Interoperable Web GIS Solutions with Open Source Software

Introduction for intermediate and advanced GIS users

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</table>
1 FOSS Overview

1.1 What is Open Source (GIS)?

Open source\(^1\) means that the source code is available to the general public for use, distribution, and modification from its original design free of charge (among a long list of other requirements). Other acronyms frequently used in the OS GIS world are FOSS\(^2\) and FOSS4G \(^3\). Free in this context is meant to express that the software is free (like in freedom or liberty) and free of charge\(^4\). While most open source geospatial software is built on the standards of the Open Geospatial Consortium (OGC) the term "Open Source" is not synonymous with Open Standards because both proprietary and open source software can be compliant with the OGC Open Standards. 

http://www.opengeospatial.org

The OGC is a consortium of proprietary companies, scientific organizations, government agencies and representatives of the open source software movement that develops and publishes software interface specifications (OGC standards).

OSGeo is the organization that supports the development of the highest quality open source geospatial software http://www.osgeo.org.

Proprietary and open source software can be compliant with OGC standards. However, adoption of OGC standards is usually higher among OS software packages. One characteristic of OS software is that it extensively uses synergies in software development. Libraries are shared to a big extent and the high adoption level of OS software makes them highly suitable for interoperable software solutions. However, Ramsey (2007)\(^5\) listed the following tribes (referring to their communal use of software programming languages or the medium, like the web

---

\(^1\)In the following referred to simply as OS
\(^2\)Free and Open Source software
\(^3\)Free and Open Source software for Geospatial (Applications)
\(^4\)Due to a short coming of the English language which has no word for it, it is also sometimes referred to as free as in beer (gratis)
\(^5\)The State of Open Source GIS, Version September 2007
Chapter 1. FOSS Overview

for which the packages are primarily designed.

Table 1: The tribes of FOSS4G

<table>
<thead>
<tr>
<th>Tribe</th>
<th>FOSS4G Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>C/C++</td>
<td>MapServer, GRASS, MapGuide, QGIS, PostGIS, OGR/GDAL, PROJ4, GEOS, FDO</td>
</tr>
<tr>
<td>Java</td>
<td>GeoTools, GeoServer, uDig, DeeGree, JUMP, gvSIG</td>
</tr>
<tr>
<td>Web</td>
<td>MapBender, OpenLayers</td>
</tr>
<tr>
<td>.Net</td>
<td>SharpMap, WorldWind, MapWindow</td>
</tr>
</tbody>
</table>

Reasons to use Open Source software

**user control** User is in control

- Pick your favorite operating system: Windows-Linux-Solaris-Mac
- No licensing issues (did we install one to many PCs with software XY?)
- Vendor independency
- Access to source code: don’t like something, need changes to the core system, need extensions - hire somebody to change it right now

**performance quality interoperability** High performance, high quality, high interoperability

- distributed programming effort, highly modular
- System heterogeneity - less prone to hacker attacks and viruses. Highly interoperable, very advanced support of OGC open standards

**support** Support - Commercial and non commercial

- Mailing lists, user groups, Conferences, IRC channels
- Fast response times for bug fixes
- typically tracked on the web, accessible and open to everybody to report or fix a bug

**free** Last but not least - It is free

1.2 The FOSS Culture

Often the FOSS movement is referred to as not only a model on how to create, distribute and license software but rather a culture. A lot of times business people don’t understand
why one would create something useful and just give it away instead of selling it. Thus, many times they infer that there must be a catch, something must be wrong with the product, since it is free it must have no value and other misconceptions.

There is much more to it than producing free and open source software. It is a way of doing things, of working together, of collaborating, a movement of people around the globe, in short a culture. It is appreciated when people using the software are giving something back to the community. That might be helping others in the user list and online forums, writing documentation about something you learned about using the software in the online wiki pages\textsuperscript{6} of the project, writing new source code or customizations and sharing it with the community. The community is working like an organism and the organism does better if all parts are working together.

1.3 History

Before the 1960’s it is safe to say that most software was free (\textit{libre}). Only in the late sixties and seventies proprietary software was born and quickly dominated the software landscape. In 1983 Richard Stallman, a former programmer at the MIT laboratories founded the Free software Foundation and the GNU Project. One of the major goals of GNU was to create a free operating system and to establish licensing terms for FOSS.

A few of the milestones for general OS software development where the first release of the Linux operating system in 1991, the release of the Apache HTTP server in 1995, and the increasing involvement of software heavy weights such as IBM (Eclipse programming platform) and SUN Microsystems (Java programming language and tools) since the late 1990’s. In 1998 the Open Source Initiative a, non-profit corporation, was created with the goal to educate about and advocate for the benefits of open source software. On their website \url{http://www.opensource.org} they state:

"Open source is a development method for software that harnesses the power of distributed peer review and transparency of process. The promise of open source is better quality, higher reliability, more flexibility, lower cost, and an end to predatory vendor lock-in. The Open Source Initiative

\textsuperscript{6}a web page/collection of pages that enable anyone to contribute, modify and share content
Chapter 1. FOSS Overview

(OSI) is a non-profit corporation formed to educate about and advocate for the benefits of open source and to build bridges among different constituencies in the open-source community. One of our most important activities is as a standards body, maintaining the Open Source Definition for the good of the community. The Open Source Initiative Approved License trademark and program creates a nexus of trust around which developers, users, corporations and governments can organize open-source cooperation.

1.4 licenses

A variety of licensing types exists for Free and Open Source FOSS4G licensing general terms. Some of them are more restrictive than others. According to the current OSGeo president Arnulf Christl’s talk at FOSS4G 2008, most of the licenses specify the user’s rights to

- run any number of copies of the software
- pass on copies of the software including the license and copyright notice
- look into the code, understand it and modify it to suit one’s needs
- pass on modified versions of the code

What is copyleft?

From a word play with the term copyright resulted the newly coined term copyleft which similarly quotes the following freedoms for users to use and study the work, copy and share the work with others, modify the work, and to distribute modified and therefore derivative works. The idea of copyleft is that work derived from the original OS software will have to be distributed under the same liberal or equivalent license terms.

Common FOSS software Licenses

The most popular OS software licenses for geospatial applications are listed below. Brief descriptions for each of these licenses (quoted from Wikipedia) are included in the resource section of this booklet.
### Table 2: List of common FOSS software licenses

<table>
<thead>
<tr>
<th>Name</th>
<th>Style</th>
<th>software</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNU-GPL</td>
<td>strong copyleft license, derived works have to be available under the same copyleft</td>
<td>GRASS, QGIS, gvSIG, Mapbender, PostGIS, GeoServer, AveiN!</td>
</tr>
<tr>
<td>LPGL</td>
<td>compromise between copyleft and more permissive licenses, has copyleft restrictions on the program itself, but not on other software linking with the program.</td>
<td>Mapnik, MapGuide</td>
</tr>
<tr>
<td>MIT</td>
<td>permissive license, permits reuse within proprietary software (license has to be distributed with that software)</td>
<td>MapServer, GDAL/OGR, Proj4</td>
</tr>
<tr>
<td>BSD</td>
<td>permissive license, little restriction, close to the public domain</td>
<td>FeatureServer, TileCache, OpenLayers</td>
</tr>
<tr>
<td>Mozilla (MPL)</td>
<td>hybrid of modified BSD and GPL.</td>
<td>MapWindow, Mozilla Firefox</td>
</tr>
</tbody>
</table>
Web GIS frameworks can either be client side based only or include a server and a client side. One pretty common client program is a modern web browser that has scripting enabled (JavaScript) and thus can run some part / or most of the application on the client computer. If an application does most of the processing on the client side it is called a thick client. Examples for thick clients are Google Earth, ArcGIS, or uDig.

If most of the processing takes place on the server and only the images are sent over to the client or are requested by the client this is called a thin client e.g. OpenLayers or Google Maps. In a simple case where all the application components are hosted on one server machine this includes at least the Spatial data such as vector and raster files and/or a spatial database. These data can then be rendered as images by
Chapter 2. FOSS Web GIS Components

a Mapping engine (e.g. MapServer, GeoServer, Mapnik or ArcIMS) and served via the HTTP web server (e.g. Apache or MS IIS) to the web. Mapping engines can be used to publish as web mapping services (WMS) or web features services to the web (WFS). The server side can also be complemented by a framework or content management system that provides for functionalities such as user authentication, user access rights management, user interface customization, tools and functionality management and more. Such an interoperable web GIS system can be extended by additional server side components that provide functionality such as caching and tiling, GIS analysis functionality (e.g. via PostGIS intersections and reprojection) or web processing services (WPS).

2.1 Web GIS Engines

2.1.1 MapServer

MapServer is a map rendering engine that was developed at the University of Minnesota (UMN), short MapServer. It is one of the most mature and most successful open source GIS projects and is implemented in C. The main focus is on rendering spatial data and in providing a development environment for spatially-enabled Internet applications. Some of the highlights about MapServer are that it supports more input data sources than most of the proprietary products, has higher performance, and the pre-compiled versions are simpler to install and set up.

There are two main ways that one can interact with MapServer using it as a CGI\(^1\) application or using one of several MapScript APIs to write your custom application. The MapScript API\(^2\) is available for PHP, Python, Perl, Ruby, Java, and C#. MapServer uses a configuration text file that commonly has the .map extension. This file tells MapServer all the information the programs needs to know to render a map. The configuration includes general information about the maps like projection, size of the map in pixels, output format etc. Individual layer tags are used to determine the classification of a layer. Examples for input formats are MapInfo files, shapefiles, PostGIS, Oracle Spatial, ArcSDE, WMS, and all GDAL and OGR formats. Output formats include GIF, JPG, PNG, all GDAL formats, WFS and WMS.

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\(^1\)Common Gateway Interface is a standard protocol for interfacing external application software with web servers.

\(^2\)An application programming interface (API) is a set of functions, procedures, methods, classes or protocols.
Chapter 2. FOSS Web GIS Components

With the release of MapServer version 6.2 its source code and several related projects where bundled to form the MapServer suite. The suite includes MapServer CGI/FCGI, MapScript, Tiny OWS and MapCache. Other useful related tools are the MapServer utilities listed on page 48. Tiny OWS is an implementation of Transactional Web Feature Service (WFS-T), a specification of the OGC that has been added to the suite as a module with the release of MapServer version 6.2.

Table 3: MapServer Project

<table>
<thead>
<tr>
<th>Main supporter of MapServer</th>
<th>MapServer Core Team, Steven Lime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Map rendering engine, web mapping development environment</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Multi platform</td>
</tr>
<tr>
<td>Project started</td>
<td>1996</td>
</tr>
<tr>
<td>Implementation</td>
<td>C</td>
</tr>
<tr>
<td>OS libraries</td>
<td>OGR/GDAL</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>BSD</td>
</tr>
</tbody>
</table>

2.1.2 GeoServer

GeoServer is a newer development than MapServer. It covers much of the functionality that MapServer does, such as rendering images from spatial data, and publishing of WMS and WFS. It has a web-based graphical configuration and management interface and stores the configuration in XML format.

Furthermore it supports transactional capabilities and shared editing (versioning) of spatial data. GeoServer also supports KML and tiled map output. Input formats include PostGIS, shapefile, ArcSDE, DB2, Oracle (soon VPF, MySQL, MapInfo, and WFS). Output formats include JPG, GIF, PNG, SVG, KML/KMZ, GML, shapefile, GeoJSON, GeoRSS, WFS and WMS. GeoServer can currently serve WFS on top of: Oracle Spatial, ArcSDE, PostGIS and shapefiles.
### Table 4: GeoServer Project

<table>
<thead>
<tr>
<th>Main supporter of GeoServer</th>
<th>The Open Planning Project (TOPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Map rendering engine, support for web based editing of data, transactions WFS-T and versioning</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Multi platform</td>
</tr>
<tr>
<td>Project started</td>
<td>2001</td>
</tr>
<tr>
<td>Implementation</td>
<td>Java, J2EE</td>
</tr>
<tr>
<td>OS libraries</td>
<td>Geotools</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>GPL 2.0</td>
</tr>
</tbody>
</table>
2.1.3 Mapnik

Mapnik is another map rendering engine which was started by Artem Pavlenko in 2005. It appears to have a lot of potential, even though the developer and user community is still small. Mapnik is written in C++ and already delivers really nice map output based on the AGG renderer. Mapnik can be used to produce maps interactively on a web server or on the desktop environment. Map output can the controlled via Python scripts and style sheets. Currently the focus is on map rendering and it does not have capabilities for editing or querying spatial data. Mapnik accepts shapefiles, PostGIS and TIFF raster as input formats, and uses a styles processor to output images in PNG, JPG, SVG, PDF, and PS formats. A tutorial for making maps with Mapnik and Python can be downloaded from http://code.google.com/p/mapnik-utils/.

<table>
<thead>
<tr>
<th>Table 5: Mapnik Project</th>
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<tbody>
<tr>
<td><strong>Main supporter of Mapnik</strong></td>
</tr>
<tr>
<td><strong>Functionality</strong></td>
</tr>
<tr>
<td><strong>Operating systems</strong></td>
</tr>
<tr>
<td><strong>Project started</strong></td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
</tr>
<tr>
<td><strong>OS libraries</strong></td>
</tr>
<tr>
<td><strong>PostGIS support</strong></td>
</tr>
<tr>
<td><strong>License</strong></td>
</tr>
</tbody>
</table>

3 Anti Grain Geometry renderer. An OS software graphic library, written in C++ that allows to render images from vector data.
Figure 2: Three maps rendered with Mapnik
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2.2 Client Side Frameworks

The following frameworks are based on JavaScript/Ajax Libraries, have no (or optional) server side dependencies and thus can be used easily on a shared hosting environment.

2.2.1 OpenLayers (OL)

OpenLayers is a pure client side mapping framework based on JavaScript and as a result is very easy to deploy. OpenLayers has no server side dependencies and provides an API that you can use independently from the data sources that supply the input data for the application. Input data sources can be tiled and pre-rendered images via WMS or commercial layers such as Bing, World Wind, Google Maps, or WMS services. Using map tiles enables a smooth map scrolling and browsing experience (slippy map) just like the commercial maps from Google, and Microsoft. Vector input for OL can come from many sources such as MapServer, GeoRSS, WFS, or KML. OpenLayers supports a variety of reusable components such as scale bars, zoom bar, layer switcher (on/off), and tools like zoom in/out and pan. Version 3 of OpenLayers (OL3) was released on August 29th 2014 and is a full re-write using modern design patterns. OL3 breaks backwards compatibility with the 2.X versions of OL. OL3 is based on Google’s Closure Tools which enable advanced compression of the library (resulting in smaller size) and ensures wide cross-browser testing. Custom builds of OL3 can be easily compiled for production software using the closure compiler.

GeoEXT http://www.geoext.org/ is a set of spatial tools extending the Ext JS JavaScript library and integrating them with OpenLayers components. It supplies an API to embed OpenLayers components such as a map or a legend in Ext panels and enables easy use of Ext components within the web application.

One easy way to include an OL maps in a web page is to simply add a JavaScript <script> tag reference to a copy of the OpenLayers .js file and one can even reference a hosted version of the OpenLayers library at http://openlayers.org/api/OpenLayers.js. OL also has tools enabling digitizing and editing of data when used in conjunction with a WFS-T enabled server like GeoServer. OL has close ties to TileCache, and Feature Server which are also projects from Metacarta Labs.

4 e.g. OpenLayers Editor (geops) http://www.geops.de/node/73
5 Transactional Web Feature Services support editing of vector data.
Table 6: OpenLayers Project

<table>
<thead>
<tr>
<th>Main supporter of</th>
<th>Functionality</th>
<th>Operating systems</th>
<th>Project started</th>
<th>Implementation</th>
<th>libraries v2:</th>
<th>libraries v3:</th>
<th>PostGIS support</th>
<th>License</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OpenLayers 2</strong></td>
<td>Client side mapping framework to develop interactive mapping applications. OL3 better optimized for use on mobile devices</td>
<td>Windows, Linux, Mac</td>
<td>2005, OL3 August 2014</td>
<td>JavaScript/Ajax</td>
<td>Prototype.js and Rico library</td>
<td>Google’s Closure Tools (compiler+library)</td>
<td>via rendering engine</td>
<td>BSD</td>
</tr>
<tr>
<td><strong>v3 OpenLayers Dev Team</strong></td>
<td></td>
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### 2.2.2 Leaflet

Leaflet is a lightweight JavaScript library for creating client side web maps that works efficiently on desktop and mobile platforms. Weighing in with only about 33KB size it is a small library that has many functions but is lacking the more advanced ‘GIS’ features that especially OpenLayers 2.X (and OL 3) caters to. It is a good choice if (download) speed is the main objective, compatibility with mobile devices is important and if more advanced features are not needed in the desired web-map. Leaflet’s functionality can be extended via a large collection number of plugins.

Leaflet also has notably been used in conjunction with the popular D3 (Data-Driven Documents) library. D3 is a JavaScript library supporting many kinds of visualizations (such as charts) that are based on a combination with HTML, SVG and CSS. Mapping capabilities have been added to D3 over time, making it an interesting alternative for in browser visualization of geographic and non geographic objects. The TopoJSON format is an extension of GeoJSON that encodes topology of vector data for effective display in a browser. The latter format...
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uses topology and therefore is eliminating redundancy in data (e.g. this means no duplicate adjacent boundaries but one shared boundary). This can result in much smaller vector file sizes (of geographic objects), that can be up to 80% smaller than their GeoJSON equivalents. D3 and Leaflet can be combined (TopoJSON is available in Leaflet via D3) as shown in this simple example. A large collection of examples shows the capabilities of the growing world of JavaScript Web maps and other interesting D3 Visualizations.

<table>
<thead>
<tr>
<th>Main supporter of Leaflet</th>
<th>Vladimir Agafonkin and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Client side mapping framework with focus on small library size and streamlined, mobile friendly functionality</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Windows, Linux, Mac, Mobile devices</td>
</tr>
<tr>
<td>Project started</td>
<td>2011</td>
</tr>
<tr>
<td>Implementation</td>
<td>JavaScript/Ajax</td>
</tr>
<tr>
<td>OS libraries</td>
<td>none</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>via rendering engine</td>
</tr>
<tr>
<td>License</td>
<td>BSD</td>
</tr>
</tbody>
</table>

### 2.3 Client-Server Side Frameworks

#### 2.3.1 Mapbender

Mapbender is a comprehensive client and server side mapping framework. It is implemented in PHP, JavaScript and XML and based on an administration database that can be housed in either MySQL or PostgreSQL. Some of its functionality such as measuring distances on a map is only available if PostgreSQL/PostGIS is used as an admin database. It features a web based administration interface to manage applications, application layout, user and group access rights, mapping services, available tool functionality and security for WMS and WFS via OWS proxy functionality. Functionality for each of the housed web mapping applications include displaying, navigating, editing and querying spatial data and maps. Input sources are solely OGC WMS compliant map services and WFS. In the near future it is envisioned to embed OpenLayers as a map viewing option.
in addition to the intrinsic Mapbender viewer.

Table 7: Mapbender Project

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Client side and server side mapping framework, based on a database (MySQL and PostgreSQL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating systems</td>
<td>Windows and Linux</td>
</tr>
<tr>
<td>Project started</td>
<td>2001</td>
</tr>
<tr>
<td>Implementation based on</td>
<td>JavaScript/Ajax, DHTML, PHP</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>MySQL or PostgreSQL</td>
</tr>
<tr>
<td>License</td>
<td>GPL</td>
</tr>
</tbody>
</table>

2.3.2 MapFish

MapFish is a client-server web mapping framework. MapFish provides tools for creating web services that allows querying and editing geographic objects. It also provides a JavaScript toolbox including specific components for interacting with MapFish web services. It consists of two parts: MapFish server and MapFish client. MapFish Client is a JavaScript framework based on OpenLayers, Ext JS and GeoExt. MapFish Server is a Python framework (based on Pylons) that extends Pylons with geospatial functionality. There are two other implementations currently available: a Ruby/Rails plug-in and PHP/Symfony plug-in. Server side functionality is implemented as a Widgets and plug-ins oriented architecture. An administration tool, MapFish Studio can help to simplify the configuration work and will allows to create new MapFish applications. User Interface (UI) components include: layer tree, authentication, geostatistics, query, routing, and editing (the last five are server side widgets). Features include offline support (based on Google Gears), and PDF printing (features printed as vectors, rotated maps, scale bar, legends, tables).
Chapter 2. FOSS Web GIS Components

![UNHCR web mapping application based on MapFish](image)

Figure 3: UNHCR web mapping application based on MapFish

Table 8: MapFish Project

<table>
<thead>
<tr>
<th><strong>Main supporter of MapFish</strong></th>
<th>Camptocamp</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functionality</strong></td>
<td>Client side and server side mapping framework, client side viewer is based on OL, supplies server side widgets, offers MapFish API</td>
</tr>
<tr>
<td><strong>Main Focus</strong></td>
<td>Adding server side framework to OpenLayers</td>
</tr>
<tr>
<td><strong>Operating systems</strong></td>
<td>Windows and Linux</td>
</tr>
<tr>
<td><strong>Project started</strong></td>
<td>2007?</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
<td>JavaScript/Ajax, DHTML, Python</td>
</tr>
<tr>
<td><strong>OS libraries</strong></td>
<td>Pylons, SQLAlchemy, GeoJSON, Shapely, JTS, and Ext JS</td>
</tr>
<tr>
<td><strong>PostGIS support</strong></td>
<td>Via rendering engine</td>
</tr>
<tr>
<td><strong>License</strong></td>
<td>GPL 3.0</td>
</tr>
</tbody>
</table>
2.3.3 More Great Frameworks

**Django** is a web development framework written in Python. It supports multiple database back-ends (PostgreSQL, MySQL, SQLite, Oracle, and MS SQL) and bundles a number of applications. Several years ago GeoDjango was merged into the Django main source code allowing it to be used as a web development framework for creating web based GIS applications.

