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Module 4.1 - Interoperability Standards - WMS, KML, and XML

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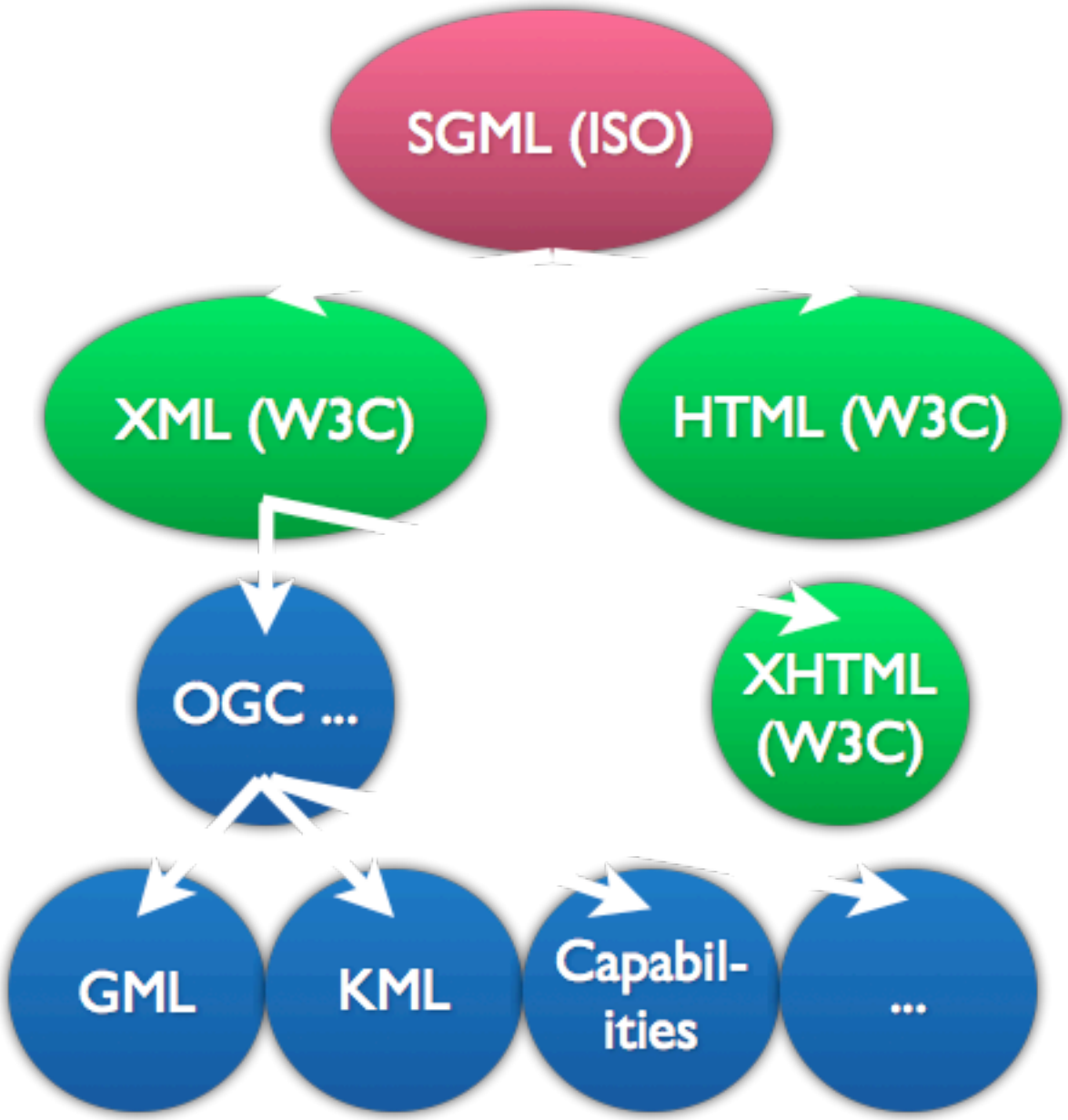
- Integration of WMS into KML

