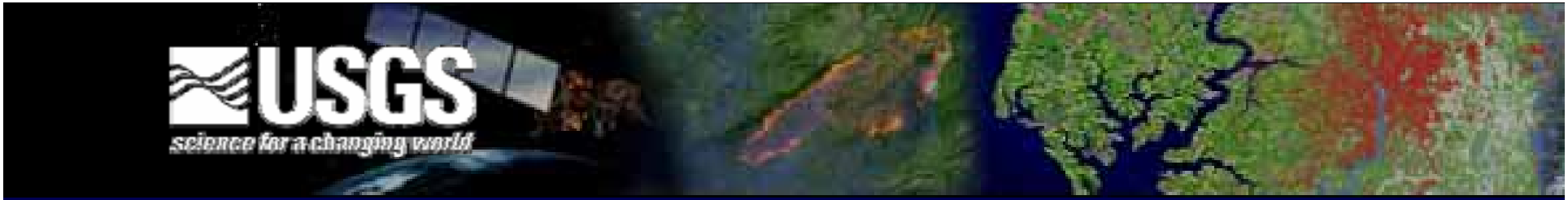

Utilizing Web Coverage Service Raster Data Processing in ArcObjects for the Land Cover Analysis Tool

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U.S. Geological Survey

Overview

- What is Web Coverage Service (WCS)
- Limitations of WCS
- Extending WCS via a brokering Web Service
  - Image analysis through Web Services
  - ArcObjects raster/image processing
- Example implementation:
  Land Cover Analysis Tool (LCAT)
- ArcObjects WCS comments

What is WCS

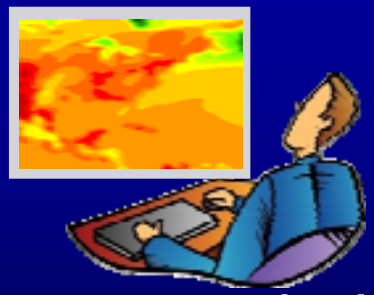
- OGC's "Coverage": Image or Raster
- Provides access to potentially detailed and rich sets of geospatial information
- Those information are useful for client-side rendering, server-side/client-side image analysis, and input into scientific models and other clients
- Conceptually it is easy think of WCS as a raster equivalent of WFS

What Is WCS

Compare to WMS, WFS

Web Map Service (WMS)
Geospatial "picture" publishing/viewing service

Web Feature Service (WFS)
Geospatial feature publishing/streaming service



Web Coverage Service (WCS)
Imagery and gridded data publishing/processing service

Keyhole Markup Language Service (KML)
Geospatial feature publishing/streaming service

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What is WCS

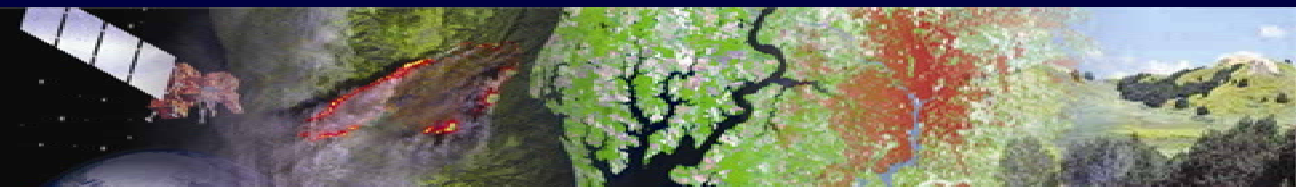
Compare to WMS, WFS cont…

- **Like WMS / WFS:**
  - **WCS allows clients to choose portions of a server's information holdings based on spatial constraints and other criteria.**
- **Unlike WMS:**
  - **WMS returns a generalized map image of a given extent, scale, and map size. Conversely, WCS returns the actual raw data of a given extent – Scale and map size are factors.**

What is WCS

Compare to WMS, WFS cont…

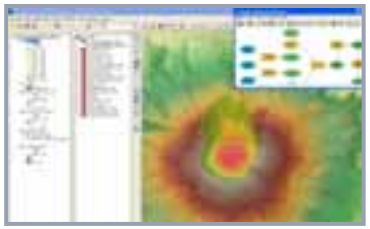
- **Unlike WMS: WCS can**
  - **Provide available data together with their detailed descriptions**
  - **Define a rich syntax for requests against these data**
  - **Return data with its original semantics (instead of pictures) which may be interpreted, extrapolated, etc. – and not just portrayed**
- **Unlike WFS:**
  - **WFS returns discrete vector geospatial features. WCS can return raster data with geospatial information such as extent, projection, band information.**