2.4 Extending GIS Capabilities

Spatial data storage solutions and additional tools for web mapping applications.

2.4.1 PostGIS - The OS Spatial Database

PostGIS is an extension for PostgreSQL and adds support for geographic objects to PostgreSQL. It enables PostgreSQL server to be used as a backend spatial database for GIS. The functionality includes data import/export, storage and retrieval of spatial geometries, and spatial indexing (R-tree) of spatial objects in PostgreSQL by adding functions, casts, and storage types. It enables spatial operations and analysis by simple means of running (spatial) SQL queries in the database. In short PostGIS is a GIS in its own right and can greatly enhance web GIS applications with additional functionality. In a sense it provides similar functions as ArcSDE but operates differently. It is not a middleware sitting on top of a database, rather it is an internal extension of the database written in C. There is no difference in the use of spatial and non-spatial objects in PostGIS and all objects are accessible via SQL queries to a GIS application.

When the first version of PostGIS was released in 2001 only MapServer accepted PostGIS as an input format, however over time it has become the standard spatial database backend for all the other open source GIS tools. ArcGIS 9.3 has read and write support for PostGIS but requires an ArcSDE license to connect. Prior to version 9.3 ArcGIS was lacking native support for PostGIS. ArcGIS version 10 and higher can connect to PostGIS. For editing this still looks a little different. In order
Table 9: PostGIS Project

<table>
<thead>
<tr>
<th>Main supporter of PostGIS</th>
<th>Refractions Research, Victoria, Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Spatial database. PostGIS is an extension for PostgreSQL</td>
</tr>
<tr>
<td>Functionality</td>
<td>Storage and retrieval of spatial data (geometries such as point, line, polygon, multipoint, multiline, multipolygon, geometrycollection). Spatial indexing. GIS functions via spatially enabled SQL. E.g. intersections, distance calculations, reprojection</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Linux, Windows</td>
</tr>
<tr>
<td>Project started</td>
<td>2001</td>
</tr>
<tr>
<td>Implementation</td>
<td>C</td>
</tr>
<tr>
<td>OS libraries</td>
<td>GEOS, Proj4, OGR, and FDO</td>
</tr>
<tr>
<td>License</td>
<td>GPL</td>
</tr>
</tbody>
</table>

To edit PostGIS feature in ArcGIS 10.1 (without ArcSDE) one will still need a middleware called Spatial Data Server (SDS) that comes with ArcGIS Server - see this blog entry. Fortunately a new free extension ST-Links SpatialKit exists that enables display and editing of PostGIS data in ArcMap 10, 10.1 and 10.2 (version 4) and version 3.0.4 works with ArcMap 9.3 without any middleware. Another third party ArcGIS extension zigGIS used to be available from Obtusesoft but has been discontinued in 2011. In addition the Data Interoperability Extension also enables earlier versions of ArcGIS to use PostGIS layers.

2.4.2 Feature Server

FeatureServer is a server software (a middleware) for publishing, aggregating and converting geospatial data in a variety of different formats for the web. Published data are made available as a common web services interface. FeatureServer is implemented as a RESTful\(^6\) Geographic Feature Service. It uses standard HTTP commands (GET, PUT, POST and DELETE) to control operations and enables dynamic capabilities to read geographic features or feature collections. Input can come from

\(^6\)REpresentational State Transfer (REST) - style of software architecture that can be used for the web
distributed sources. It can be used to translate geographic features between formats. For example a user can input an ESRI shapefile and open it in Google Earth. FeatureServer enables feature editing and server-side storage of spatial data using OpenLayers. The following data sources (storage) are supported: DBM, BerkleyDB, PostGIS, WFS, OGR, Flickr, and OSM (Open Street Map). Service input/output formats are GeoJSON (points, lines, and polygons with rings), GeoRSS Atom (Simple), KML, GML/WFS (output-only), HTML, and OSM (output-only as Open Street Map *.osm files). Four different server operation modes are available: CGI, mod_Python, Standalone wsgi HTTP server, and FastCGI.

Table 10: Feature Server Project

<table>
<thead>
<tr>
<th>Main supporter of Feature-Server</th>
<th>None (formerly it was Metacarta Labs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Server software for converting, tiling and caching of geospatial data</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Windows, Linux, Mac</td>
</tr>
<tr>
<td>Project started</td>
<td>2007?</td>
</tr>
<tr>
<td>Implementation</td>
<td>Python</td>
</tr>
<tr>
<td>License</td>
<td>BSD</td>
</tr>
</tbody>
</table>
Figure 4: Schematic view of Featureserver operation. Source: http://featureserver.org
2.4.3 TileCache

TileCache is a server software solution with caching and rendering capabilities to create your own local disk-based cache of a WMS server. The tiles can be used in a variety of clients e.g. OpenLayers, Leaflet, Google Maps, MS Bing, and WorldKit. GeoWebCache is a similar product currently under development by Metacarta Labs but is written in Java. TileCache sits in front of map rendering engines such as MapServer, GeoServer, Mapnik or ArcGIS Server, and converts requests from front end viewers (such as OpenLayers or World Wind) into requests for maps (more exactly requests for a collection of tiles that make up a map). By caching tiles on disk the performance of a web based GIS viewer such as OpenLayers can be greatly increased. Tiles are pre-rendered and there is no need for a mapping engine to create a new image at the time of a new map request. Tile size and discrete zoom levels can be configured. Tiles can either be pre-rendered for all geographic areas (tile seeding) or only be created when requested. The use of tiles (generated by TileCache) enables smooth map scrolling experiences in applications (*slippy map feeling*) similar to those of the commercial products such as Google Maps, Bing, and MapQuest Maps. Other software packages with similar functionalities are MapProxy, MapCache (part of the MapServer suite), and TileMill, (a tiling tool for non GIS experts) - see page 81.

Table 11: TileCache Project

<table>
<thead>
<tr>
<th><strong>Main supporter of TileCache</strong></th>
<th>Metacarta Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functionality</strong></td>
<td>Server middleware for converting, tiling and caching of geospatial data</td>
</tr>
<tr>
<td><strong>Operating systems</strong></td>
<td>Windows, Linux, Mac</td>
</tr>
<tr>
<td><strong>Project started</strong></td>
<td>2007?</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
<td>Python</td>
</tr>
<tr>
<td><strong>License</strong></td>
<td>BSD</td>
</tr>
</tbody>
</table>
3 Setup of an OS Web GIS Application

There is a variety of different options for building an OS web mapping application.

### Short Overview of Server Hosting Options

Depending on the goals and needs for such an undertaking one has to consider what kind of server will be available for hosting the application. For example:

- in house server with administrative access rights
- dedicated server (third party hosted machine) with root access
- shared hosting environment without root access (no administrator rights)
- hosting on a virtual cloud of computers such as Amazon EC2 or others

Dedicated servers can either be virtual servers (multiple virtual servers sharing one physical server computer) or real physical machines. While it is possible to install a web GIS application on a shared hosting environment this will not be the most common use case. For those interested in installing a GIS web mapping application on such an environment read on Aaron Raciocot’s Blog REPROJECTED GIS on a shared hosting environment. Hosting of a web GIS application on a virtual cloud of computers (such as Amazon EC2 or others) can be a good choice for certain use cases. Those environments allow for preparing images on a complete Linux server workstation installation (including GIS software stacks). Thus, those environments can be a good choice for setting up temporary servers. They can also serve as a resource for GIS analysis that has to be performed quickly. Because of pre-configured server images it is possible to start/ boot multiple machines/servers simultaneously within minutes - with all the required software installed. Those solutions are highly scalable and are available for a relatively low cost, even if you run multiple identical server machines simultaneously over a short time period.
Chapter 3. Setup of an OS Web GIS Application

3.1 Selecting components for a Web GIS

While this can be an involved and difficult process, there is a couple of basic choices to be made. Figure 5 shows the main building blocks of an interoperable web GIS solution. The data sources (in light blue) are the first building block. Data can be stored in file format or in databases. The second building block is a map rendering engine (shown as orange boxes) that can take in the data and produce some kind of map output (image or vector), which can then be served to the web either as a complete map or as a service, such as WMS or WFS (gray box) to be used in another application on the client side. Capabilities of map rendering engines can be similar to some degree, but many offer differing functionalities.

GeoServer would be the engine of choice if we need editing capabilities or need support for shared editing (versioning). MapServer might be the choice if speed is the main concern and you need very high performance to render images. Some kind of mapping framework can complement the application and make the development, management and deployment of the web GIS easier. On the framework side we have to choose if we want a client side framework only (e.g. because we want to use it on a shared hosting environment - we could use OpenLayers for that), or if we have some type of dedicated server available and we need to build a complex web application. In that case we would e.g. choose Mapbender

**interoperable web GIS**
- Data
- Map rendering engine
- Mapping framework
- Map services

**GeoServer has editing and data versioning support**

**MapServer is fast**
 Framework client side or client-server side?
Chapter 3. Setup of an OS Web GIS Application

or MapFish-OpenLayers. Which one of the frameworks we will choose depends also on the knowledge of the person (or team) working on the project (e.g. programming and scripting skills). If several of the frameworks offer the functionality needed for the project then the choice may well depend on the existing skill set of the project team. Thus, if I am already proficient with Python I might pick MapFish as my framework of choice, whereas when I am most proficient with PHP I could go with Mapbender.

Of course the framework has to enable the functionality needed for the project - or be closer to the needed functionality if new capabilities need to be developed. Many frameworks also support multiple sources of data and data intake from multiple map rendering engines to be used in the same applications. Mapbender for example can take in and manage any WMS service no matter whether it is served by GeoServer, Mapnik, MapGuide, ArcIMS, ArcGis Server, or MapServer. So the advantages and strength of several map rendering engines can be used in one framework for the greatest benefit and flexibility in the application. Additional functionalities such as the production and the caching of map image tiles, editing, aggregating, and translating of spatial data can be added by using TileCache and FeatureServer respectively. Furthermore, custom functionalities can be added using the APIs of the frameworks and the map rendering engines. PostGIS has the potential to supply GIS analysis functions to any of the frameworks. For more complicated tasks, even desktop programs such as GRASS and R (Statistical software), can be linked to the web application and potentially enable the development of a full featured web based GIS application.

3.2 Configuration of a Server for Web Mapping (on Ubuntu Linux)

When setting up a web server based on Linux operating systems one can naturally install your software components from scratch, including having to compile from source. This can be a good choice when you want to have the most up to date software or a specific software version. However, there are other options that often will be more elegant and time efficient. Using pre-complied components for your operating system (and version) can save you a great deal of time and potential compilation trouble. The UbuntuGIS project provides easy access to relatively new software versions for many FOSS4G software
Chapter 3. Setup of an OS Web GIS Application

projects. The pre-compiled packages can be installed on your Ubuntu machine using the **apt** package manager. To use apt to install OS GIS software components successfully on your Ubuntu machine there are following prerequisites

- the `apt` package manager needs to be installed (usually included with your Ubuntu operating system)
- the software package location has to be included in the list of repositories \(^1\) (this is needed for the package manager to establish access to the software packages download)

Below are examples how GIS components can be installed from the bash command line using `apt`. The system will prompt you when additional software libraries (dependencies) will need to be installed in order to make the desired component operational.

```
# install gdal
sudo apt-get install gdal-bin

# install proj
sudo apt-get install proj
```

On page 85 there is an example of how to install components using the Ubuntu and **Ubuntu GIS** repositories.

---

\(^1\) e.g. [http://trac.osgeo.org/ubuntugis/wiki/UbuntuGISRepository](http://trac.osgeo.org/ubuntugis/wiki/UbuntuGISRepository)
4 Exercises

4.1 Using OpenLayers

When doing web development some tools come in handy to debug and verify JavaScript, review requests to the server and more. Using the Firefox browser an excellent tool Firebug is available for this purpose [http://getfirebug.com/downloads](http://getfirebug.com/downloads). Firebug makes it much easier to verify CSS style sheets, the DOM in web pages, review requests made to the server, debugging JavaScript and more. This can be very useful when working with OpenLayers (OL) because it is a JavaScript library and API to track down errors during coding. For example we can review the HTTP requests that OL sends to WMS services we add to a OL map.

OpenLayers accepts a large variety of input sources and you can use it to combine data layers coming from many different locations, servers and software. OL can take in tiled or untiled data. For non-tiled vector data one has to specify the `singleTile:true` tag in the layer specification. This will perform faster for this use case than tiled layers. Tiled data is provided by all the commercial maps (Google, MS) or can be rendered and stored/cached via TileCache from your own WMS sources. In that use case this will be much faster since the tiles already exist on the server and don’t have to be produced on the fly by a rendering engine with each new map request. The OL website has resources to learn about the API and also a nice collection of examples on how to use or setup functionalities with OL. The list of examples can be found here: OpenLayers 2 and OpenLayers 3.

4.1.1 Some Important OpenLayers Objects

The OpenLayers API architecture uses an object oriented approach. The following section will introduce a few of the main components that make up a typical OL viewer web page. The main component in OL is the map object. Once the map object is defined, other components, such as data layers and tools (map controls) can be added to it.

The following JavaScript snippet (taken from ol_map_simple.html)
Chapter 4. Exercises

shows a simple definition of a map object defining the variable called `map` including the `options` variable as parameters. In this example the parameters include the map projection, map units, and map extent. Note that a JS function `window.onload` is used to initiate the OpenLayers objects when the page is first loaded in a browser. The live example is here.

```javascript
var map;
var options = {
    projection: new OpenLayers.Projection("EPSG:3857"),
    units: "m",
    maxResolution: 156543.0339,
    maxExtent: new OpenLayers.Bounds(-13776237,5870705,-13270618,6177605)
};

window.onload = function (){
    map = new OpenLayers.Map( 'map' , options ) ;
}
```

The following section is defining a variety of map layer objects: Counties and Rails as WMS layers, and empty base layer, and two Google layers. The last line of JS code below adds the layer objects to the map (object).

```javascript
var Counties = new OpenLayers.Layer.WMS( "counties",
    "/cgi-bin/mapserv.exe?map=C:/class/data/mapfiles/wacounties_wms.map",
    {layers: 'Counties', 'transparent': true}, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile: true} );
var Rail = new OpenLayers.Layer.WMS( "rail",
    "/cgi-bin/mapserv.exe?map=C:/class/data/mapfiles/wacounties_wms.map",
    {layers: 'Rail', 'transparent': true}, {isBaseLayer: false, 'opacity': 0.7, 'visibility': true, singleTile: true} );
var Cities = new OpenLayers.Layer.WMS( "cities",
    "/cgi-bin/mapserv.exe?map=C:/class/data/mapfiles/wacounties_wms.map",
    {layers: 'Cities', 'transparent': true}, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile: true} );
var Uninhabited = new OpenLayers.Layer.WMS( "uninhabited",
    "/cgi-bin/mapserv.exe?map=C:/class/data/mapfiles/wacounties_wms.map",
    {layers: 'Uninhabited', 'transparent': true}, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile: true} );

var base_empty = new OpenLayers.Layer("No Background", {isBaseLayer: true, numZoomLevels: 20, 'displayInLayerSwitcher': true, basename: "empty"]);
map.addLayer(base_empty);
var g_street = new OpenLayers.Layer.Google("Google Streets",{maxZoomLevel:20}); map.addLayer(g_street);
var g_satellite = new OpenLayers.Layer.Google("Google Satellite",{type: google.maps.MapTypeId.SATELLITE, 'maxZoomLevel':20});
```
Chapter 4. Exercises

```javascript
map.addLayers(["g_street", "g_satellite", "base_empty", "Uninhabited", "Counties"]);

In the code section below two map controls (tools) are added to the map. First the `LayerSwitcher` (to turn layers on and off) is added, then a second control `MousePosition` (enabling the display of the mouse cursor position in map coordinates) is defined and added to the map (last line of JS code below).

```javascript
var bounds = new OpenLayers.Bounds(-13776237, 5870705, -13270618, 6177605);
map.zoomToExtent(bounds);

map.addControl(new OpenLayers.Control.LayerSwitcher());
mp = new OpenLayers.Control.MousePosition();

mp.displayProjection = new OpenLayers.Projection("EPSG:3857");
map.addControl(mp);
}; // end bracket of 'window.onload' function
```

The OL API documentation can help to expand your knowledge about the API basics described in the paragraphs above. One important section of the API docs is the part about map controls. A lot of functionality is included in the OpenLayers.Control (map control) objects [http://dev.openlayers.org/docs/files/OpenLayers/Control-js.html](http://dev.openlayers.org/docs/files/OpenLayers/Control-js.html).

4.1.2 Commercial Layers in OpenLayers

Commercial map layers such as those from Google, MapQuest and Bing (Microsoft) can be directly used in OpenLayers as base (background) layers for your map. Those layer are based on scale dependent tiles (small images) that OpenLayers (or other viewers) stitch together to provide an entire map. The idea behind this architecture that the transfer of the already existing (pre-rendered) tiles is faster than requesting a new image that is rendered (image file that is generated) on the fly by a mapping engine each time the map changes (for example in a pan or zoom request by a user). Some of the commercial map providers offer their own API that can be used stand alone without OpenLayers to make map. The benefit to use OpenLayers is being able to easily switch between base layers and the added comfort of the comprehensive OpenLayers API providing many tools to add and manipulate your own data. For some of those providers that also supply a mapping API we will need to include a reference to the JavaScript of the provider
to enable the map layer to work as expected (Google, Bing)\(^1\). Note that for many cases those layers can be legally used without charge, however be aware that certain restrictions apply which may differ by provider. For example the Google terms of use indicate that the layers can be used in your maps (and in OpenLayers) free of charge, but when you want to put the same map behind a password protection you will need to purchase a professional license to comply with the terms of use. Note that the Yahoo API was officially discontinued in 2011 and that consequently maps based on it will cease working in the near future. Regarding Google API version 2 of it required to apply for a map API key that needed to be referenced in your map page (see page 107). For mapping layers of Google API version 3 no key is needed and the syntax also changes slightly. MapQuest started in 2011 to base their map tiles entirely on data from Open Street Map project. On page 107 see code snippets on how to include Google v3, MapQuest, Open Street Map, and Bing layers. There are multiple maps rendered from open street map data such as one based on Mapnik and one focusing on suitable bicycle routes.

### 4.1.3 Adding WMS data to your map

To use Google map tiles together with our own MapServer layers in OpenLayers we define the map projection as "Spherical Mercator" (that is the projection of the Google and other commercial tiled data sources). This is necessary because MapServer can re-project our data to any projection no matter what the source projection is (on the fly), but tiles offered by the tiled data sources mentioned above have a fixed map projection that we have to match to align the map tiles and our own data correctly. We set the projection in the general map definition:

```plaintext
PROJECTION
  "init=epsg:3857"
END
```

In order for MapServer to be able to decode this epsg code it has to be specified in the epsg file (that is used by Proj4). The epsg is a text file that stores map projections as a list of projection strings. So let’s go ahead and add that projection to our epsg file (the file should be located in the `c:ms4w`)

\(^1\)see page 107 for an example of an HTML page that includes such a reference
Chapter 4. Exercises

proj

nad directory). Basically the code has to be added to the file if it does not exist – best is as the first entry that speeds up MapServer to retrieve it. In Notepad++ add and save this line on top of the file:

```
# Spherical Mercator
<3857> +proj=merc +a=6378137 +b=6378137 +lat_ts=0.0 +
lon_0=0.0 +x_0=0.0 +y_0=0 +k=1.0 +units=m +nadgrids= @null +no_defs <=
```

In PostGIS similarly this is also used and all possible EPSG codes (here called SRID for Spatial Reference ID) are stored in the "spatial_ref_sys" table. We can add the SRID also to the spatial_ref_sys table (e.g. for bounding box re-projections in PostGIS from decimal degrees to Spherical Mercator) via SQL like this. Insert Google Spherical Mercator (EPSG 3857):

