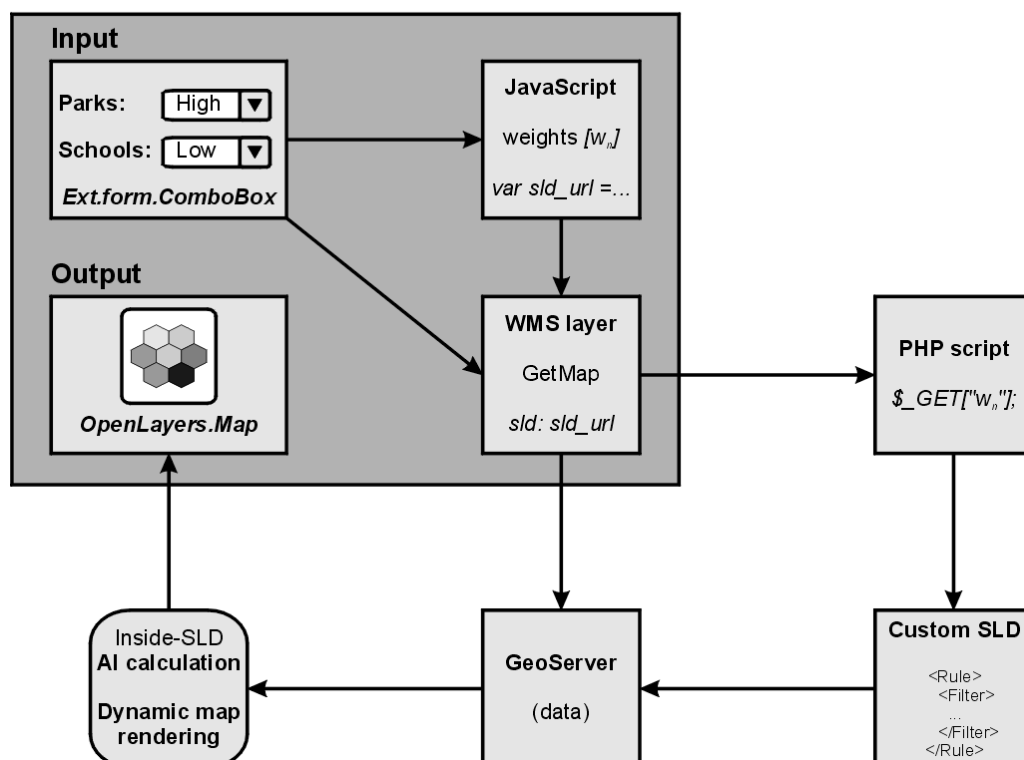
### **EXAMPLE APPLICATION**

The proposed method for creating dynamic and interactive maps has been adopted in the concept of a web-based Spatial Decision Support System (SDSS) for accessibility analysis. This systems is aimed at providing support for analysis of spatial accessibility within the city of Torun, Poland. It is designed to help citizens answer such questions as "Which part of the city has good access to primary schools and parks?" It is argued that good and equal access to services, e.g. health care (Felder & Brinkmann, 2002; Rosero-Bixby, 2004), parks and recreational areas (Erkip, 1997; Perkins et al., 2004; Oh & Jeong, 2007; Comber et al., 2008) and other facilities (Olvera et al. 2003; Burns & Inglis, 2007) is essential in providing certain quality of life. The equity of spatial accessibility is also required for a sustainable development of a city.