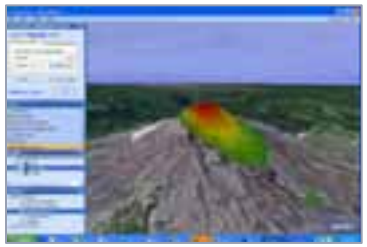


What is WCS

WCS Server and Client

OGC Clients





- ArcMap
- ArcExplorer
- ESRI Web Mapping API
- OpenLayers
- Google Earth
- Google Map
- Virtual Earth

OGC Web Services (WCS)

Web Server

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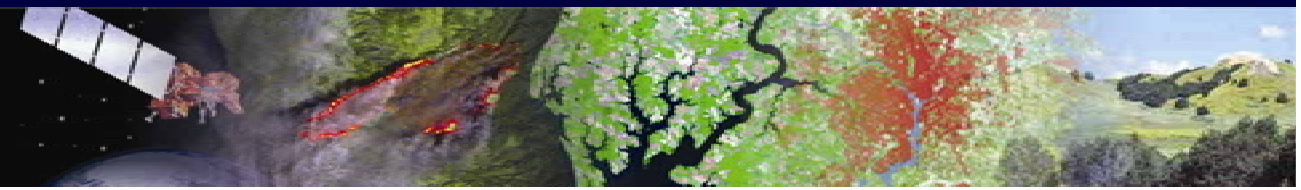
What is WCS

WCS Implementations

- MapServer – server (serve WCS)
- GeoServer – server
- ArcGIS Server – server
- ArcMap – client (read WCS)
- gvSIG – client
- GDAL – client
- GeoMedia - client and server



Limitations of WCS

- Doesn't support advanced raster operation/image processing (e.g. polygon raster clipping)
- Performance: reprojection / reformatting on a high-volume server

Extending WCS

To mitigate the limitations of WCS:

- **Broker the original WCS request**
- **Post-process the original WCS response to provide value-added functionality**

Extending WCS

Advanced Image Analysis Request

OGC Clients

- ESRI Web Mapping API
- OpenLayers
- Google Earth
- Google Map
- Virtual Earth

Extend WCS Functionality

?

- Advanced Image Analysis
  - Subset
  - Statistics
  - Surface Analysis
  - ……

Challenge:
How does client request Advanced Image Analysis component?

OGC Web Services (WCS)

Web Server

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Solution: Image Analysis through Web Services

OGC Clients

- ESRI Web Mapping API
- OpenLayers
- Google Earth
- Google Map
- Virtual Earth

Web Services Brokers WCS request

Advanced Image Analysis

- Subset
- Statistics
- Surface Analysis
- ……

OGC Web Services (WCS)

Web Server

Solution:
Broker a WCS request and post-process the reply

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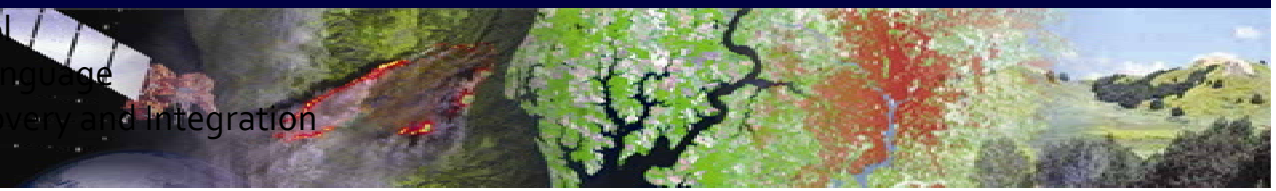
Extending WCS

Web Services

- Web services are application components
- Web services communicate using open protocols (HTTP)
- Web services are self-contained and self-describing
- XML is the basis for Web services