Extensible Markup Language - XML

XML Background



- Defined as a markup language profile of Standard Generalized Markup Language (SGML - ISO 8879:1986)
- XML 1.0 released as a W3C Recommendation in 1998
  - currently in 5th edition, released in 2008
  - version 1.1 released in 2004, but not broadly used
  - XML 1.0 (5th ed.) Recommendation

XML Design Goals

- XML shall be straightforwardly usable over the Internet.
- XML shall support a wide variety of applications.
- XML shall be compatible with SGML.
- It shall be easy to write programs which process XML documents.
- The number of optional features in XML is to be kept to the absolute minimum, ideally zero.
- XML documents should be human-legible and reasonably clear.
- The XML design should be prepared quickly.
- The design of XML shall be formal and concise.
- XML documents shall be easy to create.
- Terseness in XML markup is of minimal importance.

From XML 1.0 (5th ed.) Recommendation

XML Structure - Well Formed / Valid

- Well Formed XML - a document that conforms to the structural definition of XML. Either well-formed, or not XML
- Valid XML - a document that is both well-formed and conforms to a specific content structure defined by
  - A Document Type Definition (DTD) - the original XML specification for the definition of the content of a specific XML document
  - A Schema document - defined in a variety of languages (e.g. W3C Schema, RELAX NG, Schematron, ISO DSDL, etc.)

XML Wikipedia Article

Simple XML Document

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!-- Edited by XMLSpy® -->
<note>
    <to>Tove</to>
    <from>Jani</from>
    <heading>Reminder</heading>
    <body type="instruction" >Don't forget me this weekend!</body>
</note>
```

XML Source (modified from original): w3schools

Simple XML Document - Prolog

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!-- Edited by XMLSpy® -->
```

Includes XML Declaration and Comment

Simple XML Document - Elements

```
<note>
    <to>Tove</to>
    <from>Jani</from>
    <heading>Reminder</heading>
    <body type="instruction" >Don't forget me this weekend!</body>
</note>
```

Define blocks of content

Simple XML Document - Root Element

```
<note>
    ...
    ...
    ...
    ...
</note>
```

- Required
- There is only one
- It must be a pair of opening and closing tags

Simple XML Document - Content Elements

```
    <to>Tove</to>
    <from>Jani</from>
    <heading>Reminder</heading>
    <body type="instruction" >Don't forget me this weekend!</body>
```

- Contain all other document content
- May be paired opening and closing tags, *or*
- May be self-closing with a terminal "/" in the element, e.g. `<br />`

Simple XML Document - Attributes

```
    <body type="instruction" >Don't forget me this weekend!</body>
```

Define additional information about elements as *name=value* pairs.

Simple XML Document - Element Content

```
    <body type="instruction" >Don't forget me this weekend!</body>
```

The material contained between the opening and closing tags of an *Element*.

Simple XML Document - Valid?

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!-- Edited by XMLSpy® -->
<note>
    <to>Tove</to>
    <from>Jani</from>
    <heading>Reminder</heading>
    <body type="instruction" >Don't forget me this weekend!</body>
</note>
```

Why is this XML *well-formed* but not *valid*?

There is no DTD or Schema defined for the document against which it can be validated

Common XML Constructs That Will be Encountered

Document Type Declaration (DTD) references (PROLOG) definition, either by reference or by direct inclusion, the allowed structure of an XML document, for example:

```
<!DOCTYPE greeting SYSTEM "hello.dtd">
```

CDATA Sections blocks of XML that contain characters that would otherwise be recognized as XML markup, for example:

```
<![CDATA[<greeting>Hello, world!</greeting>]]>
```

Common XML Constructs That Will be Encountered - cont.

XML Namespace Declarations additional information included in elements to distinguish between duplicate element names, for example (declared in lines 1-3, used in lines 5-17):

```
<root
    xmlns:h="http://www.w3.org/TR/html4/"
    xmlns:f="http://www.w3schools.com/furniture">