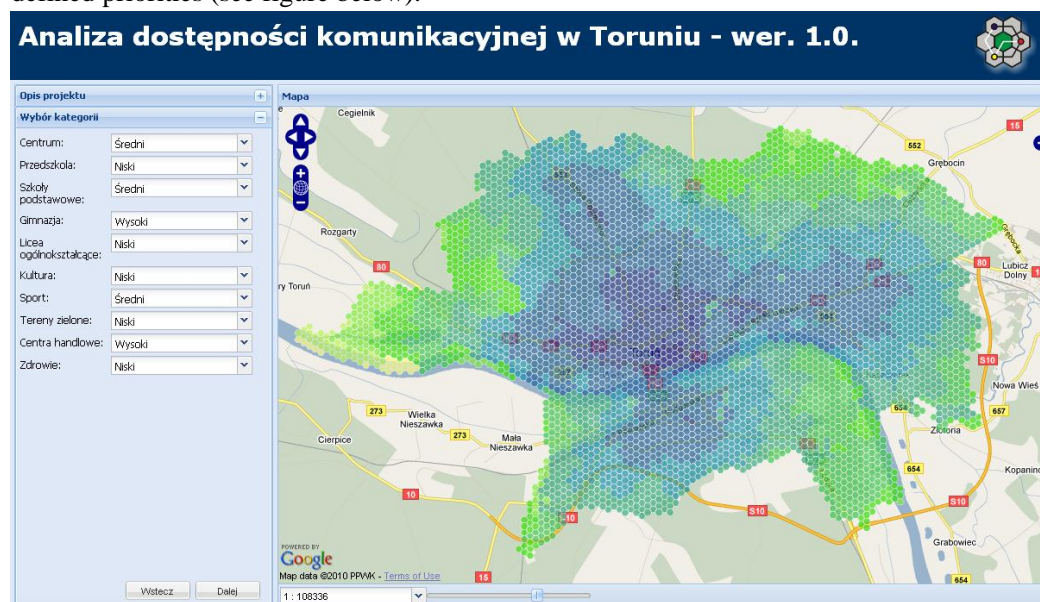
The city area is covered with a regular sampling grid of hexagons, as it provides more equally distributed polygon centroids, higher spatial resolution with the same number of sampling polygons (de Sousa et al., 2006), simpler and less ambiguous nearest neighbor analysis and greater clarity in visualization (Birch et al., 2007) than rectangular grids. For each sampling point (centroid of a hexagon) a network analysis is performed in order to find the shortest routes to different points of interest, such as hospitals and schools. On the basis of this analysis the average Accessibility Index (AI), i.e. a weighted average of accessibility to different types of facilities can be calculated. A default AI can be calculated for each hexagon assuming certain default weights. This could result in a thematic map representing spatial variations of „default“ Accessibility Index in the city area.

However, an assumption is made that every citizen has its own priorities and needs, therefore different weights should be used in AI calculations for each citizen. Parents with little children may look for a good access to kindergartens or schools, while older people may search for areas with good access to parks and health-care services. Thus a need for an interactive calculation of Accessibility Index and dynamic map rendering based on user's input. The simplified schema of the proposed SDSS is shown below.

## Web-based SDSS



The proposed system enables users to interactively set descriptive priority for each category (e.g. high priority for schools and low priority for hospitals), which are translated into weights and used in AI calculations. Based on these values dynamic SLD definition is generated by the PHP script and customized thematic map, showing the AI values with a gradient color ramp, is displayed on the screen. This map directly indicates areas with the highest, average or the lowest accessibility values, calculated with user-defined priorities (see figure below).



The proposed system is based on GeoServer, which is used as a main WMS provider. The web map interface is built using ExtJS and GeoExt frameworks. ExtJS components, such as combo boxes and panels are used to provide a user interface, which enables choosing custom map parameters. OpenLayers, the well known open source mapping library is employed to provide mapping capabilities, such as displaying WMS layer. All these components are implemented using JavaScript environment.

## CONCLUSIONS

This paper has presented how open standards, such as Web Map Service (WMS) and Styled Layer Descriptor (SLD) can be used for creating dynamic and user-oriented maps in the web environment. There is a wide range of possible applications, where this solution could be applied, e.g.:

- creating custom thematic maps based on user-defined parameters (such as class ranges, number of classes etc.),
- simulating and modeling different processes in the form of web maps (by using advanced filtering and functions within the SLD body),
- rendering maps based on virtual, on-the-fly calculated attributes.