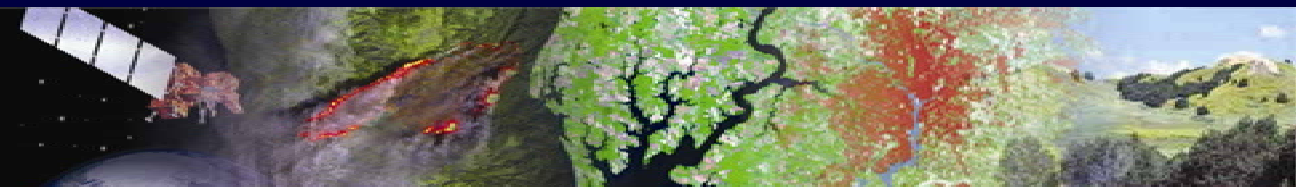
* Simple Object Access Protocol
** Web Services Description Language
*** Universal Description, Discovery and Integration



Extending WSC

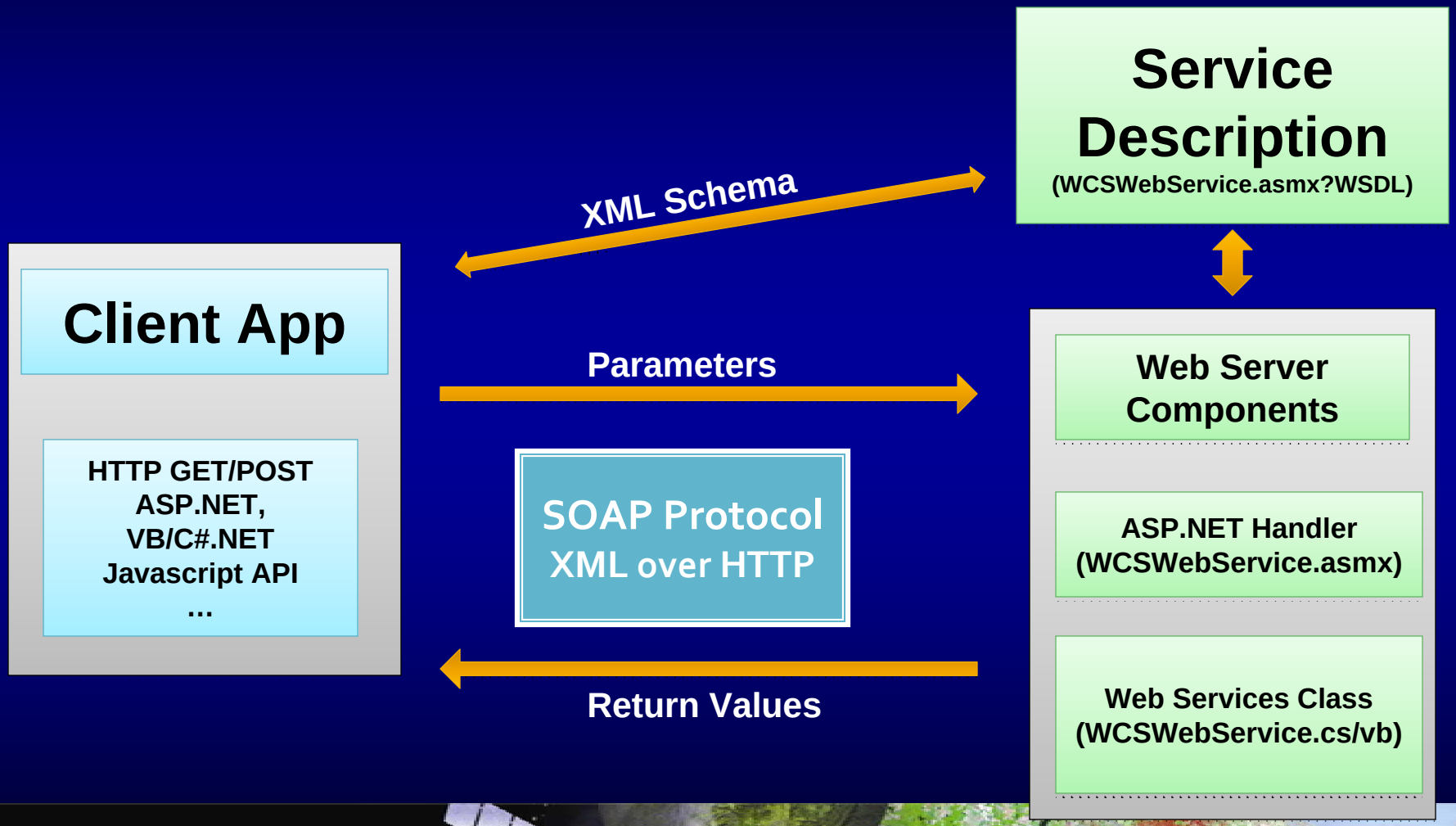
Web Services

- Web Services have three basic platform elements: SOAP*, WSDL** and UDDI ***
  - SOAP is an XML-based protocol to let applications exchange information over HTTP
  - WSDL is an XML-based language for locating and describing Web services
  - UDDI is a directory service where companies can register and search for Web services
- Key Point: Web Services expose functionality of a server to remote applications.