<h:table>
    <h:tr>
        <h:td>Apples</h:td>
        <h:td>Bananas</h:td>
    </h:tr>
</h:table>
<f:table>
    <f:legs>4</f:legs>
    <f:cost>300</f:cost>
    <f:width>3</f:width>
    <f:length>5</f:length>
    <f:height>4</f:height>
</f:table>
</root>
```

KML

KML Background

- An XML grammar originally developed as Keyhole Markup Language by Keyhole, Inc. for use in their Keyhole Earth Viewer.
- Google acquired Keyhole, Inc. in 2004
- KML version 2.2 became an OGC standard in 2008
- Two delivered KML file formats

KML an XML document, with a ".kml" extension that is directly readable and editable

KMZ a compressed (zipped) file with a ".kmz" extension, that contains at least a KML document, but may contain other files as well

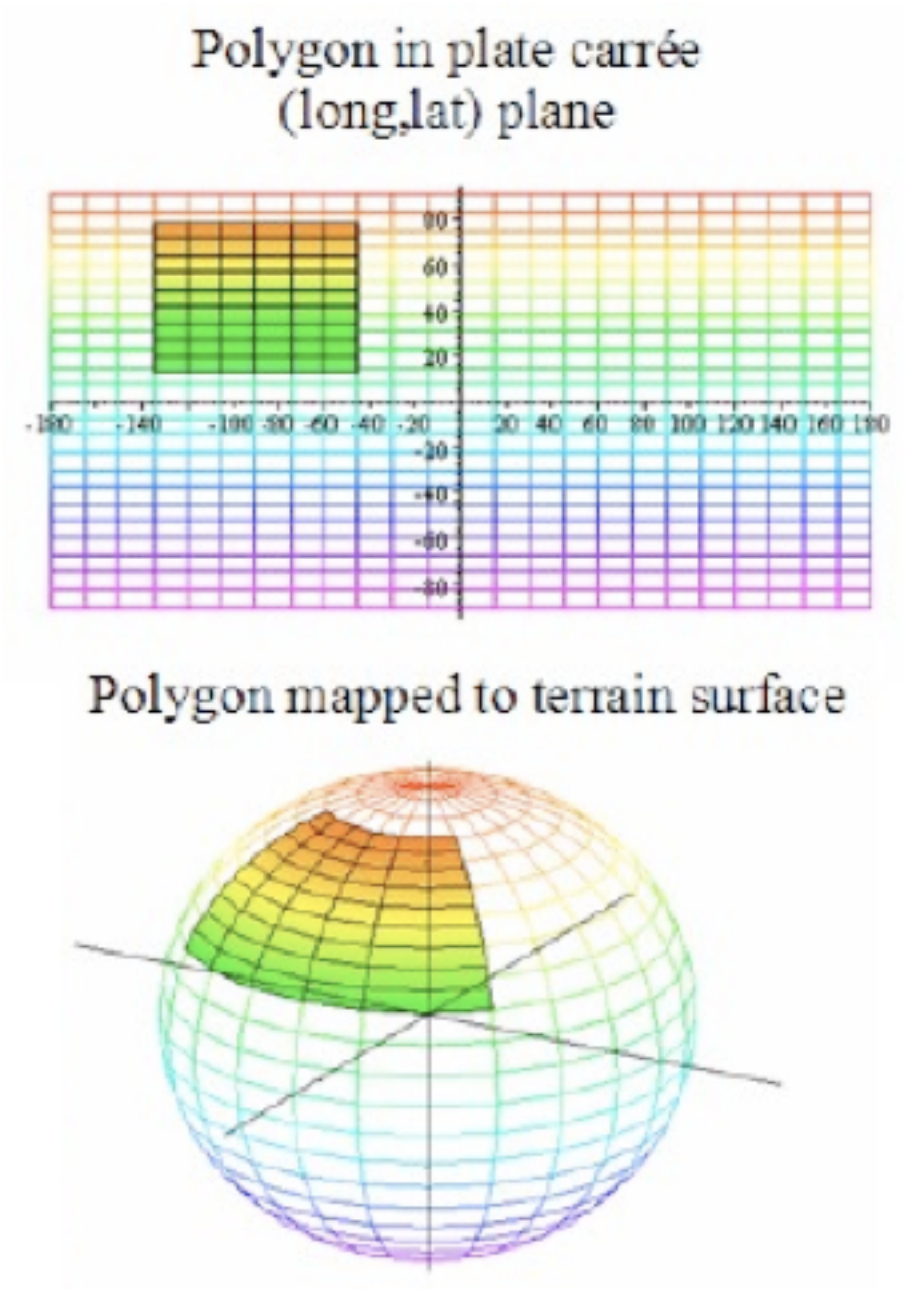
KML Capabilities

- Annotate the Earth
- Specify icons and labels to identify locations on the surface of the planet
- Create different camera positions to define unique views for KML features
- Define image overlays to attach to the ground or screen
- Define styles to specify KML feature appearance
- Write HTML descriptions of KML features, including hyperlinks and embedded images
- Organize KML features into hierarchies
- Locate and update retrieved KML documents from local or remote network locations
- Define the location and orientation of textured 3D objects

KML Content

- Model for encoding 2- and 3-dimensional geometries for use in 2-D mappers and 3-D virtual globe applications
- Uses latitude-longitude (based upon WGS84 datum) for encoding horizontal position
- Represents altitude in Meters (based upon the WGS84 ellipsoid and EGM96 geoid)

2D and 3D KML Sample