```
INSERT into spatial_ref_sys (srid,auth_name,auth_srid,proj4text,srtext) values (3857, 'spatialreference.org',3857, '+proj=merc+a=6378137+b=6378137+lat_ts=0.0+
lon_0=0.0+x_0=0.0+y_0=0+k=1.0+units=m+nadgrids=@null +wktext+no_defs ', 'PROJCS["unnamed",GEOGCS["unnamedellipse",DATUM["unknown",SPHEROID["unnamed ",6378137,0]],PRIMEM["Greenwich",0],UNIT["degree ",0.0174532925199433]],PROJECTION["Mercator_2SP"],
PARAMETER["standard_parallel_1",0],PARAMETER["central_meridian",0],PARAMETER["false_easting",0],
PARAMETER["false_northing",0],UNIT["Meter",1],
EXTENSION["PROJ4","+proj=merc+a=6378137+b=6378137+
lat_ts=0.0+lon_0=0.0+x_0=0.0+y_0=0+k=1.0+units=m+
 nadgrids=@null+wktext+no_defs "]) '
```

The Open Street Map (OSM) projection is very similar to the Google Spherical Mercator projection and sometimes also called "Google Mercator". To add it to the epsg file:

```
# SR-ORG Projection 6627 — Open Street Map (OSM)
<6627> +proj=merc +lon_0=0 +k=1 +x_0=0 +y_0=0 +ellps=WGS84 +datum=WGS84 +units=m +no_defs <=
```

Insert into PostGIS:

```
INSERT into spatial_ref_sys (srid,auth_name,auth_srid,proj4text,srtext) values (96627, 'sr-org',6627, '+proj=merc+lon_0=0+k=1+x_0=0+y_0=0+ellps=WGS84+datum=WGS84+units=m+no_defs', 'PROJCS["GoogleMercator",GEOGCS["WGS84"],DATUM["WorldGeodeticSystem1984"],SPHEROID["WGS84",6378137.0,298.257223563,AUTHORITY["EPSG","7030"]],AUTHORITY["EPSG","6326"]],PRIMEM["
```

The Open Street Map (OSM) projection is very similar to the Google Spherical Mercator projection and sometimes also called "Google Mercator". To add it to the epsg file:

```
# SR-ORG Projection 6627 — Open Street Map (OSM)
<6627> +proj=merc +lon_0=0 +k=1 +x_0=0 +y_0=0 +ellps=WGS84 +datum=WGS84 +units=m +no_defs <=
```

Insert into PostGIS:

```
INSERT into spatial_ref_sys (srid,auth_name,auth_srid,proj4text,srtext) values (96627, 'sr-org',6627, '+proj=merc+lon_0=0+k=1+x_0=0+y_0=0+ellps=WGS84+datum=WGS84+units=m+no_defs', 'PROJCS["GoogleMercator",GEOGCS["WGS84"],DATUM["WorldGeodeticSystem1984"],SPHEROID["WGS84",6378137.0,298.257223563,AUTHORITY["EPSG","7030"]],AUTHORITY["EPSG","6326"]],PRIMEM["
```

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Chapter 4. Exercises

Greenwich", 0.0, AUTHORITY["EPSG","8901"]], UNIT["degree", 0.017453292519943295], AXIS["Geodeticlatitude", NORTH], AXIS["Geodeticlongitude", EAST], AUTHORITY["EPSG","4326"], PROJECTION["Mercator_1SP"], PARAMETER["semi_minor", 6378137.0], PARAMETER["latitude_of_origin", 0.0], PARAMETER["central_meridian", 0.0], PARAMETER["scale_factor", 1.0], PARAMETER["false_easting", 0.0], PARAMETER["false_northing", 0.0], UNIT["m", 1.0], AXIS["Easting", EAST], AXIS["Northing", NORTH], AUTHORITY["EPSG","3857"]’);

Tip

There are two web sites spatialreference.org and epsg.io that are making it easier to look-up many map projections and display their definitions in multiple formats such as ESRI prj files, PostGIS insert statements, Proj4 epsg codes, MapServer map file definitions, and others.

4.1.4 OpenLayers Exercises

Viewing a basic Map in OL

1. Review the examples in the Appendix of this booklet
2. Create a new HTML page in Notepad++ (you can start with the file osgis/ol_map_simple.html as save it as osgis/firstmap.html, see the local class example live here)
3. Add additional base layers such as Google Streets, Google Hybrid and Bing to the map. You can review the syntax in alllayers.html for help, see the live example here.
4. Add two existing MapServer WMS layers to the OL map (e.g. rails and uninhabited land). Refer to osgis/ol_map_simple.html to see the syntax for adding a WMS layer. Make sure the layer is not configured as a base layer and that is switched off by default. The basic syntax of a WMS layer object in OL is documented here and has the parameters name, url, params, and options.
5. Add a MapServer legend to the page. You can use osgis/one_wms_layer.html as an example. To do this you can add a HTML image tag <img src="xy.jpg"> to the page and reference a GetLegendGraphic request to a MapServer WMS layer. You may want also to review the
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syntax in the chapter about Web Map Services. Note how HTML <div> elements and CSS styles definitions are used to layout the page.

6. Optional and advanced: Review the Code Listing for osgis/identify/map.html in the back of this booklet on page 111 and add the identify feature functionality for one WMS layer of your choice to your map. Edit the file to enable identifying features in your WMS layer. View live example here.

4.1.5 OL Examples (version 2.13)

See also the more detailed list in the resources section on page 111 "OL examples included on the class DVD".

- Identify Features Example (map.html on DVD)
- Digitize Polygons Example (mapserver_wa_digitize.php and save_polygon.php on DVD and live example)
- Measure Distance and Area Example and control documentation
- Click Event Handler Example. This event can be used to trigger any action to write inside click event script. For example we could query PostGIS, retrieve feature attributes and open a pop-up or web page.
- Review alllayers.html from the class DVD as an example how individual Commercial Layers - Google, Bing, MapQuest - can be added to a OpenLayers map along with Open Street Map tiles.

4.1.6 Optimizing OpenLayers

Over the course of the last years the OpenLayers library grew and had a lot of new functionalities added to it. While this is great and allows to build more and more complex web application using the API, the library roughly doubled in size. Here are a couple of ways one can go about optimizing OL performance.

- A general approach for your web (mapping) application can be to use HTTP compression for Apache. More information on how to configure this here.
- Another approach is to reduce the functionality of the OL library in a production environment to just the functionality needed and to strip everything else. In many cases this
can result in a OL library that is 50% or more smaller than the standard OL (version 2) built. An article by Richard Marsden about building a custom OpenLayers library can be found here.

4.1.7 OpenLayers is also used as
- data viewer in Spatial Data Integrator (Spatial ETL)
- optional viewer in Mapbender
- the default map viewer in Django (a content management system)
- a data viewer in the web based GeoServer configuration interface

4.2 Using MapServer

Mapserv.exe is the CGI portion for the MapServer package. It handles user input and directs image creation or query requests. The program accepts input via either "GET" or "POST" methods and can be used in an interactive manner or as an image engine. The documentation is available online in the reference manuals and in PDF format MapServer manual download (700+ pages). Note that the system user that is running Apache (or your HTTP Server) needs read/write permissions for the log file to make this work. You may need to create an empty log file and set the correct permissions. On Linux this is usually the user called www-data. Another method to enable logging is by setting an environment variable MS_ERRORFILE (see the MapServer manual, Chapter 5, page 86).

To run MapServer and successfully use it interactively in a browser, several prerequisites exist:
- HTTP server is installed and running ➞ Apache2
- Apache configuration is setup correctly ➞ Aliases, web directory, permissions
- If we are using a scripting language this has to be configured correctly ➞ PHP installed, php.ini setup correctly
- Libraries MapServer is depending on are installed (several have to be compiled with MapServer). GDAL, OGR, Proj etc.
Chapter 4. Exercises

- Fonts, symbol files that are referenced in your map file need to exist and be located in the correct directory
- A temp directory for the map output needs to be specified

**Note that windows fonts can be used with MapServer**

Many of those prerequisites are already taken care of when we install a pre-configured package such as MapServer for Windows (MS4W).
4.2.1 Installing MS4W - MapServer for Windows

Installation instructions for MS4W are available on the web.

The paragraphs in the next section are quoted from maptools.org.

Extracting MS4W for the first time

Please read through the following instructions before starting your installation.

1. To install the MS4W .zip file, use a compression program (e.g. SevenZip) to extract the package at the root of a drive, e.g., drive C:. If successful, you should have a new directory named ‘ms4w’ at the root of the drive you chose (e.g. C:/ms4w).

2. Start your MS4W Apache Web Server by running /ms4w/apache-install.bat (at the command line or by double-clicking it). This file installs Apache as a Windows service (called "Apache Web Server") so that it starts whenever your machine is restarted. When executed, a DOS window should pop up with the following message:

   Installing the Apache MS4W Web Server service
   The Apache MS4W Web Server service is successfully installed.
   Testing httpd.conf....
   Errors reported here must be corrected before the service can be started.
   The Apache MS4W Web Server service is starting.
   The Apache MS4W Web Server service was started successfully.
   This means that Apache is running and installed as a service.

   In order to run the apache-install.bat file in Microsoft Windows Vista, and Windows 7 and 8 follow these instructions:

   a) In Windows Explorer, go to the location of your cmd.exe file (C:/Windows/System32)
   b) Right-click the cmd.exe executable and choose Run as Administrator

---

2 Please be aware that the MS4W package may be replaced over time with the new comprehensive package OSGEO4W and its download manager http://trac.osgeo.org/osgeo4w/
Chapter 4. Exercises

c) Navigate to your ms4w folder in the command prompt window and run apache-install.bat

3. To test that Apache is running properly, open your Web browser and find your local host Web service by entering one of the following URLs:
   http://localhost or http://127.0.0.1 You should now see the main MS4W page in your Web browser. This gives you general information about your install along with configuration information. If this is your first time using MS4W it is very important that you review the listed "Features" installed within MS4W, and test them by selecting each link found on this page.

MS4W is installed!

4. Technically, at this point, MS4W is installed! However, as you may have noticed from the MS4W main index.html page, there are no applications running. What this means is that there are no Web applications like MapLab or Chameleon found within MS4W's Web-accessible directory, /ms4w/apps/. The MS4W-configured Web applications can be found on http://maptools.org/ms4w/index.phtml?page=downloads.html as separate zip files.

Optional web applications not used in this class

5. To install these Web applications into /ms4w/apps/ all that is required is to download and unzip the Web application compressed file at the same root directory as MS4W (e.g., C:). We will be working for the purposes of this class with MapServer only. Thus the following details of this paragraph are for reference only. Two things should happen when uncompressing this file. First, the Web application directory should appear within /ms4w/apps/. Second, a new httpd_*.*conf file should be added to /ms4w/httpd.d/httpd_*.*conf. (The /httpd.d/ directory contains Apache configuration files that define which files on your computer/server are Web-accessible. For each Web application that you install, a new configuration file will be found.)

Configure Aliases for use by Apache ⇒ add "osgis"

6. The definitions of these Web-accessible directories are called Web Aliases. In order to activate a Web Alias you must restart Apache. To test your latest installed application, go to the MS4W main index.html page (i.e., http://localhost/). In the applications section you should now find a link to the application you just installed. Select the link to the recently installed application to see if it is
configured correctly. Another option is find the Web Alias in the Apache configuration file\(^3\) for your application and call it from your Web browser directly.

7. To enable the use of a number of utility programs that usually are distributed with MapServer, the environment path (for your operating system) to the /ms4w/Apache/cgi-bin directory needs to be set (more information on page 47). You can

- set the path manually in your Environment Variables permanently or
- run the batch file /ms4w/setenv.bat to include this directory in your path (temporarily until next reboot)

**Installation of Notepad++**

- Notepad++: software/notepad/npp.xyz.Installer.exe
- Setup syntax highlighting for MapServer .map files

**windows 7 and earlier**

⇒ Copy *userDefineLang.xml* to

\[C:/Documents and Settings\]

\[thecurrentuser\]/Application Data/Notepad++/

⇒ Copy *mapfile.api* to

\[InstallationPath/Notepad++/plug-ins/APIs\]

**windows 8**

⇒ Copy *userDefineLang.xml* to

\[C:/Users/\]

\[thecurrentuser\]/AppData/Roaming/Notepad++/

⇒ Copy *mapfile.api* to

\[InstallationPath/Notepad++/plugins/APIs/\]

**2 Tips** for using Notepad++:

- Press CTRL+Space for auto completion.
- Make use of the effective column edit mode - using Alt + Mouse dragging.

\(^3\)c:/ms4w/Apache/conf/httpd.conf
4.2.2 Configuration of MapServer

- The CGI interface can be tested at the command line by using the "QUERY_STRING" switch, such as:
  
  \texttt{mapserv "QUERY\_STRING=map=c:/class/data/mapfiles/wacounties\_wms.map&mode=map"}

- To save the output into an image file, use the pipe command such as:
  
  \texttt{mapserv -nh "QUERY\_STRING=map=c:/class/data/mapfiles/wacounties\_wms.map&mode=map" > test.png}

**Debugging**

It can be very useful to switch on debugging for MapServer and write the output to a log file. One method to do this is to add two tags to your map file:

\begin{verbatim}
CONFIG "MS\_ERRORFILE" "c:/tmp/mapserver.log" # path to log file
DEBUG 5 # debug level 0–5 (5 is most output)
\end{verbatim}

**Configuration of MapServer output is done via a map file**

Configuration of map output with MapServer is done in the map file. The map file is not an XML file (however it probably would be one if MapServer was invented today). It uses tags similar to XML to configure the output and functionalities of MapServer. The Map file online references are located here:

- Official MapServer site
  
  \url{http://mapserver.org/mapfile/index.html#mapfile}

**be aware of map file syntax changes for MapServer version 6**

Note that in MapServer version 6 some of the map file syntax and data handling by MapServer changed from previous versions. This is especially important when using example map files from earlier MapServer versions that can be found in forums or elsewhere on the internet. To review the changes consult the migration guide

\url{http://mapserver.org/MIGRATION\_GUIDE.html#mapserver-5-6-to-6-0-migration}.

**Example of a map file**

\begin{verbatim}
MAP #Start of map file (wacounties.map)
NAME "Washington Counties"
EXTENT 600000 -800000 2750000 1000000 # bounding box (map extent)
SIZE 600 300 # size of output map in pixels
PROJECTION
\end{verbatim}
"init=epsg:2285" # Map Projection WA State Plane N in feet
END

LAYER # Data Layer object
  NAME Counties # name of layer used as a reference by MapServer
  TYPE POLYGON # spatial type
  STATUS ON # status (on/off/default)
  DATA "c:/class/data/layers/counties2008" # input data source (shape file in this case)
  CLASS # classification
    STYLE
      COLOR 255 128 128
      OUTLINECOLOR 96 96 96
      WIDTH 1
  END # Class END
END # Data Layer END
END # Map File

Create map images on the desktop: shp2img

To create a map image from a map file on the desktop shp2img can be used. The output can either be PNG or GIF. This is useful to test your map file. If all goes well an image will be returned. If the image cannot be created an error message on the command line will refer to a line number in the map file. More information at http://www.mapserver.org/utilities/shp2img.html.


-m mapfile: Map file to operate on — required
-i format: Override the IMAGETYPE value to pick output format
-o image: output filename (stdout if not provided)
-e minx miny maxx maxy: extents to render
-s sizex sizey: output image size
-l layers: layers to enable — make sure they are quoted and space separated if more than one listed
-all_debug n: Set debug level for map and all layers
-map_debug n: Set map debug level
Chapter 4. Exercises

−layer_debug layer_name n: Set layer debug level
−c n: draw map n number of times
−p n: pause for n seconds after reading the map
−d layername datavalue: change DATA value for layer

For example to create an image with the Counties and Rail layer in wacounties_wms.map:

shp2img -m c:/class/data/mapfiles/wacounties_wms.map
-l "Counties Rail" -o counties_rail_map.png

4.2.3 MapServer Exercises

4.2.3.1 Making a basic Map

1. Review the basic map file wacounties.map and create a png map image output using shp2img

2. Open the file ../data/map files/wacounties.map in Notepad and add the layers: citynames, rails, and uninhabited areas

3. Review your configuration using shp2img. Troubleshoot any errors

4. Use the reference guides and sample map files (in the end of this booklet) to find the correct syntax for classification of layers by attributes.

5. Classify one of the layers you added to wacounties.map using the EXPRESSION map tag assigning different colors for its attributes (or attribute ranges). Review one example for classification of attribute ranges using the EXPRESSION tag in the map file starting on page 100.

4.2.3.2 Making your own Map

Use the MapServer reference and sample map files in this guide for help. Review your progress periodically using the shp2img utility.

1. Either use the map file created in the above or create a new one. You may use your own data if desired.

2. Add at least five data layers and classify their cartographic representation using class tags.

3. Add scale dependency to the layers in the map file (MAXSCALE/MINSCALE or MAXDENOMSCALE/MINDEMONSCALE) so that they are only available at certain defined scales
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4. Use scale dependency for a layer to change the cartographic output for small scales (overview) and large scales (detailed) for the map output.

5. Add labels to the city layer (or another layer you have defined)

6. Add a tif image file to your map using the RASTER type layer. You may use any of the tif files located in the data/layers/catalog/topography directory. An example of a RASTER Layer (Topography) can also be found in the map file starting on page 100.

7. Add a tiled vector layer as data source to the map using the TILEITEM and TILEINDEX tags. The data/layers/catalog directory contains tiled shape files and their respective tile index shape files (containing the boundaries of the cut shape files) for lakes and rivers on multiple scales.

8. Review how you can tile shape files (and create the tile index files) yourself using the utilities shp2tile\(^4\) and tile4ms\(^5\) (see page 47. One example can be found in the map file data/mapfiles/map_file_library/alliance_base_layers.map for the 50k Tiled Layer Rivers_and_Streams.

4.2.4 Additional Topics

Review the online documentation for these interesting topics:

- Map Templates
- Query Templates
- Variable Substitution

A simple way to embed your map output in a web page are MapServer templates. This is an example "Help me a spider" of a simple HTML file and a respective map file (quoted from the book by Bill Kropla (2005): Beginning MapServer: Open Source GIS Development -Chapter two). Note that MapServer can replace variables that are embedded in brackets[] during run time. In this case MapServer will replace the [img] variable and return the rendered image.

data/mapfiles/helpmespider.html:

\(^4\) cut a big shape into a grid of adjacent shape files

\(^5\) create tile index shapefile for use with MapServer's TILEINDEX feature. This will create a shapefile of rectangular extents of all shapefiles listed. Note that the utility ogrtindex of the OGR-package has similar functionality.
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<!— MapServer Template —>
<html>
<head> <title>MapServer Easy Map</title> </head>
<body>
<form method="POST" action="/cgi-bin/mapserv.exe">
<input type="submit" value="Click Me">
<input type="hidden" name="map" value="c:/class/data/mapfiles/helpmespider.map">
</form>
<p><img src="[img]" width=800 height=400 border=0>
<p>[version]</p>
</body>
</html>

data/mapfiles/helpmespider.map:

MAP #Start of map file
NAME "Washington Counties"
EXTENT 630000 -540000 2700000 780000 # bounding box (map extent)
SIZE 600 300 # size of output map in pixels
WEB
  TEMPLATE "/ms4w/Apache/htdocs/osgis/helpmespider.html"
  IMAGEPATH "/ms4w/tmp/ms_tmp/"
  IMAGEURL "/ms_tmp/"
END
LAYER # Data Layer object
NAME Counties # name of layer used as a reference by MapServer
TYPE POLYGON # spatial type
STATUS DEFAULT # status (on/ off/default)
DATA "c:/class/data/layers/counties2008" # input data source (shapefile in this case)
  CLASS # classification
  OUTLINECOLOR 100 100 100 # color for outline boundary
END # Class END
END # Data Layer END
END # Map File END

4.2.5 Publishing Web Map Services (WMS) with MapServer

To publish a layer or layers as a WMS some additional information is required. One or more layers of a map file can be

One or more layers of a map file can be published as part of a WMS
published as part of a WMS. Depending on the settings, the layers can be accessed by a WMS client (e.g. ArcMap or uDig) independently or as an entirely configured map. A WMS will give back an image if it gets the appropriate GetMap request. Layers configured as DEFAULT will always be output to any incoming request even if they were not requested. Below is an example of a GetMap request asking for

- a map in PNG format
- with the layer States
- in projection EPSG 2285 (Washington State Plane North)
- with bounding box (extent) 630000,-540000,2700000,780000
- in 400 by 300 pixels size

http://terra2.terragis.net/cgi-bin/mapserv?map=/var/www/sites/mapdata/projects/alliance/alliance_background.map&version=1.1.1&service=WMS&request=GetMap&layers=States&srs=EPSG:2285&bbox=630000,-540000,2700000,780000&format=image/png&width=400&height=300&styles=default

The OGC standard defines the type of requests that a WMS supports. The following requests are defined by the standard:

- GetCapabilities http://<computername>/mapserver?map=../demo.map&VERSION=1.1.1&REQUEST=getCapabilities&SERVICE=wms
  \(\Rightarrow\) What can the WMS offer? Returns service-level metadata in XML format

- GetMap (example above) \(\Rightarrow\) returns a map with well-defined geographic and dimensional parameters

- getFeatureInfo (optional)
  \(\Rightarrow\) returns information about features (identify attributes)

- getLegendURL (optional)
  e.g.  http://terra2.terragis.net/cgi-bin/mapserv?map=/var/www/sites/mapdata/projects/alliance/alliance_boundaries.map&version=1.1.1&service=wms&request=getlegendgraphic&layer=Tract_Boundaries&format=image/png
  \(\Rightarrow\) returns a legend graphic

This figure illustrates a client-server architecture for geospatial web services (geoservices). Green color represents read and write paths. Dotted arrowed lines indicate mostly read-only data flow (this figure is freely available from Wikimedia Commons).
Figure 6: Client-server Architecture for geospatial web services
To change a regular layer in a map file into a WMS layer we need to define several METADATA tags for it (see example below). The wms_srs tag defines the output projection(s) that are provided by MapServer and that a client (e.g. OpenLayers) can request:

```
METADATA
  "wms_title" "PrecinctTargets"    # Name of WMS
  "wms_srs" "epsg:3857 epsg:4326" # Spherical Mercator
      and Geographic Projection
  "wms_feature_info_mime_type" "text/html" #Format of
       Query (GetFeatureInfo requests)
  "ows_enable_request" "*" # needed in MS 6 and
      higher to enable WMS requests
END
```

Note that with MapServer you need to use the MapServer layer name (defined in the map file under LAYER, NAME to request it in a HTTP request and not with the wms_title as you might expect). "The latter is used to produce the title element for the layer in a WMS GetCapabilities request and is usually displayed by WMS clients as the human-readable caption of the layer. The MapServer LAYER NAME is mapped to the <Name> element in the WMS GetCapabilities which is the unique name/id of the layer, this is the identifier by which client and server software refer to this layer in GetMap and other requests" (Daniel Morissette communication 2009). The MapServer documentation has more details about the use of WMS with MapServer: [http://mapserver.org/ogc/wms_server.html](http://mapserver.org/ogc/wms_server.html).

### 4.2.6 WMS Exercises

**Publishing your own WMS**

1. Use the map files written during the earlier MapServer exercises and publish the layers as Web Map Services

2. Verify your results via HTTP requests in a web browser (examples for requests are in the section about WMS standards)

3. Try different kind of requests - **GetMap** and **GetLegend** and save the results as files on your laptop. Use the reference guides and this booklet to find the correct syntax
4. Install any or all of the desktop GIS systems on your laptop (gvSIG, QGIS, uDig) and open your WMS on the desktop.

### 4.2.7 MapServer Performance Tips

A good resource to find more information about tuning the performance of MapServer is the reference at [http://www.mapserver.org/optimization/index.html#optimization](http://www.mapserver.org/optimization/index.html#optimization).

#### 4.2.7.1 Tuning your map file for performance:

**Use inline projection parameter definitions** *(spelled out parameters)* in place of EPSG codes. If you want to use EPSG codes, remove all unneeded projection definition records from the Proj4 database. Or put the most used on top of the file.

For every layer in a map file that has a status of ON or DEFAULT, MapServer will load that layer and prepare it for display, even if that layer never gets displayed ⇒ Switch rarely used layers off (don’t use DEFAULT for them).

#### 4.2.7.2 Optimizing the performance of vector data sources

**Splitting your data** (use of filters is slower) with ogr2ogr utility (select on certain features from a data source, and save them to a new data source).

**Shapefiles**

- **Use shptree** to generate a spatial index on your shapefile. This is quick and easy ("shptree foo.shp") and generates a .qix file. MapServer will automatically detect an index and use it. In addition to using Tileindex the data can at the same time also be indexed with shptree.

- **Use the sortshp utility** This reorganizes a shapefile, sorting it according to the values in one of its columns. If you’re commonly filtering by criteria and it’s almost always by a specific column, this can make the process slightly more efficient.

**PostGIS**
**Add indexed primary key**

```
ALTER TABLE table ADD PRIMARY KEY (gid);
```

**Spatial indexing (GIST index)**

```
CREATE INDEX table_the_geom ON table (the_geom)
USING GIST;
```

**Reorganization**

```
CLUSTER the_geom ON table;
```

**Do not close DB connection by default**

```
PROCESSING "CLOSE_CONNECTION=DEFER"
```

**Maximum Image size** influences the time needed for map rendering. Default is 2048. This can be increased by setting in the map file `MAXSIZE [integer]` in pixels.

### 4.2.8 Tools to work with MapServer

Most MapServer distributions come with a number of utility programs (see table below). To run the mapserv.exe utilities, the environment path to the `/ms4w/Apache/cgi-bin` directory must be set. You can

- set the path manually in your Environment Variables or
- run the batch file `/ms4w/setenv.bat` to include this directory in your path

For more information read the online reference guide at [http://www.mapserver.org/utils/](http://www.mapserver.org/utils/).

Additional utilities are included with MS4W in the `../m4w/tools/shapelib` directory. The tools coming with `shapelib` provide tools to work with shapefiles (read/write/update) and to write your own C programs. To mention one of them `shprewind` is a utility that can correct the winding order (sequence of vertices) in a shapefile, and can be used to repair defective shapefiles. Another handy tool is `shp2tile` that divides a (large) shapefile into multiple smaller tiled shapefiles. For more information read the user guide at [http://shapelib.maptools.org/shapelib-tools.html](http://shapelib.maptools.org/shapelib-tools.html). The GDAL utilities provide tools to manipulate raster data. To split large raster files into tiles the python utility `gdal2tiles` comes in handy. From the gdal homepage: *This utility generates a directory with small tiles and metadata, following OSGeo Tile Map Service Specification. Simple web pages with viewers based on Google Maps and OpenLayers are generated as well - so anybody can comfortably explore your maps on-line and you do not need to install or configure any*
Table 12: MapServer utility programs

<table>
<thead>
<tr>
<th>Utility name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>legend</td>
<td>create legend</td>
</tr>
<tr>
<td>msencrypt</td>
<td>encrypt encryption key for connection parameters</td>
</tr>
<tr>
<td>scalebar</td>
<td>create scalebar</td>
</tr>
<tr>
<td>shp2img</td>
<td>create mapoutput</td>
</tr>
<tr>
<td>shptree</td>
<td>create quadtree-based spatial index for a shapefile (a .qix file)</td>
</tr>
<tr>
<td>shptreevis</td>
<td>view quadtree quadrants that are part of a .qix file</td>
</tr>
<tr>
<td>sortshp</td>
<td>sort the records of a shapefile based on a single attribute column (ascending/descending order)</td>
</tr>
<tr>
<td>sym2img</td>
<td>create dump of symbol file in PNG or GIF format</td>
</tr>
<tr>
<td>tile4ms</td>
<td>create tile index shapefile for use with MapServer's TILEINDEX feature. This will create a shapefile of rectangular extents of all shapefiles listed</td>
</tr>
</tbody>
</table>

special software (like MapServer) and the map displays very fast in the web browser. You only need to upload generated directory into a web server. MapTiler is a graphical interface for the gdal2tiles utility http://www.maptiler.org/.

Tools to create MapServer configuration files

You can either write your map file manually using your favorite text editor (e.g. we have seen Notepad++ has syntax highlighting support, Textpad http://www.textpad.com/ syntax file: http://www.textpad.com/add-ons/files/syntax/map_40.zip, and UltraEdit (which itself is not free however). The utilities listed below can help you to write and manage map files:

4.2.9 Notes about MapServer

The following paragraphs are a short collection of handy notes about MapServer and by no means are intended to represent a complete guide to using MapServer. You are encouraged to explore by yourself and revert to the comprehensive MapServer
Table 13: Utility programs for creating MapServer configuration files

<table>
<thead>
<tr>
<th>Utility name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MXD2map</td>
<td>is a Java based command line utility to convert ArcGIS documents (.mxd) files to .map files. Download from <a href="http://www.mxd2map.org/index.html">http://www.mxd2map.org/index.html</a></td>
</tr>
<tr>
<td>AveiN! and AMeiN!</td>
<td>are two utility programs for ArcView 3 and ArcMap respectively that allow you to create a map and to export the result as a .map MapServer configuration file. AMeiN! translates into &quot;ArcMap einfach ins Netz!&quot; which is German for something like: &quot;Loading ArcMap projects into the web made easy!&quot;. Download from <a href="http://sourceforge.net/projects/avein/">http://sourceforge.net/projects/avein/</a></td>
</tr>
<tr>
<td>QGIS 2.X</td>
<td>can export a QGIS project as a .map file with the RT MapServer export plug-in (install via OSgeo4W as a python MapScript installation is needed)</td>
</tr>
<tr>
<td>Scribe</td>
<td>A set of utilities (GUI and Python scripts) that facilitate the creation of MapServer configuration files. More information can be found on the Github page and in initial article.</td>
</tr>
</tbody>
</table>

manual (on DVD) and also available on www.mapserver.org.

Migration from older versions

With each new release of MapServer new features will likely be added to it and bugs fixed, however with mayor version jumps (e.g. from 5.6 to 6.0) there will likely (unfortunately) be some changes to the map file syntax. New map file tags will be introduced and old ones can be replaced and deprecated. Map files obtained from the Internet or other sources can be of great help to build a cartography map file library for yourself. When you are using such map file with newer MapServer versions it will be a good idea to read the migration guide that is published in the MapServer web site. This way you can find out about potential changes that might be required to have your map file working as expected and which changes to your map file might be required. For version 6 (and for earlier versions) the document is located at http:
MapServer Image Rendering Options

MapServer includes a variety of options for producing cartographic output (generating an image file such as jpg, png or gif formats for example). Starting with MapServer version 5 a new rendering engine called AGG (Anti Grain Geometry http://www.antigrain.com) was included. Earlier versions of MapServer had only the 'GD' rendering available which has been removed in version 6 of MapServer. With AGG in newer MapServer versions all output is antialiased which enables very fine cartographic output. Some symbols such as cartographic lines (that where needed to enable anti aliasing in earlier versions of MapServer) are now deprecated (no longer supported). For more information see http://mapserver.org/output/agg.html#introduction. Below is an example for a fairly nice map output configuration balancing rendering time, file size and cartographic quality. Another good comparison of map rendering settings and out for MapServer can be found at http://linfiniti.com/2010/03/comparing-renderers-in-mapserver.

```plaintext
OUTPUTFORMAT
NAME 'AGG_Q' # arbitrary name, call in the map file
DRIVER AGG/PNG # (see below)
IMAGEMODE RGBA
TRANSPARENT OFF
FORMATOPTION "INTERLACE=OFF" # for tilecache this needs to be set to off
FORMATOPTION "QUANTIZE_DITHER=OFF"
FORMATOPTION "QUANTIZE_COLORS=256"
MIMETYPE "image/png"#
END
```

To use the option above add to your map file in the general MAP tag

```plaintext
IMAGETYPE AGG_Q
```

---

6On Wikipedia states ‘Font rasterization is the process of converting text from a vector description (as found in scalable fonts such as TrueType fonts) to a raster or bitmap description. This often involves some anti-aliasing on screen text to make it smoother and easier to read’ see http://en.wikipedia.org/wiki/Font_rasterization
Using True Type Fonts in MapServer on Windows

On many windows operating system versions you can find (true type) fonts (with the *.ttf file extension) on the file system at c:\Windows\Fonts\verdana.ttf. Those fonts can be used by MapServer for rendering labels (or even for using font characters as map symbols). In order to use the files MapServer will need to know about the location when rendering. This information can be indicated in the map file as the location of a text file that lists the fonts you are intending to use and their location (see syntax below). For example see the content of such a file list.txt below.

```plaintext
FONTSET "fonts/list.txt"
```

If the fonts are in the same directory (copy and list only the ones that you are really always using) the content of the text file list.txt could look as shown below to enable fonts verdana, verdana-italic, and wingdng3 (a windows font with many simple symbols)

```
verdana    verdana.ttf
verdana-italic    verdanai.ttf
wingdng3    WINGDNG3.TTF
```
4.3 Using PostGIS

One consideration in the beginning: When to use a spatial database instead of files? Basically a database should only be used in particular use cases:

- editing (multiple users)
- unified storage and access
- bulk processing

Prequisites: PostgreSQL and PostGIS installed

4.3.1 Installing PostGIS

Chapter two of the document "Introduction to PostGIS" (in the workshop materials: Postgis-introduction.pdf) outlines the installation of PostgreSQL and PostGIS. Instead of PostgreSQL version 8.0 in our workshop we are installing newer versions of PostgreSQL and PostGIS accordingly. Note that there were considerable changes from PostGIS version 1.5.X to PostGIS 2.X that also affect the installation process. In the sections below the PostGIS version to which they apply is indicated. In our workshop exercises we will create a database called "osgis" instead of "BC" (as named in the document "Introduction to PostGIS").

- Install PostgreSQL
- Install PostGIS
- Create plpgsql language
  on the SQL console: createlang plpgsql mydb

Changes from PostGIS 1.5.X to versions 2.X

Some highlights of the new functionalities in PostGIS 2.0 and up include raster data support (storage and spatial and analysis functions), comprehensive support for handling 3D data with surfaces and relationships, and the introduction of topology for vector data. Raster files (such as tif files e.g.) can be loaded into the data base using the command line utility raster2pgsql which has similar syntax as shape2pgsql for loading ESRI shapefiles. Raster data can stored be used in two ways with PostGIS - inside and outside the data base. Inside stored raster are loaded into the database as a blob, whereas
out-db rasters are images located on the file system and referenced in a table from within the database (see -R switch in the command line utility reference). This workshop will not cover details of working with PostGIS rasters.

Note that to enable deprecated functionalities in PostGIS 2.X (database functions available in prior versions of PostGIS but not by default in PostGIS 2.X) you can run specific SQL queries in order to enable those. This might be relevant especially if importing data from a PostGIS 1.5 system into PostGIS 2.X after an upgrade (in order to not to have to rewrite many of the functions used in your application).

```bash
# change to SQL script directory
cd C:/Program Files/PostgreSQL/9.3/share/contrib/postgis-2.0/
# enable legacy functions in PostGIS 2.X
psql -d osgis -p 5432 -f legacy.sql
```

**Setup of PostGIS versions 1.5.X (and older)**

The initial step will always be to create a new database. This can be accomplished by either

- using [PgAdmin](https://www.pgadmin.org/) (the GUI based administration tool) on the command line: `createdb osgis -U postgres`

In order to load and enable all PostGIS functionality in PostgreSQL we need to run the following two SQL scripts:

**Loading PostGIS functions, casts etc into the db**

```
c:/Program Files (x86)/PostgreSQL/9.3/share/contrib/postgis-1.5/postgis.sql
```

**Loading the spatial reference table into PostGIS**

```
c:/Program Files (x86)/PostgreSQL/9.3/share/contrib/postgis-1.5/spatial_ref_sys.sql
```

Instead of running these scripts above we also could create a spatially enabled database from a template that has the tables and functions already loaded.

**Setup of PostGIS versions 2.X (and newer)**

Again the initial step will be to create a new database. This can be accomplished by either

- using [PgAdmin](https://www.pgadmin.org/) (the GUI based administration tool) on the command line: `createdb osgis -U postgres`
Chapter 4. Exercises

Starting with version 2.0 PostGIS is a regular Extension of PostgreSQL and can be installed in the same way as other additions to the database as follows:

**Install PostGIS into a database on the command line**
CREATE EXTENSION postgis;

**Install topology support and functions**
CREATE EXTENSION postgis_topology;

**Install tiger data based geocoder**
CREATE EXTENSION postgis_tiger_geocoder;

**Enable fuzzy string match functions for geocoder**
CREATE EXTENSION fuzzystmatch;

4.3.2 Interacting with PostGIS

There are at least two options to interact with PostGIS. One can either use the command line utilities from a DOS prompt, or the Administration tool pgAdminIII that comes with PostGIS. For big data sets it is advisable that we use the command line since that can handle larger datasets than pgAdmin seems to be able to digest.

**PostGIS - command line**

There are manuals covering this topic available so we list here some examples only:

**Creating a database**
createdb osgis -U postgres

**Deleting a database**
dropdb osgis -U postgres

**connecting to a db**
psql -U postgres -d osgis

*after that any sql or psql command can be used*

**psql command to list all tables**
\dt

**psql command list all column of table counties2008**
\d counties2008

**Running SQL from file**
-U postgres -d osgis -f thepath/myfile.sql
PostGIS - Simple Spatial SQL Queries

Some of these examples are taken from the sql file postgis-introduction.sql

— Distance Query

```sql
create table points ( pt geometry, name varchar );
insert into points values ( 'POINT(0 0) ' , ' Origin ' );
insert into points values ( 'POINT(5 0) ' , ' XAxis ' );
insert into points values ( 'POINT(0 5) ' , ' YAxis ' );
select name, AsText( pt ), Distance (pt , 'POINT(5 5) ' ) from points;
drop table points;
```

— Creating a spatial index

```sql
create index counties2008_gidx on counties2008 using gist (the_geom);
```

— Intersection

```sql
select NAME from counties2008 where counties2008 .the_geom &&
    transform ( (( setsrid (( MakePoint(-122.206834, 47.611421)) ,4326)) ) ,2285) and intersects (counties2008 .the_geom,transform(((setsrid((MakePoint(-122.206834, 47.611421)),4326)) ),2285));
```

— Select one spatial feature and reproject:

```sql
select astext ( transform (the_geom,4326) ) from counties2008 limit 1;
```

— Reproject two points from geographic (SRID 4326) to spherical Mercator projection (SRID 3857) and output as test

```sql
select astext(transform((SETSRID(Makepoint(-88.2,37.7),4326)),3857)),
    astext(transform((SETSRID(Makepoint(84.6,41.8),4326)),3857));
```
Chapter 4. Exercises

4.3.3 pgAdmin - Administration of PostGIS

Connecting to a PostgreSQL database in pgAdmin:

![New Server Registration](image)

Figure 7: pgAdmin - Connecting to a DB Server
Figure 8: pgAdmin - Administration Tool for PostgreSQL
Chapter 4. Exercises

4.3.4 Utilities for PostGIS

PostGIS - Import and Export

Two utilities that come with PostGIS allow the import and export of shapefiles from and to PostGIS. Using shp2pgsql one can convert a shapefile into a SQL statement that can be loaded into PostGIS. Using pgsql2shp, a PostGIS layer can be exported and written to a shapefile.

Located in
c:/Program Files (x86)/PostgreSQL/9.3/bin/shp2pgsql.exe

For example to convert the shapefile IN_2008.shp (projection is decimal degrees - SRID 4326) and write to a SQL file "in_2008.sql" use this command (-i option is to use short integers):

shp2pgsql -i -s 4326 IN_2008.shp in_2008 > in_2008.sql

Now to load the data into PostGIS either copy the contents of in_2008.sql into the SQL window of pgAdmin and run or run the SQL from the command line:

-U postgres -d osgis -f thepath/in_2008.sql

In order to load GIS data sources other than shapefiles the ogr2ogr utility can be used (see the table in the resource section for supported data formats). Another option to import data into PostGIS is the OGR Converter Tool, a plug-in that you can install with QGIS). This is an example of loading a dataset from an ESRI Personal Geodatabase into PostGIS using ogr2ogr on the command line:

ogr2ogr -f "PostgreSQL" PG:\"host=localhost user=postgres port=5432 dbname=postgis_in_action password=mypassword\" gadm_v0dot9.mdb -lco GEOMETRY_NAME=the_geom -where "ISO='USA'" -t_srs "EPSG:2163" -nln "us.admin_boundaries" gadm
Loading data from a file into PostGIS and making them spatial

The following work flow is an example to create a table in PostGIS, to load data into the empty table and then converting it into a spatial data set.

— Creating and empty table called wa_voters via SQL

```sql
CREATE TABLE wa_voters
(
    house_number varchar(20),
    predir varchar(6),
    street_name varchar(50),
    postdir varchar(20),
    city varchar(50),
    state varchar(10),
    zip varchar(12),
    latitude float8,
    longitude float8,
    county_code varchar(8),
    ward varchar(12),
    precinct_code varchar(40),
    precinct_name varchar(40),
    code int2,
) WITH OIDS;
ALTER TABLE wa_voters OWNER TO postgres;
```

— Load data with the copy command

```sql
COPY wa_voters FROM '/mnt/storage/wa_voters.txt';
```

— Create spatial features from the new data:

— To add a geometry column (only really needed for PostGIS 1.5 and earlier, but also can still be used in PostGIS 2.X!):

```sql
SELECT AddGeometryColumn('', 'wa_voters', 'the_geom', 4326, 'POINT', 2);
```

— when using PostGIS 2.0 and up one can use instead a column for the geometry in the table definition or add the column subsequently:

```sql
ALTER TABLE wa_voters ADD COLUMN the_geom geometry(Point, 4326);
```

— Update new column with features generated by the Makepoint function, with EPSG (SRID) 4326 (that’s decimal degrees)

```sql
UPDATE wa_voters SET the_geom = SETSRID(Makepoint(longitude, latitude), 4326);
```
— Create a spatial index (very IMPORTANT) on the geometry column:
CREATE INDEX wa_voters_gidx ON wa_voters USING gist(the_geom);

— create sequence (for unique id field):
CREATE SEQUENCE wa_voters_gid_seq

— Add serial Column with unique id called "gid" (also updates all existing fields)
ALTER TABLE wa_voters ADD COLUMN gid serial;
ALTER TABLE wa_voters ALTER COLUMN gid SET STORAGE PLAIN;
ALTER TABLE wa_voters ALTER COLUMN gid SET NOT NULL;
ALTER TABLE wa_voters ALTER COLUMN gid SET DEFAULT nextval('wa_voters_gid_seq'::regclass);

And finally delete the records from the imported table where we could not build a geometry. We just delete entries where geometry is empty: delete from wa_voters where the_geom is null;
Built internal query index for PostgreSQL using the vacuum command:
VACUUM ANALYZE;
Now finally the newly loaded data is usable as input for MapServer.
4.3.5 PostGIS Exercises

1. Review the examples in this chapter.

2. Create a database with the name osgis and a database user osgis using pgAdmin.

3. Spatially enable the new osgis database (create PostGIS extension). Verify if the PostGIS spatial functions are available.

4. Import two shapefiles into PostGIS using shp2pgsql (as described in section 4.3.4 on page 58).

5. Run all the examples listed in Section "Simple Spatial SQL Queries" on page 55 as listed to see the functionalities of PostGIS in action for yourself, or use your own spatial data in similar queries.

6. Following the example in section "Loading data from a file into PostGIS and making them spatial" on page 59 load data from a text file into PostGIS and convert them into a spatial data set. You can use the text file /data/layers/point/locations.csv for this exercise.

7. How could we efficiently store spatial data in multiple projections in PostGIS? What would be a simple way to do this?

8. Write a spatial SQL Select query that uses a SQL WHERE clause with the intersection (true/false) of two features (a point location and a County polygon e.g.) to return the name of the County polygon at the point location. Review this section of the PostGIS documentation for help.

4.3.6 Exercises - PostGIS Layers in MapServer

Additional topics to be covered in the MapServer exercises after completing the chapter on PostGIS:

1. Import a shape file layer of your choice into PostGIS using shp2pgsql (or the shape file loader in pgAdmin)

2. Add the new PostGIS layer to the map file (note use the CONNECTIONTYPE and CONNECTION tags). An example of a PostGIS Layer (Census Tracts Query") can also be found in the map file starting on page 100.
4.3.7 Using PostGIS with MapServer


The data statement for a PostGIS layer in a map file can be very simple:

```
DATA "the_geom from the_table"
```

Very simple, but: how does MapServer know what primary key to use in queries? And what SRID to use when creating the bounding box selection for drawing maps? The answer is, it asks the database for that information. With two extra queries. Every time it processes the layer. However, if you are explicit about your unique key and SRID in configuration, MapServer can, and does, skip querying the back-end for that information.

```
DATA "the_geom from the_table using unique gid using srid=4326"
```

Another good thing is to specify that the open DB connection should not be closed by default (useful for fast-cgi mode and for multiple PostGIS layers in one map file)

```
PROCESSING "CLOSE_CONNECTION=DEFER"
```
4.3.8 Some Notes on PostGIS

To identify which versions of PostGIS and PostgreSQL you are running the following SQL queries can be used:

```sql
SELECT postgis_lib_version();
-- lists PostGIS version (short) : "1.4.0"

SELECT postgis_full_version();
-- lists PostGIS version including GEOS and PROJ version: "POSTGIS ="1.4.0" GEOS="3.1.1–CAPI–1.6.0" PROJ="Rel. 4.6.1, 21 August 2008" USE_STATS"

SELECT version();
-- lists PostgreSQL version: "POSTGIS="1.4.0" GEOS="3.1.1–CAPI–1.6.0" PROJ="Rel. 4.6.1, 21 August 2008" USE_STATS"
```

Information about tuning a PostGIS installation is included in the document "Postgis-for-power-users.ppt" included on the DVD.

The following SQL statements illustrate the use of PostGIS spatial functions: ST_DWithin, ST_Line_Locate_Point, and ST_Line_Interpolate_Point. The queries are extracts from PHP scripts and contain some PHP variables; e.g. $xcoord.

---

**st_within example**

---

**get closest road in tiger data**

```sql
SELECT fullname, tlid, astext(the_geom) FROM roads WHERE ST_DWithin(roads.the_geom, GeomFromText('POINT($xcoord $ycoord)', 9102003), 50) ORDER BY ST_Distance(roads.the_geom, GeomFromText('POINT($xcoord $ycoord)', 9102003)) limit 1;
```

---

**find closest point on tiger data road segment**

```sql
SELECT ST_Line_Locate_Point(ST_LineFromText('LINESTRING($thestreet_wkt_extract_coords)',9102003),GeomFromText('POINT($xcoord $ycoord)', 9102003));
```

---

**calculate point location ratio along tiger data road segment**

```sql
SELECT astext(ST_Line_Interpolate_Point(ST_LineFromText('LINESTRING($thestreet_wkt_extract_coords)',9102003), $theratio));
```

---

The following example illustrates the powerful aggregate functions in PostGIS to create new datasets via union of polygons.

---

**Query 1: Union all counties of the county polygon data set "us_counties" to create the dataset "us_border". This operation unions all individual datasets into one polygon encompassing the area of the entire US.**
Chapter 4. Exercises

```sql
select st_union(the_geom)
into us_border
from us_counties;

−− Query 2: Union all counties of the county polygon data set "us_counties" to create the dataset "us_states". This operation unions all individual datasets and groups them by states (that is union all County polygon features into one polygon that belong to the same state).

select st_union(the_geom), state_name
into us_states
from us_counties
group by state_name;
```
5 Appendix

5.1 OS Desktop GIS Tools

SpatiaLite is a spatial DBMS built on top of SQLite. Both formats are file based and thus are light weight and portable. The spatial components depend on the PROJ and GEOS libraries. Related tools include the RasterLite library to handle Raster data and spatialite-gis (a minimalistic GIS tool). SpatiaLite has the potential to replace shapefiles as a simple data exchange format. Starting with version 1.1 QGIS can read the format, support by OGR/GDAL was included since version 1.7.0.

Quantumnik is a plug-in for QGIS that enables the use of Mapnik as an alternative rendering engine in QGIS. This is useful because Mapnik is said to render the nicest looking maps of all web mapping engines. It also supports on-the-fly translation of QGIS layers and styles into Mapnik objects, enables the export of QGIS projects into Mapnik XML map files, and the loading of Mapnik XML for dynamic rendering in QGIS. The plug-in also requires a working installation of Mapnik. Download here.
5.2 Basic Libraries - Using PROj, OGR, and GDAL

GDAL - the Geospatial Data Abstraction Library (raster) and OGR - the OpenGIS Simple Features Reference Implementation (vector) are a set of tools for reading, writing and processing of raster and vector data sets in many different formats (tables are in the resource section). They are the base for many Desktop GIS systems, e.g. ArcGIS. OGR greatly extends the input formats MapServer can read: Oracle Spatial, ESRI Geodatabase (MDB), TIGER, and MapInfo. PROJ4 is a library for cartographic projection routines. It includes a stand alone projection utility proj and includes support for more than 2500 projections (epsg and esri lists).

About Proj4

The Proj4 project is hosted at http://trac.osgeo.org/proj. The processing of data involving projection routines in OGR and GDAL are based on the Proj library. The Proj4 utilities include:

- Program proj.exe and library proj.dll
- Projection definition files epsg and esri (in proj_lib dir)

Using OGR

OGR includes a collection of utility programs that can be used on the command line to process vector data.

- ogrinfo http://www.gdal.org/ogr/ogrinfo.html
  The ogrinfo utility lists various information about an OGR supported data source.

- ogr2ogr http://www.gdal.org/ogr/ogr2ogr.html
  This program can be used to convert simple features data between file formats performing various operations during the process such as spatial or attribute selections, reducing the set of attributes, setting the output coordinate system or even reprojecting the features during translation.

1EPSG - The European Petroleum Survey Group http://www.epsg.org
• ogrtindex http://www.gdal.org/ogr/ogrtindex.html

The ogrtindex program can be used to create a tile index - a file containing a list of the identities of a bunch of other files along with their spatial extents. This is primarily intended to be used with the UMN MapServer for tiled access to layers using the OGR connection type.

Where is my ArcCatalog? To get meta information about a vector file you can use ogrinfo. For example on the command line we can find out what type of data is stored in counties2008.shp:

```bash
ogrinfo counties2008.shp
```

This gives us:

```
INFO: Open of ‘counties2008.shp’
    using driver ‘ESRI Shapefile’ successful.
1: counties2008 (Polygon)
```

What do the following commands give us?

```bash
ogrinfo counties2008.shp counties2008
```

or connecting to PostGIS layer counties:

```bash
ogrinfo PG:"host=127.0.0.1 user=postgres password=
    postgres dbname=osgis port=5432" counties --summary
```
Chapter 5. Appendix

Determine which spatial types (point, line polygon..) the following data sets are:

- data1.shp
- sunarea.tab
- whatsisit.kml
- data4.shp

**ogr2ogr** Type in `ogr2ogr` at the command line. This will list the options available with the utility. This gives us

Usage: `ogr2ogr [−−help=general] [−skipfailures] [−append] [−update] [−gt n] [−select field_list] [−where restricted_where] [−sql <sql statement>] [−spat xmin ymin xmax ymax] [−preserve_fid] [−fid FID] [−a_srs srs_def] [−t_srs srs_def] [−s_srs srs_def] [−f format_name] [−overwrite] [[−dsco NAME=VALUE] ...] [−segmentize max_dist] dst_datasource_name src_datasource_name [−lco NAME=VALUE] [−nln name] [−nlt type] [layer [layer ...]]

- `−f format_name`: output file format name, possible values are: "ESRI Shapefile", "MapInfo File", "TIGER", "S57", "DGN", "Memory", "BNA", "CSV", "GML", "GPX", "KML", "GeoJSON", "Interlis 1", "Interlis 2", "GMT", "SQLite", "ODBC", "PostgreSQL", "MySQL", "Geoconcept" ...

- Use ogr2ogr to reproject one of the files listed above to a different projection of your choice. Note: use `-t_srs` to specify the target projection.

- Produce a shapefile containing all uninhabited areas that are bigger than 500000000 (square feet) using ogr2ogr:
  Use a select statement with ogr2ogr. Base data is uninhabited.shp, the attribute containing the square feet values is "AREA".

- How can we at the same time convert the output result to a different format - like Geographic Markup Language (GML) or Census Tiger files (TIGER)?
• Create a batch file to convert 3 shapefiles to MapInfo files at once.

Using ogrtindex we can create tile indexes: A shapefile that contains the shapes of data that is split into small tiles which is good practice for larger datasets for use with MapServer.

Using GDAL

Using gdalinfo we can get meta information about raster files.

- Use gdalinfo to retrieve information about "wa_shade_1km.tif". What information does this give us?
- Convert the tiff raster wa_shade_1km.tif into an ECW image using gdal_translate.
- Reproject wa_shade_1km.tif using gdal_translate into geographic projection(epsg:4326). Verify that the output projection is indeed geographic.

5.3 OS Desktop GIS Programs

There is software that supports almost any task one can think of related to the processing, the analysis and the publishing of geospatial data. The following lists software for a variety of common applications in GIS, Remote Sensing and data analysis.

5.3.1 Geographic Resources Analysis Support System (GRASS)

GRASS was originally started in 1982 by the US Army to implement functionality not available in other GIS systems at the time. After it was discontinued in 1995, its revival started in 1997 by Baylor University. Since 2001 the main development is housed at ITC. In 2008 the first standalone windows version was released in April with version 6.2.3. The system was originally started as a Raster GIS and Remote Sensing image analysis software but over the years extensive vector support was added. The capabilities are comparable with Arc/Info and in addition covers image analysis.
Chapter 5. Appendix

Table 14: OS Geospatial Desktop Programs

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic Resources Analysis Support System (GRASS)</td>
<td>Desktop GIS</td>
</tr>
<tr>
<td>User friendly Desktop Internet GIS (uDig) and JGrass</td>
<td></td>
</tr>
<tr>
<td>Quantum GIS (QGIS) and Open Ocean Map</td>
<td></td>
</tr>
<tr>
<td>OpenJUMP</td>
<td></td>
</tr>
<tr>
<td>gvSIG</td>
<td></td>
</tr>
<tr>
<td>MapWindow</td>
<td></td>
</tr>
<tr>
<td>The Generic Mapping Tools (GMT)</td>
<td>Raster map automation</td>
</tr>
<tr>
<td>Spatial Data Integrator</td>
<td>Extract Translate Load (ETL)</td>
</tr>
<tr>
<td>Open Source software Image Map (OSSIM)</td>
<td>Remote Sensing</td>
</tr>
<tr>
<td>The R Project for Statistical Computing (R)</td>
<td>Statistical software, scripting language</td>
</tr>
</tbody>
</table>

Table 15: GRASS Project

<table>
<thead>
<tr>
<th>Main supporter of GRASS</th>
<th>GRASS Development Team, ITC, Trento, Italy (since 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Comprehensive Desktop GIS and Image analysis</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Unix/Linux, Windows (2008)</td>
</tr>
<tr>
<td>Project started</td>
<td>1982, open source since 1999</td>
</tr>
<tr>
<td>Implementation</td>
<td>C</td>
</tr>
<tr>
<td>OS libraries</td>
<td>OGR/GDAL</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>GPL</td>
</tr>
</tbody>
</table>

The Masters Thesis by Buchanan compares the functionality of Arc/Info 9.0 and GRASS 6.0 (see in references). One conclusion is that GRASS has some weaknesses in the ease of use of the user interface. However, this can be mediated by using QGIS (with the GRASS plug-in) or JGrass/uDig to remote
control its functionality.

5.3.2 User friendly Desktop Internet GIS (uDig) and JGrass

One of the goals of uDig, the "User-friendly Desktop Internet GIS" is to bring Internet resources to the desktop GIS user. It is a desktop GIS with editing capabilities based on the GeoTools library and has strong capabilities to connect to Internet resources such as WMS/WFS and other network resources. Thus it combines the strength of a Desktop viewer, editor and general GIS with access to web based services, databases and other resources. JGrass is a uDig based GIS for hydrological and geomorphological analysis. uDig is the UI for JGrass. The functions in JGrass are either GRASS functions rewritten in Java or wrapped GRASS analysis functions. To install it, use a package that includes uDig from the JGrass website.

Table 16: uDig Project

<table>
<thead>
<tr>
<th>Main supporter of uDig</th>
<th>Refractions Research, Victoria, Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Multilingual Desktop GIS</td>
</tr>
<tr>
<td>Functionality</td>
<td>Strong WMS/WFS support, Styled Layer Descriptor (SLD) support, vector editing, advanced map theming using ColorBrewer</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Multi platform, Unix/Linux, Windows (2008)</td>
</tr>
<tr>
<td>Implementation</td>
<td>Java, using Eclipse for development GeoTools</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>LGPL</td>
</tr>
</tbody>
</table>

5.3.3 Quantum GIS (QGIS)

QGIS was originally developed as a GIS viewing environment for the Linux desktop but is available for Solaris, Windows and Mac operating systems. Data sources for Quantum GIS can be PostGIS and shapefiles as vector data sources. Internally, QGIS uses the OGR library and therefore supports all OGR raster formats e.g. DEM, ArcGrid, ERDAS, SDTS, and GeoTIFF.
Table 17: Quantum GIS (QGIS) Project

<table>
<thead>
<tr>
<th>Main supporter of Quantum GIS</th>
<th>Gary Sherman and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Desktop GIS Viewer</td>
</tr>
<tr>
<td>Functionality</td>
<td>Can be used as a UI to GRASS GIS with GRASS Plug-in, Python bindings allow for programmatic interaction</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Multi platform</td>
</tr>
<tr>
<td>Project started</td>
<td>2002</td>
</tr>
<tr>
<td>Implementation</td>
<td>C++, Depends on QT widget</td>
</tr>
<tr>
<td>OS libraries</td>
<td>OGR/GDAL</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>GPL</td>
</tr>
</tbody>
</table>

5.3.4 OpenJUMP - JUMP (JAVA Unified Mapping Platform)

OpenJUMP

JUMP is the "JUMP Unified Mapping Platform". It did experience some ups and downs during its development and as a result is available in a variety of "flavors" such as JUMP, OpenJUMP, and Kosmo. It was designed as an environment extensible platform into which spatial data conflation could be embedded (which was a major initial goal for its support by the British Columbia Ministry of Sustainable Resource Management). It provides functionality for viewing, and processing of spatial data. GML or "Geography Markup Language" is used for its main data format, but also can read and write shapefile, dxf and PostGIS vector data formats. Notably OpenJUMP is a great tool for editing, QA and correction of spatial data with problem solving capabilities.
Table 18: OpenJUMP Project

<table>
<thead>
<tr>
<th>Main supporter of OpenJUMP</th>
<th>Vivid Solutions and Kosmo-SAIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Desktop GIS in a Variety of &quot;Flavors&quot; (JUMP / OpenJUMP / Kosmo)</td>
</tr>
<tr>
<td>Functionality</td>
<td>Desktop GIS - Viewer - Analysis, powerful editing and QA environment, e.g. shape-file problem resolving capabilities</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Multi platform</td>
</tr>
<tr>
<td>Project started</td>
<td>2002</td>
</tr>
<tr>
<td>Implementation</td>
<td>Java</td>
</tr>
<tr>
<td>OS libraries</td>
<td>JTS Topology Suite</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>LGPL</td>
</tr>
</tbody>
</table>
5.3.5 gvSIG - Generalitat Valencia Sistema de Información Geográfica

gvSIG is a project of the Spanish province of Valencia. The goals of the project are to provide an open source GIS that is platform independent and based on open source standards. Basically the capabilities should be comprehensive enough to replace ESRI’s ArcView 3 desktop GIS. The user interface and functionalities of gvSIG are similar to ArcView 3, but in addition has capabilities to connect to Internet mapping services. The integration of a new labeling library "PAL" enables better labeling and brings gvSIG closer to having the same labeling support that is available in proprietary software such as ArcGIS. Another Java based project of the autonomous region of Extremadura called Sextante can be installed as a plug-in and offers more than 300 spatial analysis functions.

Table 19: gvSIG Project

<table>
<thead>
<tr>
<th>Main supporter of gvSIG</th>
<th>Generalitat Valencia (GVA) - Province of Valencia, Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Desktop GIS</td>
</tr>
<tr>
<td>Functionality</td>
<td>Multilingual Desktop GIS - Viewer - Analysis, analysis functions can be greatly extended when installing Sextante</td>
</tr>
<tr>
<td>Operating systems</td>
<td>Unix/Linux, Windows</td>
</tr>
<tr>
<td>Project started</td>
<td>2003</td>
</tr>
<tr>
<td>Implementation</td>
<td>Java</td>
</tr>
<tr>
<td>OS libraries</td>
<td>GeoTools and JTS</td>
</tr>
<tr>
<td>PostGIS support</td>
<td>Yes</td>
</tr>
<tr>
<td>License</td>
<td>GPL</td>
</tr>
</tbody>
</table>
5.4 General Resources

5.4.1 Popular FOSS4G Licenses

GNU-GPL

Quoted from http://en.wikipedia.org/wiki/GNU_General_Public_License: The GNU General Public License (GNU GPL or simply GPL) is a widely used free software license, originally written by Richard Stallman for the GNU project. The GPL is the most popular and well-known example of the type of strong copyleft license that requires derived works to be available under the same copyleft. Under this philosophy, the GPL is said to grant the recipients of a computer program the rights of the free software definition and uses copyleft to ensure the freedoms are preserved, even when the work is changed or added to. This is in distinction to permissive free software licenses, of which the BSD licenses are the standard examples. The GNU Lesser General Public License (LGPL) is a modified, more permissive, version of the GPL, originally intended for some software libraries. There is also a GNU Free Documentation License, which was originally intended for use with documentation for GNU software, but has also been adopted for other uses, such as the Wikipedia project. The Affero General Public License (GNU AGPL) is a similar license with a focus on networking server software. The GNU AGPL is similar to the GNU General Public License, except that it additionally covers the use of the software over a computer network, requiring that the complete source code be made available to any network user of the AGPLed work, for example a web application. The Free Software Foundation recommends that this license is considered for any software that will commonly be run over the network.

LPGL

Quoted from http://en.wikipedia.org/wiki/LGPL: The GNU Lesser General Public License (formerly the GNU Library General Public License) or LGPL is a free software license published by the Free Software Foundation. It was designed as a compromise between the strong-copyleft GNU General Public License or GPL and permissive licenses such as the BSD licenses and the MIT License. The GNU Lesser General Public License was written in 1991 (and updated in 1999, and again in 2007) by Richard Stallman, with legal advice from Eben Moglen. The LGPL places copyleft restrictions on the program itself but does not apply these restrictions to other software that merely links with the program. There are, however, certain other restrictions on this software. The LGPL is primarily used for software libraries, although it is also used by some stand-alone applications, most notably Mozilla and OpenOffice.org.

MIT

Quoted from http://en.wikipedia.org/wiki/MIT_license: The MIT License is a free software license originating at the Massachusetts Institute of Technology (MIT), used by the MIT X Consortium. It is a permissive license, meaning that it permits reuse within proprietary software on the condition that the license is distributed with that software, and GPL-compatible, meaning that
the GPL permits combination and redistribution with software that uses the MIT License. According to the Free Software Foundation, the MIT License is more accurately called the X11 license, since MIT has used many licenses for software and the license was first drafted for the X Window System. Software packages that use the MIT License include Expat, PuTTY, Mono development platform class libraries, Ruby on Rails, Lua 5.0 onwards and the X Window System, for which the license was written. Some software packages dual license their products under the MIT License, such as older versions of the cURL library, which allowed recipients to choose either the Mozilla Public License or the MIT License.

**BSD**

Quoted from [http://en.wikipedia.org/wiki/BSD_license](http://en.wikipedia.org/wiki/BSD_license): BSD licenses represent a family of permissive free software licenses. The original was used for the Berkeley Software Distribution (BSD), a Unix-like operating system for which the license is named. The original owners of BSD were the Regents of the University of California because BSD was first written at the University of California, Berkeley. The first version of the license was revised, and the resulting licenses are more properly called modified BSD licenses. Permissive licenses, sometimes with important differences pertaining to license compatibility, are referred to as "BSD-style licenses". Several BSD-like licenses, including the New BSD license, have been vetted by the Open Source Initiative as meeting their definition of open source. The licenses have few restrictions compared to other free software licenses such as the GNU General Public License or even the default restrictions provided by copyright, putting it relatively closer to the public domain.

**Mozilla**

Quoted from [http://en.wikipedia.org/wiki/Mozilla_Public_License](http://en.wikipedia.org/wiki/Mozilla_Public_License): The Mozilla Public License (MPL) is a free and open source software license. Version 1.0 was developed by Mitchell Baker when she worked as a lawyer at Netscape Communications Corporation and version 1.1 at the Mozilla Foundation.[3] The MPL is characterized as a hybridization of the modified BSD license and GNU General Public License. The MPL is the license for the Mozilla Application Suite, Mozilla Firefox, Mozilla Thunderbird and other Mozilla software. The MPL has been adapted by others as a license for their software, most notably Sun Microsystems, as the Common Development and Distribution License for OpenSolaris, the open source version of the Solaris 10 operating system, and by Adobe, as the license for its Flex product line.
Chapter 5. Appendix

5.4.2 Books


5.4.3 Articles


Comparison Of Geographic Information System Software (ArcGIS 9.0 And GRASS 6.0): Implementation And Case Study MS Thesis by Todd R. Buchanan, Fort Hays State University. 100 pages.


Current state of technology and potential of Smart Map Browsing (2007) in web browsers using the example of the Free web mapping application OpenLayers by Emanuel Schütze. 128 pages.


5.4.4 General Web Sites

Table 20: FOSS4G web sites

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free GIS Project</td>
<td><a href="http://www.freegis.org">http://www.freegis.org</a></td>
</tr>
<tr>
<td>Open source GIS list</td>
<td><a href="http://opensourcegis.org">http://opensourcegis.org</a></td>
</tr>
<tr>
<td>Map Tools</td>
<td><a href="http://maptools.org">http://maptools.org</a></td>
</tr>
<tr>
<td>OSGeo</td>
<td><a href="http://www.osgeo.org">http://www.osgeo.org</a></td>
</tr>
</tbody>
</table>
## 5.4.5 Open source utilities

Table 21: Open source utilities

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Feature Library (OGR)</td>
<td><a href="http://www.gdal.org/ogr">www.gdal.org/ogr</a></td>
</tr>
<tr>
<td>Geospatial Data Abstraction Library (GDAL)</td>
<td><a href="http://www.gdal.org">www.gdal.org</a></td>
</tr>
<tr>
<td>GeoTools</td>
<td><a href="http://geotools.org/">http://geotools.org/</a></td>
</tr>
<tr>
<td>PROJ4 (Cartographic Projections Library)</td>
<td><a href="http://trac.osgeo.org/proj">http://trac.osgeo.org/proj</a></td>
</tr>
<tr>
<td>FWTools (utility collection)</td>
<td><a href="http://fwtools.maptools.org">http://fwtools.maptools.org</a></td>
</tr>
<tr>
<td>MapTiler (GUI to tile Rasters)</td>
<td><a href="http://www.maptiler.org/">http://www.maptiler.org/</a></td>
</tr>
<tr>
<td>GMT</td>
<td><a href="http://gmt.soest.hawaii.edu">http://gmt.soest.hawaii.edu</a></td>
</tr>
<tr>
<td>TerraLib</td>
<td><a href="http://www.terralib.org">http://www.terralib.org</a></td>
</tr>
<tr>
<td>Spatial Data Integrator (ETL tool)</td>
<td><a href="http://www.spatialdataintegrator.com">www.spatialdataintegrator.com</a></td>
</tr>
<tr>
<td>Geokettle (ETL tool)</td>
<td><a href="http://www.geokettle.org">www.geokettle.org</a></td>
</tr>
<tr>
<td>Open Source Software Image Map (OSSIM)</td>
<td><a href="http://www.ossim.org">http://www.ossim.org</a></td>
</tr>
<tr>
<td>The R Project for Statistical Computing</td>
<td><a href="http://www.r-project.org">http://www.r-project.org</a></td>
</tr>
</tbody>
</table>
### 5.4.6 Web Mapping Software

Table 22: Web Mapping Software

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MapServer</td>
<td><a href="http://mapserver.org">http://mapserver.org</a></td>
</tr>
<tr>
<td>MapServer and Node.js</td>
<td><a href="https://github.com/pagameba/node-mapserver">https://github.com/pagameba/node-mapserver</a></td>
</tr>
<tr>
<td>GeoServer</td>
<td><a href="http://geoserver.org">http://geoserver.org</a></td>
</tr>
<tr>
<td>Mapnik</td>
<td><a href="http://www.mapnik.org">http://www.mapnik.org</a></td>
</tr>
<tr>
<td>Mapnik and Node.js</td>
<td><a href="https://github.com/mapnik/node-mapnik">https://github.com/mapnik/node-mapnik</a></td>
</tr>
<tr>
<td>Deegree</td>
<td><a href="http://www.deegree.org">http://www.deegree.org</a></td>
</tr>
<tr>
<td>MapGuide</td>
<td><a href="http://mapguide.osgeo.org">http://mapguide.osgeo.org</a></td>
</tr>
<tr>
<td>OpenLayers</td>
<td><a href="http://www.openlayers.org">www.openlayers.org</a></td>
</tr>
<tr>
<td>Polymaps (JS, SVG)</td>
<td><a href="http://polymaps.org/">http://polymaps.org/</a></td>
</tr>
<tr>
<td>Leaflet (lightweight JS Library)</td>
<td><a href="http://leaflet.cloudmade.com">http://leaflet.cloudmade.com</a></td>
</tr>
<tr>
<td>Modestmaps (lightweight JS Library)</td>
<td><a href="http://modestmaps.com">http://modestmaps.com</a></td>
</tr>
<tr>
<td>Mapstraction (lightweight JS Library)</td>
<td><a href="http://mapstraction.com">http://mapstraction.com</a></td>
</tr>
<tr>
<td>Mapbender</td>
<td><a href="http://www.mapbender.org">www.mapbender.org</a></td>
</tr>
<tr>
<td>MapFish</td>
<td><a href="http://www.mapfish.org">http://www.mapfish.org</a></td>
</tr>
<tr>
<td>GeoDjango (now merged into Django)</td>
<td><a href="https://www.djangoproject.com/">https://www.djangoproject.com/</a></td>
</tr>
<tr>
<td></td>
<td>formerly</td>
</tr>
<tr>
<td>MapQuery (for use with jQuery)</td>
<td><a href="http://mapquery.org">http://mapquery.org</a></td>
</tr>
<tr>
<td>D3 (Data-Driven Documents)</td>
<td><a href="http://d3js.org/">http://d3js.org/</a></td>
</tr>
</tbody>
</table>

### 5.4.7 Additional tools for use with OpenLayers

Table 23: OpenLayers additional tools

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>i2maps (geocomputing environment to use with OpenLayers)</td>
<td><a href="http://ncg.nuim.ie/i2maps">http://ncg.nuim.ie/i2maps</a></td>
</tr>
<tr>
<td>Acidmaps (interpolated map images with Geoserver/OpenLayers )</td>
<td><a href="http://acidmaps.org">http://acidmaps.org</a></td>
</tr>
<tr>
<td>OpenLayers Editor (from Geops)</td>
<td><a href="https://github.com/geops/ole">https://github.com/geops/ole</a></td>
</tr>
</tbody>
</table>
5.4.8 Map Tiling engines

Table 24: Map Tiling engines

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>TileCache</td>
<td><a href="http://www.tilecache.org">www.tilecache.org</a></td>
</tr>
<tr>
<td>GeoWebCache</td>
<td><a href="http://geowebcache.org">http://geowebcache.org</a></td>
</tr>
<tr>
<td>MapProxy (tiles, server proxy, security)</td>
<td><a href="http://mapproxy.org">http://mapproxy.org</a></td>
</tr>
<tr>
<td>MapCache</td>
<td><a href="http://www.mapserver.org/">http://www.mapserver.org/</a></td>
</tr>
<tr>
<td></td>
<td>mapcache/</td>
</tr>
<tr>
<td>Tilemill (map styling)</td>
<td><a href="http://mapbox.com/tilemill">http://mapbox.com/tilemill</a></td>
</tr>
</tbody>
</table>

5.4.9 Databases and Additional Software

Table 25: Databases and Additional Software

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PostgreSQL</td>
<td><a href="http://www.postgresql.org">www.postgresql.org</a></td>
</tr>
<tr>
<td>PostGIS</td>
<td><a href="http://postgis.refractions.net">http://postgis.refractions.net</a></td>
</tr>
<tr>
<td>SpatiaLite</td>
<td><a href="http://www.gaia-gis.it/spatialite">http://www.gaia-gis.it/spatialite</a></td>
</tr>
<tr>
<td>Geocouch (document based db)</td>
<td><a href="https://github.com/couchbase/geocouch">https://github.com/couchbase/geocouch</a></td>
</tr>
<tr>
<td>Proj4js</td>
<td><a href="http://proj4js.org">http://proj4js.org</a></td>
</tr>
<tr>
<td>FeatureServer</td>
<td><a href="http://featureserver.org/">http://featureserver.org/</a></td>
</tr>
<tr>
<td>WAS,WSS, and WSC (52N Security Community)</td>
<td><a href="http://52north.org">http://52north.org</a></td>
</tr>
<tr>
<td>GeoPrisma (security)</td>
<td><a href="http://geoprisma.org">http://geoprisma.org</a></td>
</tr>
<tr>
<td>GeoShield (security)</td>
<td><a href="http://sites.google.com/site/geoshieldproject">http://sites.google.com/site/geoshieldproject</a></td>
</tr>
<tr>
<td>GeoExt</td>
<td><a href="http://www.geoext.org">http://www.geoext.org</a></td>
</tr>
<tr>
<td>Ext JS</td>
<td><a href="http://www.sencha.com">http://www.sencha.com</a></td>
</tr>
</tbody>
</table>
5.4.10 Desktop GIS List

Table 26: Desktop GIS

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MapWindow</td>
<td><a href="http://www.mapwindow.org">www.mapwindow.org</a></td>
</tr>
<tr>
<td>OpenJump</td>
<td><a href="http://openjump.org">http://openjump.org</a></td>
</tr>
<tr>
<td>GRASS</td>
<td><a href="http://grass.osgeo.org">http://grass.osgeo.org</a></td>
</tr>
<tr>
<td>QGIS</td>
<td><a href="http://www.qgis.org">http://www.qgis.org</a></td>
</tr>
<tr>
<td>Quantumnik</td>
<td><a href="https://github.com/springmeyer/quantumnik/">https://github.com/springmeyer/quantumnik/</a></td>
</tr>
<tr>
<td>gvSIG</td>
<td><a href="http://www.gvsig.org">http://www.gvsig.org</a></td>
</tr>
<tr>
<td>gvSIG CE</td>
<td><a href="http://gvsigce.org/">http://gvsigce.org/</a></td>
</tr>
<tr>
<td>uDig</td>
<td><a href="http://udig.refractions.net">http://udig.refractions.net</a></td>
</tr>
<tr>
<td>JGrass</td>
<td><a href="http://code.google.com/p/jgrass">http://code.google.com/p/jgrass</a></td>
</tr>
<tr>
<td>TerraLib</td>
<td><a href="http://www.terralib.org">http://www.terralib.org</a></td>
</tr>
</tbody>
</table>

5.4.11 GIS Samplers, Live DVDs, and Compilations

Table 27: GIS Samplers, Live DVDs, and Compilations

<table>
<thead>
<tr>
<th>Name</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSGEO Live DVD image</td>
<td><a href="http://live.osgeo.org">http://live.osgeo.org</a></td>
</tr>
<tr>
<td>GIS Virtual Machine</td>
<td><a href="http://www.gisvm.com">http://www.gisvm.com</a></td>
</tr>
<tr>
<td>MapServer for Windows</td>
<td><a href="http://maptools.org/ms4w/index.phtml">http://maptools.org/ms4w/index.phtml</a></td>
</tr>
<tr>
<td>OSGEO for Windows</td>
<td><a href="http://trac.osgeo.org/osgeo4w">http://trac.osgeo.org/osgeo4w</a></td>
</tr>
<tr>
<td>Ubuntu GIS</td>
<td><a href="https://wiki.ubuntu.com/UbuntuGIS">https://wiki.ubuntu.com/UbuntuGIS</a></td>
</tr>
</tbody>
</table>
5.4.12 Conferences

Table 28: Free and Open Source Software for Geospatial (FOSS4G)

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Dates</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Nottingham, UK</td>
<td>September 17-21, 2013</td>
<td><a href="http://2013.foss4g.org">http://2013.foss4g.org</a></td>
</tr>
<tr>
<td>2010</td>
<td>Barcelona, Spain</td>
<td>September 6-9, 2010</td>
<td><a href="http://2010.foss4g.org">http://2010.foss4g.org</a></td>
</tr>
<tr>
<td>2009</td>
<td>Sydney, Australia</td>
<td>October 20-23, 2009</td>
<td><a href="http://2009.foss4g.org">http://2009.foss4g.org</a></td>
</tr>
<tr>
<td>2007</td>
<td>Victoria, Canada</td>
<td>September 2007</td>
<td><a href="http://www.foss4g2007.org">http://www.foss4g2007.org</a></td>
</tr>
<tr>
<td>2006</td>
<td>Lausanne, Switzerland</td>
<td>September 2006</td>
<td><a href="http://www.foss4g2006.org">http://www.foss4g2006.org</a></td>
</tr>
</tbody>
</table>

5.4.13 User Groups

Cascadia Users of Geospatial Open Source: Seattle based GIS user group. Monthly meeting every 3rd Wednesday, 6:00 pm. Mostly in the LizardTech offices, located near Pioneer Square. http://www.cugos.org

5.4.14 Mailing Lists

Table 29: Mailing Lists

<table>
<thead>
<tr>
<th>List</th>
<th>email or URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>List archives</td>
<td><a href="http://osgeo-org.1803224.n2.nabble.com">http://osgeo-org.1803224.n2.nabble.com</a></td>
</tr>
<tr>
<td>Mapbender</td>
<td><a href="mailto:mapbender_users@lists.osgeo.org">mapbender_users@lists.osgeo.org</a></td>
</tr>
<tr>
<td>PostGIS</td>
<td><a href="mailto:postgis-users@postgis.refractions.net">postgis-users@postgis.refractions.net</a></td>
</tr>
<tr>
<td>PostgreSQL</td>
<td><a href="mailto:pgsql-general@postgresql.org">pgsql-general@postgresql.org</a></td>
</tr>
<tr>
<td>MapServer</td>
<td><a href="mailto:mapserver-users@lists.osgeo.org">mapserver-users@lists.osgeo.org</a></td>
</tr>
<tr>
<td>GeoServer</td>
<td><a href="mailto:geoserver-users@lists.sourceforge.net">geoserver-users@lists.sourceforge.net</a></td>
</tr>
<tr>
<td>OpenLayers</td>
<td><a href="mailto:users@OpenLayers.org">users@OpenLayers.org</a></td>
</tr>
<tr>
<td>TileCache</td>
<td><a href="mailto:tilecache@OpenLayers.org">tilecache@OpenLayers.org</a></td>
</tr>
<tr>
<td>MapFish</td>
<td><a href="mailto:users@mapfish.org">users@mapfish.org</a></td>
</tr>
</tbody>
</table>

5.4.15 Internet Relay Chat (IRC)

URL: irc://freenode.net Channels for Mapbender, PostGIS, PostgreSQL, MapServer, GeoServer, OpenLayers, and MapFish. One client to use for IRC is Chatzilla. Chatzilla is an add-on to Mozilla Firefox. More information here
### 5.4.16 Meeting the Pros

Table 30: Meeting the Pros

<table>
<thead>
<tr>
<th>Name</th>
<th>Focus</th>
<th>blog/website/info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet OSGeo (Blog Aggregator)</td>
<td>All mixed</td>
<td><a href="http://planet.osgeo.org">http://planet.osgeo.org</a></td>
</tr>
<tr>
<td>Paul Ramsey</td>
<td>PostGIS, MapServer</td>
<td><a href="http://blog.cleverelephant.ca">http://blog.cleverelephant.ca</a></td>
</tr>
<tr>
<td>Christopher Schmidt</td>
<td>OpenLayers, FeatureServer</td>
<td><a href="http://crschmidt.net/blog">http://crschmidt.net/blog</a></td>
</tr>
</tbody>
</table>
5.4.17 Installing a Web GIS Server from the Ubuntu GIS Repository

Note that this is not a comprehensive guide but in short one needs to add the Ubuntu repositories to the server apt list, which on a typical system is located at /etc/apt/sources.list. It is a good idea to determine exactly which operating system version the server is running (if you not already aware of it) for example see below you are running Ubuntu Hardy Heron.

```bash
lsb_release -c
> hardy
% this means you are running the hardy version of Ubuntu
```

The following lines need to be added to the sources.list using a text editor:

```bash
deb http://ppa.launchpad.net/ubuntugis/ppa/ubuntu hardy main
deb-src http://ppa.launchpad.net/ubuntugis/ppa/ubuntu hardy main
```

The next step is to authenticate the repository (314DF160 is the OpenPGP key of the Ubuntu GIS repository):

```bash
sudo apt-key adv --keyserver keyserver.ubuntu.com --recv-keys 314DF160
```

Starting with Ubuntu 9.10 (Karmic Koala) the Launchpad PPA (Personal Package Archive) repositories can also be added via command line (without manually editing the sources.list file and no need to authenticate the repository):

```bash
sudo apt-get install python-software-properties
sudo add-apt-repository ppa:ubuntugis/ppa
```

After updating your apt utility software package list you will be ready to start the GIS installation

```bash
sudo apt-get update
```

The following is an example for an installation sequence to set-up a Web Mapping enabled GIS Server. You see that all available packages can be installed (and also later be removed if needed) not only GIS components.