Extending WCS

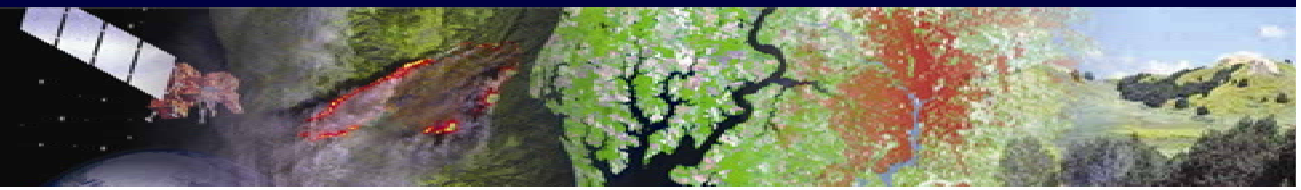
Visual Studio .NET Web Services



Extending WCS

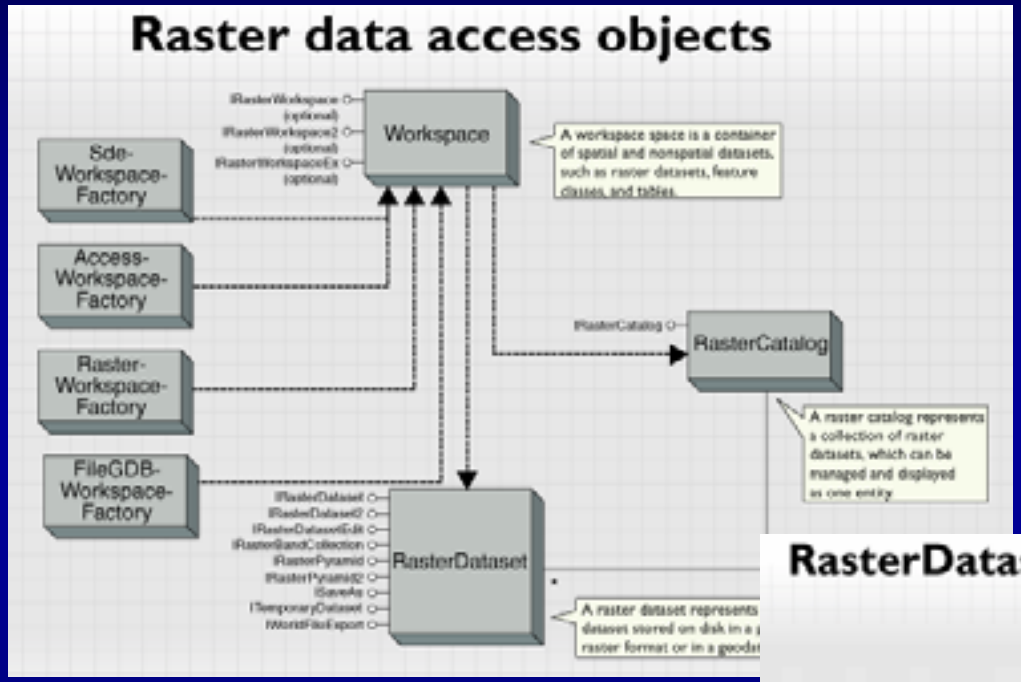
ArcObjects Image(Raster) Analysis

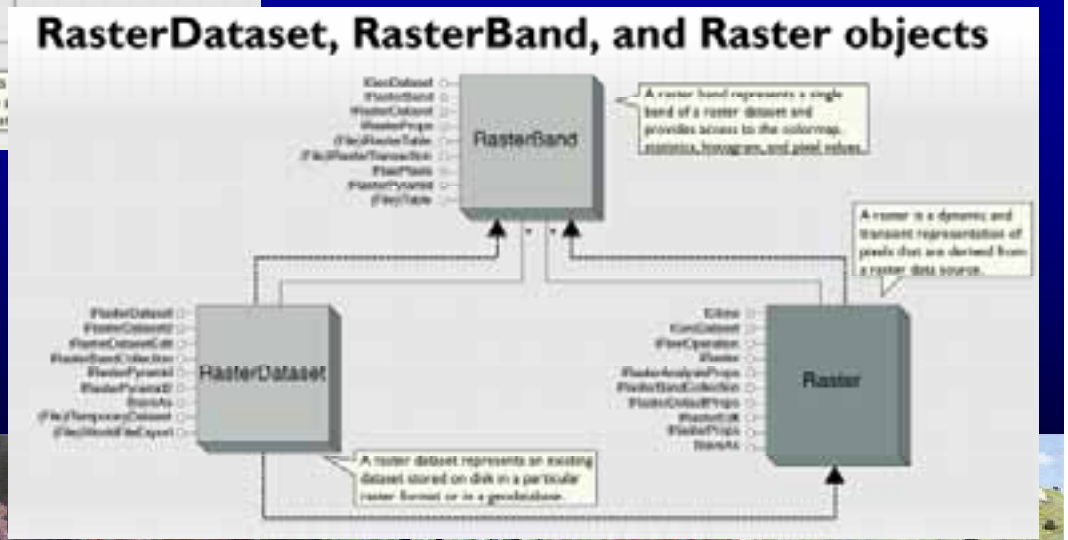
- The DataSourcesRaster library contains raster related objects in three categories
  - Objects used for accessing raster data from various data sources including file system, Personal geodatabase, File geodatabase and ArcSDE geodatabase;
  - Objects used for geodata transformation and pixel filtering, and
  - Objects used for raster mosaicking, raster loading, and other miscellaneous objects.

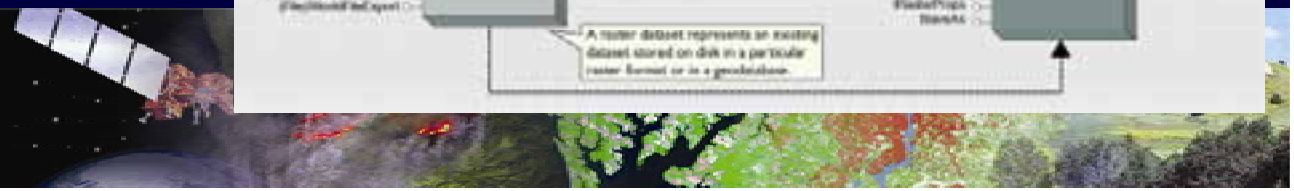


Extending WCS

ArcObjects Image(Raster) Analysis cont…







Extending WCS

ArcObjects WCS Support

- ArcGIS 9.3+
- Development licensing
  - ArcView
  - ArcEditor
  - ArcInfo
  - Engine Developer Kit
- Development licensing
  - ArcView
  - ArcEditor
  - ArcInfo
  - Engine Runtime
- References:
  - ESRI.ArcGIS.Carto
  - ESRI.ArcGIS.DatasourcesRaster
  - ESRI.ArcGIS.Geodatabase
  - ESRI.ArcGIS.esriSystem

Extending WCS

ArcObjects WCS Support cont…

- **WCSLayer class**
  - Create WCS layer from URL
  - Get raster from WCS layer

```
'WCS service uniform resource locator (URL).
Dim URL As String = "http://localhost:8000/cgi-bin/mapserv.exe?"

'Create WCSLayer from the first coverage.
Dim wcslayer As IWCSLayer = New WCSLayerClass()
wcslayer.Create(URL, layerName, "1.0.0") 'Test layer is "Landcover_2001"

'Access raster.
Dim rasterlayer As IRasterLayer = CType(wcslayer, IRasterLayer)

Dim pRaster As IRaster2 = CType(rasterlayer.Raster, IRaster2)
Dim pRasterdataset As IRasterDataset = pRaster.RasterDataset
```