```
<kml xmlns="http://www.opengis.net/kml/2.2">
<Document>
    <Placemark>
        <Polygon>
            <altitudeMode>
                clampToGround
            </altitudeMode>
            <outerBoundaryIs>
                <LinearRing>
                    <coordinates>
```

```
                        -135,78.5,300000
                        -135,12.5,300000
                        -45,12.5,300000
                        -45,78.5,300000
                        -135,78.5,300000
                    </coordinates>
                </LinearRing>
            </outerBoundaryIs>
        </Polygon>
    </Placemark>
</Document>
</kml>
```

KML Example

Example from: KML 2.2 Specification (fig. 6)

High-Level KML Content Types

Features including documents, folders, placemarks, network links

Geometries including points, linestrings, polygons, models, locations

Overlays including ground overlays, lat-lon boxes, photo overlays, screen overlays

Styles styles, substyles, icons, label styles

High-Level KML Content Types - cont.

Links read, update, create, delete, change

Views camera, look at

Time time span, timestamp

KML Demonstration and References

New Mexico State Boundary KML File | KMZ File (from NM RGIS)

New Mexico State Boundary KML File http://maps.google.com/maps?*q=http://karlbenedict.com/GEOG485-585/lectures/examples/tl_2010_35_state10.kml*

Google Code KML Documentation

OGC KML Implementation specification

OGC Web map Services - WMS

WMS - Overview

- Open Geospatial Consortium standard for requesting
  - Service Metadata (`GetCapabilities`) - an XML file representing information about a specific WMS service and its component layers

  - Map Images (`GetMap`) - graphic files representing one or more layers from a single WMS service for a specified area of interest, and, optionally, for a specified point in time
  - Feature Information (`GetFeatureInfo`) - a basic representation (in a variety of formats) of the attributes associated with a specific pixel location in a map image
- A WMS will return to the requesting system one of the above products OR an error message (in XML by default)
- Related Style Layer Descriptor standard supports dynamic updating of visualization options
- OGC WMS Documentation Access Page

WMS *GetCapabilities* Request

Request Parameter	1.0	1.1	1.1.1	1.3.0	Description
WMTVER=1.0.0	R				Request version
VERSION=version		O	O	O	Request version
SERVICE=WMS	R	R	R	R	Service type
REQUEST=capabilities	R				Request name
REQUEST=GetCapabilities		R	R	R	Request name
UPDATESEQUENCE=string		O	O	O	Sequence number or string for cache control
Vendor-specific parameters	O				Vendor-specific parameters

R=Required / O=Optional

WMS *GetMap* Request (Core)

Request Parameter	1.0	1.1	1.1.1	1.3.0	Description
WMTVER=1.0.0	R				Request version
VERSION=version		R	R	R	Request version.
REQUEST=map	R				Request name.
REQUEST=GetMap		R	R	R	Request name.
LAYERS=layer_list	R	R	R	R	Comma-separated list of one or more map layers. Optional (ver. 1.1, 1.1.1) if SLD parameter is present.