```bash
# install apache version 2
sudo apt-get install apache2

# install php
sudo apt-get install php5 libapache2-mod-php5
sudo apt-get install php5-cli
sudo apt-get install php5-cgi
sudo apt-get install php5-mysql # for MySql
sudo apt-get install php5-pgsql # for PostgreSQL

# install gdal
sudo apt-get install gdal-bin
```
# install proj
    sudo apt-get install proj

# install PostgreSQL and PostGIS
    sudo apt-get install postgresql-8.4.4
    apt-get install postgresql-server-dev-8.4 libpq-dev
    apt-get install libgeos-dev
    sudo apt-get install postgis-1.5

At this point you may take care of initial PostgreSQL housekeeping tasks (but you can also save that for later)

    # To set a password for the postgres database user this on the
    command line
    psql -c "ALTER user postgres WITH PASSWORD 'postgres';"

    # Switch to postgres user
    sudo su - postgres

    # Create the plgsql language inside the database template:
    createlang -d template_postgis plpgsql

Continue with the installation of Mapserver and Tilecache:

# install mapserver
    sudo apt-get install cgi-mapserver
    sudo apt-get install mapserver-bin

# install python image library
    sudo apt-get install libjpeg62 libjpeg62-dev zlib1g-dev

# install tilecache
    sudo apt-get install tilecache
### 5.4.18 GDAL and OGR Formats

**Table 31: GDAL Raster Formats**

<table>
<thead>
<tr>
<th>Long Format Name</th>
<th>Code</th>
<th>Creation</th>
<th>Georef.</th>
<th>Max.size</th>
<th>Compiled by default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arc/Info ASCII Grid</td>
<td>AAIGrid</td>
<td>Yes</td>
<td>Yes</td>
<td>2GB</td>
<td>Yes</td>
</tr>
<tr>
<td>ACE2</td>
<td>ACE2</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>ADRG/ARC Digitized Raster (.gen/.thf)</td>
<td>ADRG</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Arc/Info Binary Grid (.adf)</td>
<td>AIG</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>AIRSAR Polarimetric</td>
<td>AIRSAR</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Magellan BLX Topo (.blx, .xlb)</td>
<td>BLX</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Bathymetry Attributed Grid (.bag)</td>
<td>BAG</td>
<td>No</td>
<td>Yes</td>
<td>2GiB</td>
<td>No, needs <code>libhdf5</code></td>
</tr>
<tr>
<td>Microsoft Windows Device Bitmap (.bmp)</td>
<td>BMP</td>
<td>Yes</td>
<td>Yes</td>
<td>4GiB</td>
<td>Yes</td>
</tr>
<tr>
<td>BSB Nautical Chart Format (.kap)</td>
<td>BSB</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes, can be disabled</td>
</tr>
<tr>
<td>VTP Binary Terrain Format (.bt)</td>
<td>BT</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>CEOS (Spot for instance)</td>
<td>CEOS</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>DRDC COASP SAR Processor Raster</td>
<td>COASP</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>TerraSAR-X Complex SAR Data Product</td>
<td>COSAR</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Convair PolGASP data</td>
<td>CPG</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>USGS LULC Composite Theme Grid</td>
<td>CTG</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Spot DIMAP (metadata.dim)</td>
<td>DIMAP</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>ELAS DIPEx</td>
<td>DIPEX</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>DODS / OPeNDAP</td>
<td>DODS</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>No, needs <code>libdap</code></td>
</tr>
<tr>
<td>First Generation USGS DOQ (.doq)</td>
<td>DOQ1</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>New Labelled USGS DOQ (.doq)</td>
<td>DOQ2</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Long Format Name</td>
<td>Code</td>
<td>Creation</td>
<td>Georef.</td>
<td>Max.size</td>
<td>Compiled by default</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>--------</td>
<td>----------</td>
<td>---------</td>
<td>----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Military Elevation Data (.dt0, .dt1, .dt2)</td>
<td>DTED</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Arc/Info Export E00 GRID</td>
<td>E00GRID</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>ECRG Table Of Contents (TOC.xml)</td>
<td>ECRGTOC</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>ERDAS Compressed Wavelets (.ecw)</td>
<td>ECW</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>No, needs ECW SDK</td>
</tr>
<tr>
<td>ESRI .hdr Labelled</td>
<td>EHdr</td>
<td>Yes</td>
<td>Yes</td>
<td>No limits</td>
<td>Yes</td>
</tr>
<tr>
<td>Endas Imagine Raw</td>
<td>EIR</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>NASA ELAS</td>
<td>ELAS</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>ENVI .hdr Labelled Raster</td>
<td>ENVI</td>
<td>Yes</td>
<td>Yes</td>
<td>No limits</td>
<td>Yes</td>
</tr>
<tr>
<td>Epsilon - Wavelet compressed images</td>
<td>EPSILON</td>
<td>Yes</td>
<td>No</td>
<td>–</td>
<td>No, needs EPSILON library</td>
</tr>
<tr>
<td>ERMapper (.ers)</td>
<td>ERS</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Envisat Image Product (.n1)</td>
<td>ESAT</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>EOSAT FAST Format</td>
<td>FAST</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>FIT</td>
<td>FIT</td>
<td>Yes</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>FITS (.fits)</td>
<td>FITS</td>
<td>Yes</td>
<td>No</td>
<td>–</td>
<td>No, needs libcfitsio</td>
</tr>
<tr>
<td>Fuji BAS Scanner Image</td>
<td>FujiBAS</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Generic Binary (.hdr Labelled)</td>
<td>GENBIN</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Oracle Spatial Geo-Raster</td>
<td>GEORASTER</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>No, needs Oracle client libraries</td>
</tr>
<tr>
<td>GSat File Format Graphics Interchange Format (.gif)</td>
<td>GFF</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Gif</td>
<td>GIF</td>
<td>Yes</td>
<td>No</td>
<td>2GB</td>
<td>Yes (internal GIF library provided)</td>
</tr>
<tr>
<td>WMO GRIB1/GRIB2 (.grb)</td>
<td>GRIB</td>
<td>No</td>
<td>Yes</td>
<td>2GB</td>
<td>Yes, can be disabled</td>
</tr>
<tr>
<td>GMT Compatible netCDF</td>
<td>GMT</td>
<td>Yes</td>
<td>Yes</td>
<td>2GB</td>
<td>No, needs libnetcdf</td>
</tr>
<tr>
<td>GRASS Rasters</td>
<td>GRASS</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>No, needs libgrass</td>
</tr>
<tr>
<td>GRASS ASCII Grid</td>
<td>GRASS</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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### GDAL Raster Formats continued from previous page

<table>
<thead>
<tr>
<th>Long Format Name</th>
<th>Code</th>
<th>Creation</th>
<th>Georef.</th>
<th>Max.size</th>
<th>Compiled by default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Software ASCII Grid</td>
<td>GSAG</td>
<td>Yes</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Golden Software Binary Grid</td>
<td>GSBG</td>
<td>Yes</td>
<td>No</td>
<td>4GB</td>
<td>Yes</td>
</tr>
<tr>
<td>Golden Software Surfer 7 Binary Grid</td>
<td>GS7BG</td>
<td>No</td>
<td>No</td>
<td>4GiB</td>
<td>Yes</td>
</tr>
<tr>
<td>GSC Geogrid</td>
<td>GSC</td>
<td>Yes</td>
<td>No</td>
<td>–</td>
<td>Yes (internal libtiff and libgeotiff provided)</td>
</tr>
<tr>
<td>TIFF / BigTIFF / GeoTIFF (.tif)</td>
<td>GTiff</td>
<td>Yes</td>
<td>Yes</td>
<td>4GiB classical TIFF / limits BigTIFF</td>
<td>No for</td>
</tr>
<tr>
<td>NOAA .gtx vertical datum shift</td>
<td>GTX</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>GXF - Grid eXchange File</td>
<td>GXF</td>
<td>No</td>
<td>Yes</td>
<td>4GiB</td>
<td>Yes</td>
</tr>
<tr>
<td>Hierarchical Data Format Release 4 (HDF4)</td>
<td>HDF4</td>
<td>Yes</td>
<td>Yes</td>
<td>2GiB</td>
<td>No, needs lbdf</td>
</tr>
<tr>
<td>Hierarchical Data Format Release 5 (HDF5)</td>
<td>HDF5</td>
<td>No</td>
<td>Yes</td>
<td>2GiB</td>
<td>No, needs libhdf5</td>
</tr>
<tr>
<td>HF2/HFZ heightfield raster</td>
<td>HF2</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Erdas Imagine (.img)</td>
<td>HFA</td>
<td>Yes</td>
<td>Yes</td>
<td>No limits2</td>
<td>Yes</td>
</tr>
<tr>
<td>Image Display and Analysis (WinDisp)</td>
<td>IDA</td>
<td>Yes</td>
<td>Yes</td>
<td>2GB</td>
<td>Yes</td>
</tr>
<tr>
<td>ILWIS Raster Map (.mpr,.mpl)</td>
<td>ILWIS</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Intergraph Raster</td>
<td>INGR</td>
<td>Yes</td>
<td>Yes</td>
<td>2GiB</td>
<td>Yes</td>
</tr>
<tr>
<td>USGS Astrogeology ISIS cube (Version 2)</td>
<td>ISIS2</td>
<td>Yes</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>USGS Astrogeology ISIS cube (Version 3)</td>
<td>ISIS3</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>JAXA PALSAR Product Reader (Level 1.1/1.5)</td>
<td>JAXAPALSAR</td>
<td>No</td>
<td>No</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Japanese DEM (.mem)</td>
<td>JDEM</td>
<td>No</td>
<td>Yes</td>
<td>–</td>
<td>Yes (internal libjpeg provided)</td>
</tr>
<tr>
<td>JPEG JFIF (.jpg)</td>
<td>JPEG</td>
<td>Yes</td>
<td>Yes</td>
<td>4GB</td>
<td>No, needs CharLS library</td>
</tr>
<tr>
<td>JPEG-LS</td>
<td>JPEGLS</td>
<td>Yes</td>
<td>No</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>
## Chapter 5. Appendix

<table>
<thead>
<tr>
<th>Long Format Name</th>
<th>Code</th>
<th>Creation</th>
<th>Georef.</th>
<th>Max.size</th>
<th>Compiled by default</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPEG2000 (.jp2, .j2k)</td>
<td>JPEG2000</td>
<td>Yes</td>
<td>Yes</td>
<td>2GiB</td>
<td>No, needs libjasper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No, needs ECW SDK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No, needs Kakadu library</td>
</tr>
<tr>
<td>JPEG2000 (.jp2, .j2k)</td>
<td>JP2ECW</td>
<td>Yes</td>
<td>Yes</td>
<td>500MB</td>
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### Chapter 5. Appendix

#### GDAL Raster Formats continued from previous page

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## Table 32: OGR Vector Formats

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<td>SDTS</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Norwegian SOSI Standard</td>
<td>SOSI</td>
<td>No</td>
<td>Yes</td>
<td>No, needs FYBA library</td>
</tr>
<tr>
<td>SQLite/SpatiaLite</td>
<td>SQLite</td>
<td>Yes</td>
<td>Yes</td>
<td>No, needs libsqlite3 or libspatialite</td>
</tr>
<tr>
<td>SUA</td>
<td>SUA</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SVG</td>
<td>SVG</td>
<td>No</td>
<td>Yes</td>
<td>No, needs libexpat</td>
</tr>
<tr>
<td>UK .NTF</td>
<td>UK. NTF</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>U.S. Census TIGER/Line</td>
<td>TIGER</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

94
<table>
<thead>
<tr>
<th>Long Format Name</th>
<th>Code</th>
<th>Creation</th>
<th>Georef.</th>
<th>Compiled by default</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFK data</td>
<td>VFK</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VRT - Virtual Datasource</td>
<td>VRT</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>OGC WFS (Web Feature Service)</td>
<td>WFS</td>
<td>Yes</td>
<td>Yes</td>
<td>No, needs libcurl</td>
</tr>
<tr>
<td>X-Plane/Flightgear aeronautical data</td>
<td>XPLANE</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
5.5 Sample Map files for MapServer

A basic map file

MAP #Start of map file
NAME "Washington Counties"
EXTENT 600000 −800000 2750000 1000000 # bounding box (map extent)
SIZE 600 300 # size of output map in pixels
LAYER # Data Layer object
   NAME Counties # name of layer used as a reference by MapServer
   TYPE POLYGON # spatial type
   STATUS DEFAULT # status (on/off/default)
   DATA ". / / / layers/counties2008" # input data source (shapefile in this case)
CLASS # classification
   OUTLINECOLOR 100 100 100 # color for outline boundary
END # Class END
END # Data Layer END
END # Map File END

An intermediate map file

MAP # Start of map file
NAME "alliance"
EXTENT 630000 −540000 2700000 780000 # Bounding box coordinates in Projection set below (epsg:2285)
FONTSET "../layers/fonts/fonts.txt" # Fonts files for true type fonts
SIZE 400 400 # output size of the map in pixels
UNITS FEET # map units
IMAGECOLOR 204 221 255 #
IMAGETYPE PNG # output file type
INTERLACE ON # enable interlacing for png image (faster loading)

   PROJECTION # start
   projection of the map
"init=epsg:2285"  # epsg :2285 from epsg coming with Proj4 is
Washington State Plane North
  # projection
end tag

LEGEND
  #
  keysize 15 15  # size of legend
  boxes
  keyspacing 5 2  # spacing
  between legend boxes
END  # legend end tag

# Start of web interface definition
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

WEB
  # start general web
  definitions
    METADATA  # Metadata tag
      start
      "wms_title" "Layers"  # name of WMS
        service, below location of the configuration map
        file
      "wms_onlineresource" "http://localhost/mapserver/
          mapserv.exe?map=d:/web/mapdata/projects/alliance/
          alliance.map"
      "wms_srs" "epsg:2285 epsg:4326"  # list of spatial
          reference systems, multiple entries enable
          multiple outputs to be requested
      "wms_feature_info_mime_type" "text/html"  # format of
          the GetFeatureInfo request when identifying
          feature attributes
      "ows_enable_request" "*"  # for MapServer version
      >= 6 WMS output needs to be enabled explicitly
      END  # end Metadata
    END  # end tag general
web definitions

# Start of symbol definitions
#%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
### Symbol Definitions

```plaintext
SYMBOL
symbol definitions
NAME 'point'
TYPE ELLIPSE
POINTS 1 1 END
FILLED TRUE
# start vector symbol
END
# end vector symbol

# Start of layer definitions
LAYER
NAME "States"
TYPE POLYGON
STATUS ON
DATA "./wa_states"
TEMPLATE "templates/wa_states_template.html"
CLASS
color 240 240 230
# Color (in this case polygon fill)
DUMP true
# parameter that is required to enable WMS output
PROJECTION
projection of the layer
"init=epsg:2285"
epsg:2285 from epsg coming with Proj4 is Washington State Plane North
END
# layer projection end tag
```
Chapter 5. Appendix

METADATA start
"wms_title" "States"   # name of this individual WMS layer
"wms_srs" "epsg:2285 epsg:4326"   # list of spatial reference systems this layer is available in
"wms_feature_info_mime_type" "text/html"   # format of the GetFeatureInfo request
"ows_enable_request" "*"   # for MapServer version >= 6 WMS output needs to be enabled explicitly
END   # Metadata tag start

END   # end layer tag

# End of map file
A more complex map file with a PostGIS layer

MAP  # Start of map file
NAME "alliance_all2"
EXTENT 630000 −540000 2700000 780000
FONTSET "/var/www/fonts/fonts.txt"
SIZE 400 400
MAXSIZE 16384
UNITS FEET
IMAGECOLOR 204 221 255
IMAGETYPE PNG_1
# IMAGETYPE PNG
# INTERLACE ON

OUTPUTFORMAT
NAME 'AGG'
DRIVER AGG/PNG
IMAGEMODE RGB
FORMATOPTION "INTERLACE=ON"
END

OUTPUTFORMAT
NAME 'AGG_Q'
DRIVER AGG/PNG
IMAGEMODE RGB
FORMATOPTION "QUANTIZE_FORCE=ON"
FORMATOPTION "QUANTIZE_DITHER=OFF"
FORMATOPTION "QUANTIZE_COLORS=256"
FORMATOPTION "INTERLACE=ON"
END

OUTPUTFORMAT
NAME 'PNG_1'
DRIVER "GD/PNG"
MIMETYPE "image/png"
IMAGEMODE PC256
EXTENSION "png"
END

### Start of projection definition ###
# NAD83 / Washington North (ftUS) epsg <2285>
# PROJECTION
# "proj=lcc"
# "lat_1=48.733333333333333"
# "lat_2=47.5"
# "lat_0=47"
# "lon_0=-120.83333333333333"
# "x_0=500000.0001016001"
# "y_0=0"
# "ellps=GRS80"
# "datum=NAD83"
# "to_meter=0.3048006096012192"
# END

PROJECTION
   "init=epsg:2285"
END

LEGEND
   keysize 16 12
   keyspacing 5 2
   TRANSPARENT ON
   LABEL
       PARTIALS FALSE
       TYPE TrueType
       FONT 'verdana'
       SIZE 8
       COLOR 1 1 1
   END
END

# Start of web interface definition
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # #

WEB
   HEADER "templates/general_header_template.html"
   FOOTER "templates/general_footer_template.html"
   ERROR "http://alliance.terragis.net/mapserver_error.html"
   EMPTY "http://alliance.terragis.net/query_empty.html"
   LOG "/var/www/sites/mapbender/log/mapserver_ocla.log"
   METADATA
   "wms_title" "alliance_all"
   "wms_onlineresource" "http://alliance.terragis.net/cgi-bin/mapserver.fcgi?map=/var/www/mapdata/projects/alliance/alliance2.map"
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"wms_srs" "epsg:2285 epsg:4326"
"wms_feature_info_mime_type" "text/html"
"ows_enable_request" "*" # for MapServer version
>= 6 WMS output needs to be enabled explicitly
END

# Start of symbol definitions
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
SYMBOL
  NAME 'point'
  TYPE ELLIPSE
  POINTS 1 1 END
  FILLED TRUE
END

# Start of layer definitions
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
LAYER
  NAME "States"
  # GROUP "Boundaries"
  TYPE POLYGON
  STATUS ON
  DATA "mapdata/catalog/political/wa_states"
  HEADER "templates/table_header_template.html"
  FOOTER "templates/table_footer_template.html"
  TEMPLATE "templates/wa_states_template.html"
  CLASS
    COLOR 240 240 230
END
  DUMP true
  METADATA
    "wms_title" "States"
    "wms_srs" "epsg:2285 epsg:4326"
    "wms_feature_info_mime_type" "text/html"
END

LAYER
  NAME "Topography"
  TYPE RASTER
Chapter 5. Appendix

EXPRESSION ([INSTITUTN] > 400 AND [INSTITUTN] <= 1500)
STYLE
COLOR 178 194 141
END

CLASS
NAME "1,501 − 4,000"
EXPRESSION ([INSTITUTN] > 1500 AND [INSTITUTN] <= 4000)
STYLE
COLOR 255 240 204
END

CLASS
NAME "4,001 − 8,500"
EXPRESSION ([INSTITUTN] > 4000 AND [INSTITUTN] <= 8500)
STYLE
COLOR 255 153 153
END

CLASS
NAME "More than 8.500"
EXPRESSION ([INSTITUTN] > 8500)
STYLE
COLOR 230 0 0
END

LAYER
NAME "Census Tracts Query"
CONNECTIONTYPE postgis
CONNECTION "user=test password=test dbname=test host=localhost"
PROCESSING "CLOSE_CONNECTION=DEFER"
DATA "the_geom from (select the_geom, id, fipsstco, trt2000, stfid, tractid, area, acres, sq_miles, pop_100, name, gid from wa_tracts %replacementvalue%) as temp using unique gid using SRID=2285"
TYPE POLYGON
# TRANSPARENCY 50
A map file layer with a raster tile index

# Start of layer definitions

LAYER

NAME "Orthos2008"
TILEINDEX "/data/ortho_image_index"  # shapefile of the raster tile extents
# can be produced using gdaltindex (builds a shapefile with a record for each input raster file, an attribute containing the file name, and a polygon geometry outlining the raster.)
TILEITEM "location"  # attribute containing the file name (in dbf file)
TYPE RASTER
STATUS OFF
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PROJECTION
  "init=esri:4326"
END
DUMP true
METADATA
"wms_title" "Orthos2008"
"wms_srs" "epsg:4326 epsg:3857"
"wms_feature_info_mime_type" "text/html"
"ows_enable_request" "*" # for MapServer version
  >= 6 WMS output needs to be enabled explicitly
END
END
5.6 OpenLayers Viewer: Examples OL 2

Commercial background layers and MapServer WMS

Note that this example using Google maps v3.2 (work with OpenLayers 2.10 and higher). Compare the example on the DVD: data/openlayers/ol_map_simple.html.