The advantage of this methodology is that it is entirely based on open standards, which are implemented using free and open source technology. It provides fast and reliable access to map images through WMS services and easily customizable styling with a combination of Styled Layer Descriptor and PHP scripting. Further research will focus on the development and implementation of the proposed concept of the SDSS system for accessibility analysis.

## REFERENCES

- Birch, CPD, Oom, SP & Beecham, JA 2007, 'Rectangular and hexagonal grids used for observation, experiment and simulation in ecology', *Ecological Modelling*, vol. 206, no. 3, pp. 347–359.
- Burns, CM & Inglis, AD 2007, 'Measuring food access in Melbourne: access to healthy and fast foods by car, bus and foot in an urban municipality in Melbourne', *Health & place*, vol. 13, no. 4, pp. 877–885.
- Comber, A, Brunsdon, C & Green 2008, 'Using a GIS-based network analysis to determine urban greenspace accessibility for different ethnic and religious groups', *Landscape and Urban Planning*, vol. 86, no. 1, pp. 103–114.
- de Sousa, L, Nery, F, Sousa, R & Matos, J 2006, 'Assessing the accuracy of hexagonal versus square tilled grids in preserving DEM surface flow directions', *proceedings of the 7th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences*, edited by Caetano, M & Painho, M.
- Erkip, (Beler) F 1997, 'The distribution of urban public services: the case of parks and recreational services in Ankara', *Cities*, vol. 14, issue 6, pp. 353–361.
- Felder, S & Brinkmann, H 2002, 'Spatial allocation of emergency medical services: minimising the death rate or providing equal access', *Regional Science and Urban Economics*, vol. 32, no. 1 (2002), pp. 27–45.
- Microsoft 2010, Maximum URL length is 2,083 characters in Internet Explorer, viewed 11 October 2010, <<http://support.microsoft.com/kb/208427>>.
- OGC 2002, *Styled Layer Descriptor Implementation Specification*, Open Geospatial Consortium.
- OGC 2002a, *Web Map Service Implementation Specification*, Open Geospatial Consortium.
- OGC 2005, *OpenGIS® Filter Encoding Implementation Specification*, Open Geospatial Consortium.
- OGC 2007, *Styled Layer Descriptor profile of the Web Map Service Implementation Specification*, Open Geospatial Consortium.
- OGC 2010, *Web Map Service | OGC®*, viewed 11 October 2010, <<http://www.opengeospatial.org/standards/wms>>.
- Oh, K & Jeong, S 2007, 'Assessing the spatial distribution of urban parks using GIS', *Landscape and urban planning*, vol. 82, pp. 25–32.
- Olvera, LD, Plat, D & Pochet, P 2003, 'Transportation conditions and access to services in a context of urban sprawl and deregulation. The case of Dar es Salaam', *Transport policy*, vol. 10, no. 4, pp. 287–298.
- Perkins, HA, Heynen, N & Wilson, J 2004, 'Inequitable access to urban reforestation: the impact of urban political economy on housing tenure and urban forests'. *Cities*, vol. 21, no. 4, pp. 291–299.
- Rosero-Bixby, L 2004, 'Spatial access to health care in Costa Rica and its equity: a GIS-based study', *Social Science & Medicine*, vol. 58, no. 7, pp. 1271–1284.
- W3C 1999, *World Wide Web Consortium, HTTP/1.1:Protocol Parameters*, The Internet Society, Internet RFC 2616, Fielding et al., viewed 11 October 2010, <<http://www.w3.org/Protocols/rfc2616/rfc2616-sec3.html#sec3.2.1>>.
- Zipf, A 2005, 'Using Styled Layer Descriptor (SLD) for the dynamic generation of user-and context-adaptive mobile maps—a technical framework', *Web and Wireless Geographical Information Systems*, pp. 183–193.