STYLES=style_list	R	R	R	R	Comma-separated list of one rendering style per requested layer. Optional if SLD parameter is present.
SRS=namespace:identifier	R	R	R		Spatial Reference System.
CRS=namespace:identifier				R	Spatial Reference System.
BBOX=minx,miny,maxx,maxy	R	R	R	R	Bounding box corners (lower left, upper right) in SRS units.
WIDTH=output_width	R	R	R	R	Width in pixels of map picture.

WMS GetMap Request (Core) - cont.

Request Parameter	1.0	1.1	1.1.1	1.3.0	Description
HEIGHT=output_height	R	R	R	R	Height in pixels of map picture.
FORMAT=output_format	R	R	R	R	Output format of map.
TRANSPARENT=TRUE or FALSE	O	O	O	O	Background transparency of map (default=FALSE).
BGCOLOR=color_value	O	O	O	O	Hexadecimal red-green-blue color value for the background color (default=0xFFFFFF).
EXCEPTIONS=exception_format	O	O	O	O	The format in which exceptions are to be reported by the WMS (default=XML).
TIME=time		O	O	O	Time value of layer desired.
ELEVATION=elevation		O	O	O	Elevation of layer desired.
Other sample dimensions		O	O	O	Values of other dimensions as appropriate.
Vendor specific parameters	O	O	O	O	Vendor specific parameters

WMS GetFeatureInfo Request

Request Parameter	1.0	1.1	1.1.1	1.3.0	Description
WMTVER=1.0.0	R				Request version.
VERSION=version		R	R	R	Request version.
REQUEST=feature_info	R				Request name.
REQUEST=GetFeatureInfo		R	R	R	Request name.
`<map_request_copy>`	R	R	R	R	Partial copy of the Map request parameters that generated the map for which information is desired
QUERY_LAYERS=layer_list	R	R	R	R	Comma-separated list of one or more layers to be queried.
INFO_FORMAT=output_format	O	O	O	R	Return format of feature information (MIME type).
FEATURE_COUNT=number	O	O	O	O	Number of features about which to return information (default=1).

WMS GetFeatureInfo Request - cont.

Request Parameter	1.0	1.1	1.1.1	1.3.0	Description
X=pixel_column	R	R	R		X coordinate in pixels of feature (measured from upper left corner=0)

I=pixel_column				R	i coordinate in pixels of feature in Map CS
Y=pixel_row	R	R	R		Y coordinate in pixels of feature (measured from upper left corner=0)
J=pixel_row				R	j coordinate in pixels of feature in Map CS
EXCEPTIONS=exception_format		O	O	O	The format in which exceptions are to be reported by the WMS (default=XML).
Vendor-specific parameters	O	O	O		Optional experimental parameters.

WMS Sample Requests - GetCapabilities

```
http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/services/ogc/wms?
    SERVICE=wms&
    REQUEST=GetCapabilities&
    VERSION=1.1.1
```

Live Link

```
<?xml version='1.0' encoding="ISO-8859-1" standalone="no" ?>
<!DOCTYPE WMT_MS_Capabilities SYSTEM "http://schemas.opengis.net/wms/1.1.1/
WMS_MS_Capabilities.dtd"
 [
 <!ELEMENT VendorSpecificCapabilities EMPTY>
 ]>  <!-- end of DOCTYPE declaration -->

<WMT_MS_Capabilities version="1.1.1">

<!-- MapServer version 6.0.3 OUTPUT=GIF OUTPUT=PNG OUTPUT=JPEG OUTPUT=KML SUPPORTS=PROJ
SUPPORTS=AGG SUPPORTS=FREETYPE SUPPORTS=ICONV SUPPORTS=WMS_SERVER SUPPORTS=WMS_CLIENT
SUPPORTS=WFS_SERVER SUPPORTS=WFS_CLIENT SUPPORTS=WCS_SERVER SUPPORTS=SOS_SERVER
INPUT=POSTGIS INPUT=OGR INPUT=GDAL INPUT=SHAPEFILE -->