```html
<html>
<head>
<title>MapServer WMS Layer on Top of Commercial maps</title>
<script src="../openlayers/OpenLayers.js"></script>
<script src="http://maps.google.com/maps/api/js?v=3.2&sensor=false"></script>
<script type="text/javascript">
var map;
var options = {
  projection: new OpenLayers.Projection("EPSG:3857"),
  units: "m",
  maxResolution: 156543.0339,
  maxExtent: new OpenLayers.Bounds(-13776237, 5870705,
                                   -13270618, 6177605)
};

window.onload = function(){
  map = new OpenLayers.Map( 'map' , options ) ;
  var Counties = new OpenLayers.Layer.WMS( "counties",
    "/cgi-bin/mapproxy.exe?map=C:/class/data/mapfiles/
    wacounties_wms.map", {layers: 'Counties', 'transparent': true}, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile:true} ) ;
  var Rail = new OpenLayers.Layer.WMS( "rail",
    "/cgi-bin/mapproxy.exe?map=C:/class/data/mapfiles/
    wacounties_wms.map", {layers: 'Rail', 'transparent': true }, {isBaseLayer: false, 'opacity': 0.7, 'visibility': true , singleTile:true} ) ;
  var Cities = new OpenLayers.Layer.WMS( "cities",
    "/cgi-bin/mapproxy.exe?map=C:/class/data/mapfiles/
    wacounties_wms.map", {layers: 'Cities', 'transparent': true }, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile:true} ) ;
  var Uninhabited = new OpenLayers.Layer.WMS( "uninhabited",
    "/cgi-bin/mapproxy.exe?map=C:/class/data/mapfiles/
    wacounties_wms.map", {layers: 'Uninhabited', 'transparent': true }, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile:true} ) ;
};
</script>
</head>
</html>
```
Chapter 5. Appendix

```javascript
transparent': true}, {isBaseLayer: false, 'opacity': 0.7, 'visibility': false, singleTile: true});

var base_empty = new OpenLayers.Layer("No Background", {isBaseLayer: true, numZoomLevels: 20, 'displayInLayerSwitcher': true, basename: "empty"});
map.addLayer(base_empty);
var g_street = new OpenLayers.Layer.Google("Google Streets", {'maxZoomLevel': 20}); map.addLayer(g_street);
var g_satellite = new OpenLayers.Layer.Google("Google Satellite", {type: google.maps.MapTypeId.SATELLITE, 'maxZoomLevel': 20});
var g_hybrid = new OpenLayers.Layer.Google("Google Hybrid", {type: google.maps.MapTypeId.HYBRID, 'maxZoomLevel': 20});
var g_physical = new OpenLayers.Layer.Google("Google Physical", {type: google.maps.MapTypeId.TERRAIN, 'maxZoomLevel': 20});
map.addLayers([g_street, g_hybrid, g_satellite, g_physical, base_empty, Uninhabited, Cities, Rail, Counties]);

var bounds = new OpenLayers.Bounds(-13776237, 5870705, -13270618, 6177605);
map.zoomToExtent(bounds);
map.addControl(new OpenLayers.Control.LayerSwitcher());
mp = new OpenLayers.Control.MousePosition();

mp.displayProjection = new OpenLayers.Projection("EPSG:3857");
map.addControl(mp);
}; // end bracket of window.onload function
</script>
</head>
<body>
<div id="title"> <h1 class="style2">Simple OL Map — OS Web GIS Class</h1> </div>
</body>
</html>

Commercial layers in OpenLayers 2

Below are some HTML/Javascript code snippets to illustrate how to add commercial layers to an OpenLayers map. For a full example file look at /data/openlayers/alllayers.html on the DVD.

<!— MapQuest Layer —>
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```
    name: "MapQuestOSM",
    // attribution: "Data CC-By-SA by <a href='http://openstreetmap.org/'>OpenStreetMap</a>",
    sphericalMercator: true,
    url: 'http://otile1.mqcdn.com/tiles/1.0.0/osm/${z}/${x}/${y}.png',
    clone: function (obj) {
        if (obj === null) {
            obj = new OpenLayers.Layer.OSM(
                this.name, this.url, this.getOptions());
        }
        obj = OpenLayers.Layer.XYZ.prototype.clone.apply(this, [obj]);
        return obj;
    },
    CLASS_NAME: "OpenLayers.Layer.MapQuestOSM"
});

<!— Bing Layers ——>
// API key for http://openlayers.org. Please get your own at
// http://bingmapsportal.com/ and use that instead.
var BingApiKey = "AqTGBsziZHIJYYxgivLBf0hVdrAk9mWO5cQcb8Yux8sW5M8c8opEC2lZqKR1ZZXF";
var b_street = new OpenLayers.Layer.Bing({'key': BingApiKey, type: "Road",name: "Bing Roads map"});
b_street.buffer = 0; map.addLayer(b_street);
var b_satellite = new OpenLayers.Layer.Bing({'key': BingApiKey,type: "Aerial", name: "Bing Aerial"});
b_satellite.buffer = 0; map.addLayer(b_satellite);
var b_hybrid = new OpenLayers.Layer.Bing({'key': BingApiKey,type: "AerialWithLabels",name: "Bing Hybrid"});
b_hybrid.buffer = 0; map.addLayer(b_hybrid);

<!— Open Street Map Layer ——>
var mapnik = new OpenLayers.Layer.OSM("Open Street Map");
mapnik.buffer = 0; map.addLayer(mapnik);

<!— Google V3 API Layers ——>
<html>
<head>
    <!— include the Google V3.2 API, no key needed but still need to include the API—>
```
var g_streets = new OpenLayers.Layer.Google("Google Roads", // the default
    {numZoomLevels: 20}
    // default type, no change needed here);

var g_satellite = new OpenLayers.Layer.Google(
    "Google Satellite",
    {type: google.maps.MapTypeId.SATELLITE, numZoomLevels: 22}
    // in OL 2.9 and Google v2 this used to be {type: G_SATELLITE_MAP,
    // numZoomLevels: 22});
g_satellite.buffer = 0; map.addLayer(g_satellite); // add to map no tile buffer

var g_hybrid = new OpenLayers.Layer.Google(
    "Google Hybrid",
    {type: google.maps.MapTypeId.HYBRID, numZoomLevels: 20}
    // in OL 2.9 and Google v2 this used to be {type: G_HYBRID_MAP,
    // numZoomLevels: 20});
g_hybrid.buffer = 0; map.addLayer(g_hybrid); // add to map no tile buffer

var g_terrain = new OpenLayers.Layer.Google(
    "Google Terrain",
    {type: google.maps.MapTypeId.TERRAIN}
    // in OL 2.9 and Google v2 this used to be {type: G_PHYSICAL_MAP});
</script>
</head>
</html>
Chapter 5. Appendix

OpenLayers examples included on the class DVD

A long list of general OL examples can be found here for OL 2.X and here for OL 3. Another interesting web page with OpenLayers 2 examples can be found here. There are five examples included on the DVD in the /data/openlayers/identify directory:

- **map.html** Identify office location point features on the map (often multiple in one location); display attributes using a MapServer query template (compare code listing in the next section). If you like to implement this example locally you can import the location point data from the DVD data/layers/officelocations.shp into PostGIS using shp2pgsql. View live example here.

- **map_controls.html** Example of multiple controls in OL: edit tool bar, scale bar, and navigation tool bar (pan and zoom). The navigation tool bar is placed in a <div> tag to change it’s position (located outside the right upper corner of the map). View live example here.

- **map_dynamic.html** Demo of a dynamic MapServer layer. Click on the map to highlight a County. This is a server side implementation and uses the dynamic (PostGIS based) MapServer Layer querylayer in query.map. Clicking on a County on the map triggers an Ajax call and runs a query to PostGIS (via the getCounty.php script) to retrieve the County name. This value is then used for the replacement variable updating the dynamic layer in OL. Sounds tricky doesn’t it? But this set-up enables any functionality to be run on the retrieved feature on the server side in PostGIS, including analysis like buffers and intersections or any custom function you may want to write in PL/pgSQL. View live example here.

- **map_staticbuffer.html** Similar to map_dynamic.html, but also buffers the County feature geometry before highlighting on the map. View live example here.

- **alllayers.html** Example file with many base layers at once: Google (v3.2), Bing, Open Street Map, and MapQuest. Compare the code snippets for the individual map layer on page 108. View live example here.

Map files and OL style sheet used with the above examples:

- **style.css** OL standard style sheet

- **query.map** map file with two dynamic layers called querylayer and bufferlayer (including a MapServer replacement variable

- **identify.map** map file with a point layer of office locations with specified MapServer query templates, e.g. locations_template.html

- **getCounty.php** returns the County name from the counties layer in PostGIS

Below is a list of the MapServer query templates used in map.html (for retrieving the identified feature attributes and styling of the output). When running a query, all of the template below are assembled (in the listed sequence) at runtime by MapServer. The result is a HTML table including the results.
Code Listing for map.html: Example for identifying attributes in OL (getfeatureinfo request)

This example is included on the DVD /data/OpenLayers/identify/map.html along with the map file identify.map.

```html
<html>
<head>
<title>Template Example</title>
<style type="text/css">
    #mapandlegend {
        width: 940;
        height: 650;
        position: relative;
    }
    #map {
        width: 700;
        height: 600;
        border: 1px solid black;
    }
    #thelegend {
        width: 220;
        height: 100;
        border: 1px solid black;
        padding: 12px;
        position: absolute;
        top:0px;
        right:−10px;
    }
    #results {
        width: 220;
        height: 160;
        right: 0;
        position: absolute;
        top:140px;
        font-size: 10 pt;
```
Chapter 5. Appendix

```javascript
var options = {
    maxResolution: 898,
    projection: new OpenLayers.Projection("EPSG:2285"),
    units: "m",
    tileSize: new OpenLayers.Size(256, 256),
    maxExtent: new OpenLayers.Bounds(680000, -150000, 1600000, 740000)
};

window.onload = function (){
    map = new OpenLayers.Map( 'map' , options ) ;
    var base = new OpenLayers.Layer.WMS("Base Map",
        "http://alliance.terragis.net/cgi-bin/mapserv?map=/var/www
        /mapdata/projects/alliance/alliance2.map" , {layers: 'States,Puget_Sound,Counties,Cities,Roads,Lakes,Rivers,
        Major_City_Names,Main_City_Names,City_Names' ,
        transparent': true}, {isBaseLayer:true , 'opacity': 1,
        'visibility ': true, singleTile:true} ) ;

    var locations = new OpenLayers.Layer.WMS( "Office Locations",
        "http://localhost/cgi-bin/mapserv.exe?map=C:/class/data/
        mapfiles/identify.map" , {layers: 'locations' ,
        transparent': true, 'WEBSQL': 'roads'}, {isBaseLayer:
        false , 'opacity': 0.7 , 'visibility ': false, singleTile
        :true} ) ;

    var bounds = new OpenLayers.Bounds(680000, -150000, 1600000, 740000);
    map.addLayers([base,locations]);
    map.zoomToExtent(bounds);
    map.addControl( new OpenLayers.Control.LayerSwitcher() );
    mp=new OpenLayers.Control.MousePosition();
    mp.displayProjection = new OpenLayers.Projection("EPSG:2285");
    map.addControl(mp);

    map.events.register('click', map, function (e) {
        OpenLayers.Util.getElementById('results').innerHTML = "One second...";
        var url = locations.getFullRequestString({
```
REQUEST: "GetFeatureInfo",
EXCEPTIONS: "application/vnd.ogc.se_xml",
BBOX: locations.map.getExtent().toBBOX(),
X: e.xy.x,
Y: e.xy.y,
INFO_FORMAT: 'text/html',
MODE: 'nquery',
FEATURE_COUNT: 2,
QUERY_LAYERS: locations.params.LAYERS,
WIDTH: locations.map.size.w,
HEIGHT: locations.map.size.h});

OpenLayers.loadURL(url, '', this, setHTML);
OpenLayers.Event.stop(e);
}

function setHTML(response) {
OpenLayers.Util.getElement('results').innerHTML = response.responseText;
}

</script>
</head>
<body><div id="title">Template Example — Office Location Map</div>
<div id="mapandlegend">
<div id="map"></div>
<div id="thelegend"><span class="style1">Offices</span>
<div><img src="http://localhost/cgi–bin/mapserv.exe?map=C:/class/data/mapfiles/identify.map&version=1.1.1&service=WMS&request=GetLegendGraphic&layer=locations&format=image/png" alt="Offices"></div>
</div>
<div id="results"></div>
</div>
</body>
</html>
Chapter 5. Appendix

```html
<div><img src="http://orca.terragis.net/cgi-bin/mapserv?map=/var/www/mapdata/projects/examples/identify.map&version=1.1.1&service=WMS&request=GetLegendGraphic&layer=locations&format=image/png" alt="Offices"></div>
</body>
</html>
```
Example for using TileCache layers in OpenLayers 2

A description for installing TileCache can be found here: [http://tilecache.org](http://tilecache.org) The following lines of code illustrate how TileCache based layers can be added to the JavaScript section in the OL web page:

```javascript
```

The snippet below shows the configuration of one of the above TileCache layers **mymap_base** in tilecache.cfg (the TC configuration file). The value for `maxresolution` can be determined as follows: Take your `maxExtent` and find the width of it in map units. This is literally the value of east minus the west in our case below:

\[-117.115453 - (-117.459654) = 0.344201 \text{ degrees}\]

Now we need to divide the width by the number of pixels in which it should be rendered. Given that a tile defaults to 256x256, this means that dividing the width by 256 would fit the entire map into 1 tile. Dividing by 1024 (256*4) fits it into 4 tiles. Example:

\[0.344201 / 1024 = 0.000672267578125\]

The value above is the **maxResolution** for our example. This should be used in the definition on the OpenLayers page. In tilecache.cfg this value needs to be entered along with the `maxExtent` and the **numZoomLevels** (number of zoom levels):

```ini
[mymap_base] type=WMS
metaTile=true
url=http://localhost/cgi-bin/mapserv?map=/maps/mymap.map
srs=EPSG:4326
layers=Ocean,Parks,Landmarks,Lakes,Rivers,Lagoons,Roads,Railway,Citynames
bbox=-117.459654,32.960546,-117.115453,33.282610
maxresolution = 0.0003361337890625
levels=7
extent_type=loose
```
5.7 PAQs: Participant Asked Questions

How can the output of the MapServer legend be styled?

The LEGEND definition in the map file gives you a fair amount of customization options such as label font, font size, key icon width and height etc. Images can be used for the legend by specifying the KEYIMAGE parameter in the CLASS object.

```
LEGEND
  keysize 16 12  # width and height of generated icon
  keyspaceing 5 2  # spacing between icons
  TRANSPARENT ON  # background set transparent
  LABEL
    TYPE TRUETYPE  # Font category
    FONT 'verdana'  # Font (needs to be installed and path known to mapserver
    SIZE 8  # Font Size
    COLOR 1 1 1  # RGB color value
END
END
```

Another option is to use MapServer HTML templates instead of the legend graphics (gif format) generated by default. A simple solution is to incorporate a HTTP GetLegendGraphic request as a HTML image source tag into our web page or application. More information at mapserver.org.

Which charting tools are available for use in my web application?

One simple option are the MapServer Chart layers. They provide simple Pie and Bar charts and are easily configured. Pie Charts are the default chart type. This can also be set by typing

```
PROCESSING "CHART_TYPE=PIE"
```

In the following example (taken from the MapServer documentation) for each shape in the layer’s data source, the STYLE SIZE is used to set the relative size (value) of each pie slice, with the angles of the slices that are automatically computed so as to form a full pie:

```
LAYER
  NAME "Ages"
  TYPE CHART
  CONNECTIONTYPE postgis
  CONNECTION "blabla"
  DATA "the_geom from demo"
  PROCESSING "CHART_TYPE=pie"
  PROCESSING "CHART_SIZE=30"
  STATUS ON
  CLASS
```
In the example above, if for a given shape we have v1006=1000, v1007=600 and v1008=400 then the actual pie slices for each class will be respectively 50, 30 and 20 percent of the total pie size.

Here are three more options to explore:

In MS4W OWTchart a CGI based solution is included: http://www.maptools.org/owtchart. "The OWTChart Engine produces GIF images of virtually any type of chart from a set of input parameters. The program can be used as a CGI in a web server environment, in which case it will return a GIF image with the chart built from the parameters found in the QUERY_STRING part of the URL, or from the body of a POST request."

How can we connect from MapServer to MS SQL Server 2008?

Answer: via a MapServer plug-in. This example is taken from http://mapserver.org/development/rfc/ms-rfc-38.html?highlight=sql%20server mapserver.org

```
LAYER
  NAME "Roads"
  CONNECTIONTYPE PLUGIN
  PLUGIN "C:\class\software\ms4w\Apache\specialplugins\msplugin_mssql2008.dll"
```
How can we join data from a DBF file to a shapefile in MapServer?

Below is an example of a shapefile based map layer including a one-to-many join of legal service provider offices (DBF file) to a region polygon shapefile (one region with multiple legal aid providers that can have multiple offices each). The following query templates are used (included on the DVD in data/templates/join):

- table_header_template.html
- table_footer_template.html
- region_sum_template.html
- region_providers_officelist_template.html

```
LAYER
  NAME "Providers_Regions"
  TYPE POLYGON
  DATA "mapdata/projects/alliance/layers/region_sum"
  HEADER "templates/table_header_template.html"
  FOOTER "templates/table_footer_template.html"
  TEMPLATE "templates/region_sum_template.html"
  JOIN
    NAME officelist
    TABLE "mapdata/projects/alliance/layers/region_providers_officelist.dbf"
    FROM REG_ID
```
Below are listings of the two template files involved.

<!-- MapServer Template -->
<!-- region_providers_officelist_template.html -->
<tr><td style="width: 50px">[ officelist_FTE_MAP ] FTE</td>
<td>[ officelist_NAME ] [ officelist_OFFICENAM ], [ officelist_STREET ] [ officelist_SUITE ], [ officelist_CITY ], [ officelist_STATE ] [ officelist_ZIP ]</td></tr>

<!-- MapServer Template -->
<!-- region_sum_template.html -->
<tr><th colspan="3">Provider FTE</th><th>Region [ REG_ID ] [ REGION ]</th></tr>
<tr><td colspan="3">Number of Attorneys in Region "[ REGION ]"</td><td align="center">[ SUM_ATTORN ]</td></tr>
<tr><td colspan="3">FTE sum</td><td align="center">[ PROVIDER_S ]</td></tr>
<tr><td colspan="3">Northwest Justice Project</td><td align="center">[ NWJP ]</td></tr>
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Columbia Legal Services</strong></td>
<td>[CLS]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pro Bono FTE equivalents</strong></td>
<td>[PROBONO]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mediation Services</strong></td>
<td>not available</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CLEAR FTE equivalents</strong></td>
<td>[CLEAR_FTE]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Specialty Legal Aid Providers</strong></td>
<td>[SPECIALTY]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[join_officelist]
How can we create a dynamic layer with MapServer and PostGIS?

Below is an example of a (MapServer map file) layer definition using a MapServer replacement variable (embedded in "%" strings). MapServer will replace the variable with its value when the layer is requested at run time. For example you can use a variable you retrieved via a query against a PostGIS database via a PHP POST request to your server. Note that the variable value can be any string that PostGIS can handle in a SQL query, including all PostGIS functions. Working with OpenLayers the `mergeNewParams` method can be called on the map layer (see below) to update a layer dynamically. To avoid any MapServer errors initially set the replacement variable to a SQL string that evaluates to retrieve zero features (nothing displayed for the query layer on the map initially). Make sure to use uppercase characters for the variable name in the map file and the OL page (this is necessary in order to have the variable names match exactly because OL converts the params to all uppercase).

In a map file you can define a dynamic, PostGIS based layer similar to this:

```
LAYER
    NAME "querylayer"
    GROUP "querylayer"
    TYPE POLYGON
    STATUS ON
METADATA
    "wms_title" "querylayer"
    "wms_srs" "epsg:2285 epsg:4326"
    "wms_feature_info_mime_type" "text/html"
END
DUMP true
CONNECTIONTYPE postgis
CONNECTION "user=postgres password=postgres dbname= osgis host=localhost"
DATA "the_geom from (%WEBSQL%) as subquery using unique gid using SRID=2285"
# %WEBSQL% will be replaced at run time by MapServer.
# e.g. "select * from counties where name ilike 'King'"
# this translates at runtime to the full statement:
# DATA "the_geom from (select * from counties where name ilike 'King') as subquery using unique gid using SRID=2285"
DUMP true
CLASS
    NAME "Query Result"
STYLE
    OUTLINECOLOR 255 0 0
```
In the OL page include the dynamic layer, and an update function (and call the update function when appropriate):


// merge parameter from the PHP post: call update() function for this
update_query();

function update_query() {
  var querystring = "<?PHP echo $mapquery; ?>";
  querylayer.mergeNewParams(‘WEBSQL’:querystring});
}

Using this set-up you can even write your own pgSQL functions for use with the MapServer replacement variable. There are virtually no limits to use this ...
Chapter 5. Appendix

Can I use ESRI File Geodatabases as input for MapServer?

Read access to ESRI file geodatabases is supported via OGR (the software version needs to be GDAL version >= 1.9). Note two main requirements: Only file geodatabases created by ArcGIS version 10.0 can be used read, and your GDAL/OGR software build needs to contains the file geodatabase FileGDB driver. For more information see http://mapserver.org/input/vector/filegdb.html Below is an example for a map file with a file geodatabase layer.

```
LAYER
  NAME "fgdb_poly"
  TYPE POLYGON
  STATUS OFF
  CONNECTIONTYPE OGR
  CONNECTION "./data/filegdb/us_states.gdb"
  DATA "statesp020"
  LABELITEM "US STATE"
CLASS
  NAME "US States"
  STYLE
    COLOR 255 120 120
    OUTLINECOLOR 0 0 0
  END
LABEL
  COLOR 255 255 255
  OUTLINECOLOR 0 0 0
  END
END
END
```

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