<Service>
  <Name>OGC:WMS</Name>
  <Title>rgis Dataset (6ca5428a-a78c-4c82-8120-da70dc92f2cc)</Title>
  <Abstract>WMS Service for rgis dataset State Boundary - 2010</Abstract>
        <KeywordList>
          <Keyword>rgis</Keyword>
          <Keyword> New Mexico</Keyword>
        </KeywordList>
  <OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://
  gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/services/ogc/wms"/>
  <ContactInformation>
    <ContactPersonPrimary>
      <ContactPerson>GStore Support</ContactPerson>
      <ContactOrganization>Earth Data Analysis Center</ContactOrganization>
    </ContactPersonPrimary>
      <ContactPosition>technical support</ContactPosition>
    <ContactAddress>
        <AddressType>Mailing address</AddressType>
```

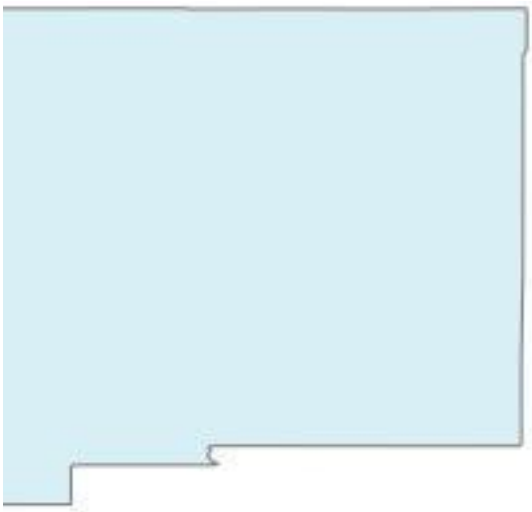
```
        <Address>Earth Data Analysis Center, MSC01 1110, 1 University of New Mexico</Address>
        <City>Albuquerque</City>
        <StateOrProvince>NM</StateOrProvince>
        <PostCode>87131</PostCode>
        <Country>US</Country>
      </ContactAddress>
        <ContactVoiceTelephone>(505) 277-3622</ContactVoiceTelephone>
        <ContactFacsimileTelephone>(505) 277-3614</ContactFacsimileTelephone>
    <ContactElectronicMailAddress>devteam@edac.unm.edu</ContactElectronicMailAddress>
    </ContactInformation>
    <Fees>None</Fees>
    <AccessConstraints>none</AccessConstraints>
  </Service>

  <Capability>
    <Request>
      <GetCapabilities>
        <Format>application/vnd.ogc.wms_xml</Format>
        <DCPType>
          <HTTP>
            <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
            "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
            services/ogc/wms?"/></Get>
            <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
            "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
            services/ogc/wms?"/></Post>
          </HTTP>
        </DCPType>
      </GetCapabilities>
      <GetMap>
        <Format>image/png</Format>
        <Format>image/gif</Format>
        <Format>image/jpeg</Format>
        <Format>image/png; mode=8bit</Format>
        <Format>image/tiff</Format>
        <Format>application/vnd.google-earth.kml+xml</Format>
        <Format>application/vnd.google-earth.kmz</Format>
        <DCPType>
          <HTTP>
            <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
            "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
            services/ogc/wms?"/></Get>
            <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
            "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
            services/ogc/wms?"/></Post>
          </HTTP>
        </DCPType>
      </GetMap>
      <GetFeatureInfo>
        <Format>text/plain</Format>
        <Format>application/vnd.ogc.gml</Format>
        <DCPType>
          <HTTP>
            <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
```

```
87            "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
88            services/ogc/wms?"/></Get>
89            <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
90            "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
91            services/ogc/wms?"/></Post>
92          </HTTP>
93        </DCPType>
94      </GetFeatureInfo>
95      <DescribeLayer>
96        <Format>text/xml</Format>
97        <DCPType>
98          <HTTP>
99            <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
100           "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
101           services/ogc/wms?"/></Get>
102           <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
103           "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
104           services/ogc/wms?"/></Post>
105         </HTTP>
106       </DCPType>
107     </DescribeLayer>
108     <GetLegendGraphic>
109       <Format>image/png</Format>
110       <Format>image/gif</Format>
111       <Format>image/jpeg</Format>
112       <Format>image/png; mode=8bit</Format>
113       <DCPType>
114         <HTTP>
115           <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
116           "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
117           services/ogc/wms?"/></Get>
118           <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
119           "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
120           services/ogc/wms?"/></Post>
121         </HTTP>
122       </DCPType>
123     </GetLegendGraphic>
124     <GetStyles>
125       <Format>text/xml</Format>
126       <DCPType>
127         <HTTP>
128           <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
129           "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
130           services/ogc/wms?"/></Get>
131           <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href=
132           "http://gstore.unm.edu/apps/rgis/datasets/6ca5428a-a78c-4c82-8120-da70dc92f2cc/
133           services/ogc/wms?"/></Post>
134         </HTTP>
135       </DCPType>
136     </GetStyles>
137   </Request>
138   <Exception>
139     <Format>application/vnd.ogc.se_xml</Format>
140     <Format>application/vnd.ogc.se_inimage</Format>
```

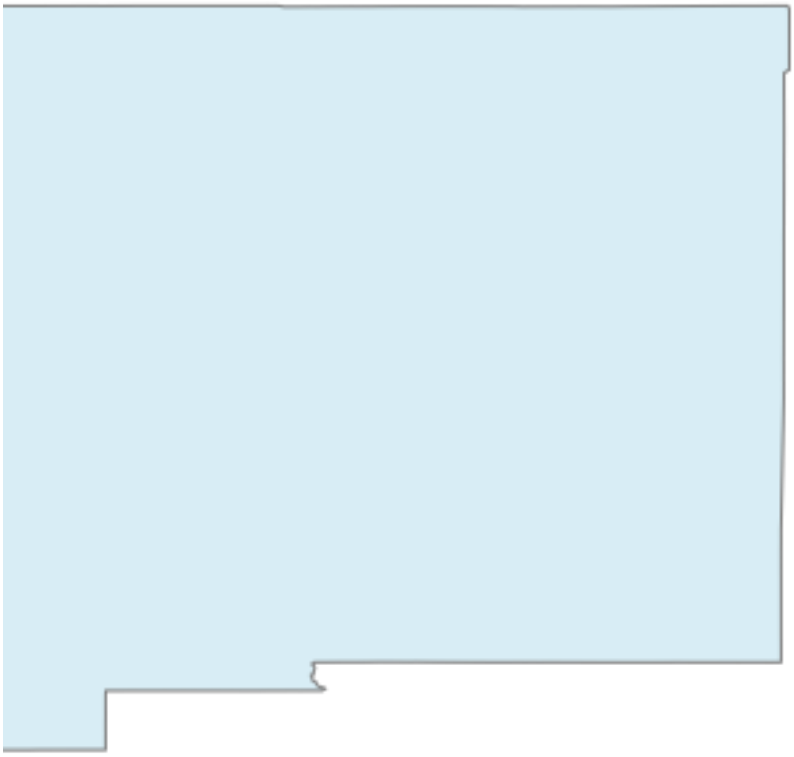
```
      <Format>application/vnd.ogc.se_blank</Format>
    </Exception>
    <VendorSpecificCapabilities />
    <UserDefinedSymbolization SupportSLD="1" UserLayer="0" UserStyle="1" RemoteWFS="0"/>
    <Layer>
      <Name>RGIS_Dataset</Name>
      <Title>rgis Dataset (6ca5428a-a78c-4c82-8120-da70dc92f2cc)</Title>
      <Abstract>WMS Service for rgis dataset State Boundary - 2010</Abstract>
      <KeywordList>
       <Keyword>rgis</Keyword>
       <Keyword> New Mexico</Keyword>
      </KeywordList>
      <SRS>EPSG:4269</SRS>
      <SRS>EPSG:4326</SRS>
      <SRS>EPSG:4267</SRS>
      <SRS>EPSG:26913</SRS>
      <SRS>EPSG:26912</SRS>
      <SRS>EPSG:26914</SRS>
      <SRS>EPSG:26713</SRS>
      <SRS>EPSG:26712</SRS>
      <SRS>EPSG:26714</SRS>
      <SRS>EPSG:3857</SRS>
      <LatLonBoundingBox minx="-109.05" miny="31.3322" maxx="-103.002" maxy="37.0003" />
      <BoundingBox SRS="EPSG:4326"
                  minx="-109.05" miny="31.3322" maxx="-103.002" maxy="37.0003" />
      <Layer queryable="0" opaque="0" cascaded="0">
          <Name>tl_2010_35_state10</Name>
          <Title>tl_2010_35_state10</Title>
          <Abstract>State Boundary - 2010</Abstract>
          <KeywordList>
            <Keyword></Keyword>
          </KeywordList>
          <SRS>epsg:4326</SRS>
          <LatLonBoundingBox minx="-109.05" miny="31.3322" maxx="-103.002" maxy="37.0003" />
          <BoundingBox SRS="epsg:4326"
                      minx="-109.05" miny="31.3322" maxx="-103.002" maxy="37.0003" />
          <MetadataURL type="FGDC-STD-001-1998">
            <Format>text/xml</Format>
            <OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:type="simple"
            xlink:href="http://gstore.unm.edu/apps/rgis/datasets/
            6ca5428a-a78c-4c82-8120-da70dc92f2cc/metadata/FGDC-STD-001-1998.xml"/>
          </MetadataURL>
      </Layer>
    </Layer>
  </Capability>
  </WMT_MS_Capabilities>
```

WMS Sample Requests - GetMap



```
http://gstore.unm.edu/apps/rgis/datasets/
6ca5428a-a78c-4c82-8120-da70dc92f2cc/
services/ogc/wms?
    VERSION=1.1.1&
    SERVICE=WMS&
    REQUEST=GetMap&
    BBOX=-109,31,-102.9,37.1&
    LAYERS=tl_2010_35_state10&
    WIDTH=200&
    HEIGHT=200&
    SRS=EPSG:4326&
    FORMAT=image/jpeg&
    STYLES=
```

link



```
http://gstore.unm.edu/apps/rgis/datasets/
6ca5428a-a78c-4c82-8120-da70dc92f2cc/
services/ogc/wms?
    VERSION=1.1.1&
    SERVICE=WMS&
    REQUEST=GetMap&
    BBOX=-109,31,-102.9,37.1&
    LAYERS=tl_2010_35_state10&
    WIDTH=300&
    HEIGHT=300&
    SRS=EPSG:4326&
    TRANSPARENT=TRUE&
    FORMAT=image/png&
    STYLES=
```

link

Integraton of WMS and KML

- The KML GroundOverlay element may be used to integrate a network accessible map image into a client
- A WMS service may be used to as the source of a KML GroundOverlay element
- KML includes parameterizations that allow for dynamic generation of WMS requests using client bounding box information
- Time-enabled WMS may be accessed through use of manually configured time parameters in WMS URLs and TimeStamp or TimeSpan KML elements

Sample WMS-KML Integration

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2" xmlns:gx="http://www.google.com/kml/ext/2.2"
    xmlns:kml="http://www.opengis.net/kml/2.2" xmlns:atom="http://www.w3.org/2005/Atom">
    <GroundOverlay>
        <name>RGIS Counties WMS</name>
        <Icon>
            <href>http://gstore.unm.edu/apps/rgis/datasets/107046/services/ogc/wms?
            VERSION=1.1.1&amp;amp;SERVICE=WMS&amp;amp;REQUEST=GetMap&amp;amp;BBOX=-109,31,-102.9,37.1
            &amp;amp;LAYERS=tl_2010_35_state10&amp;amp;WIDTH=800&amp;amp;HEIGHT=800&amp;amp;SRS=EPSG:4326
            &amp;amp;FORMAT=image/png&amp;amp;STYLES=</href>
            <viewRefreshMode>onStop</viewRefreshMode>
        </Icon>
        <LatLonBox>
            <north>37.32753828398865</north>
            <south>30.86418272137246</south>
            <east>-101.3630220689848</east>
            <west>-110.6891149310152</west>
        </LatLonBox>
    </GroundOverlay>
</kml>
```

Sample KML File