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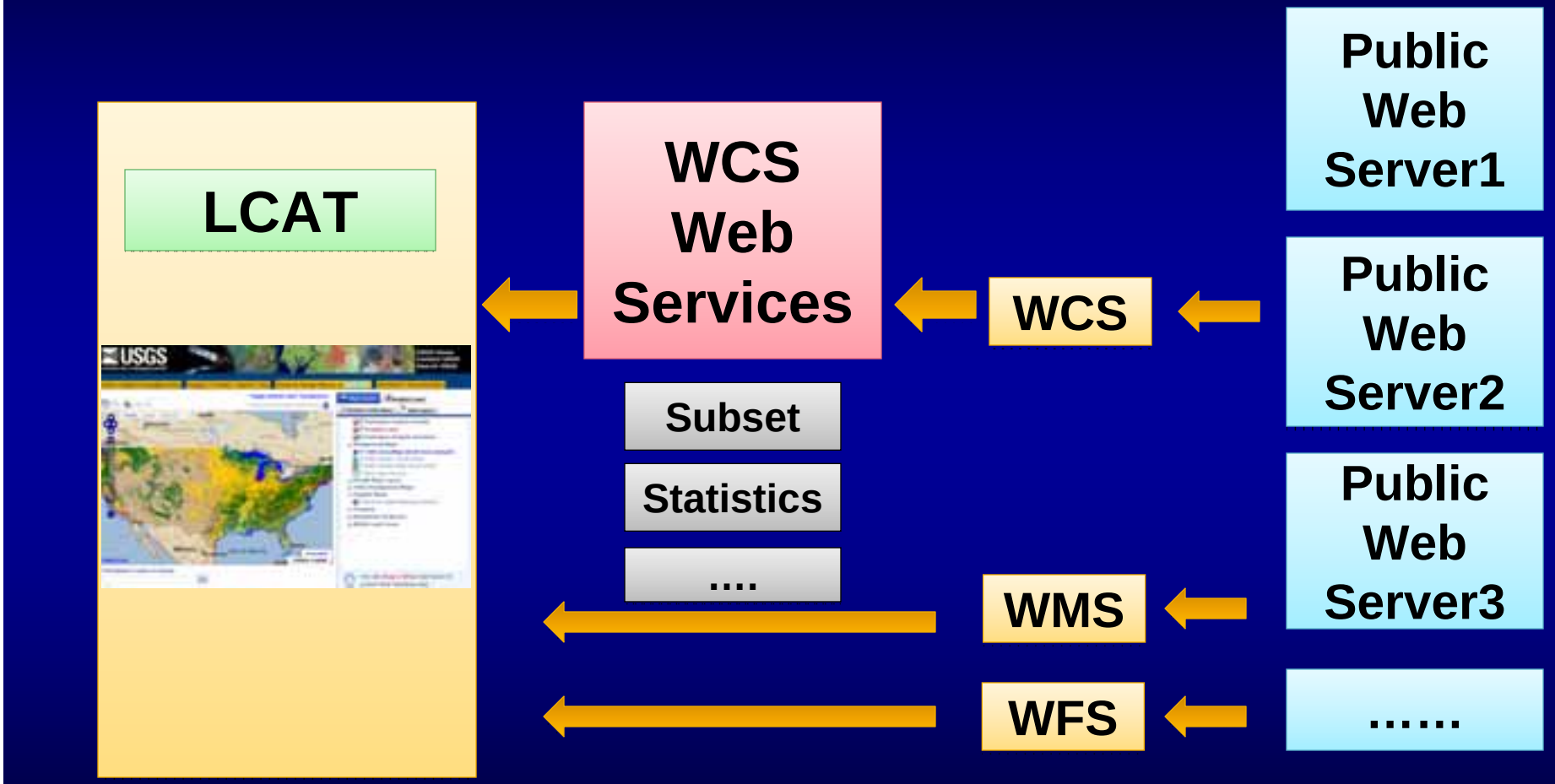
Example Implementation

- **The Land Cover Analysis Tool (LCAT) is an application built by the U.S. Geological Survey's Eastern Geographic Science Center that provides enhanced public access to the National Land Cover Database (NLCD).**
- **LCAT allows users to quickly navigate, display, analyze, and download NLCD datasets defined by a bounding box or a polygon boundary.**
- **LCAT leverages WCS Web Service enabling raster analysis functionality.**

Example Implementation

Web Raster Processing in LCAT



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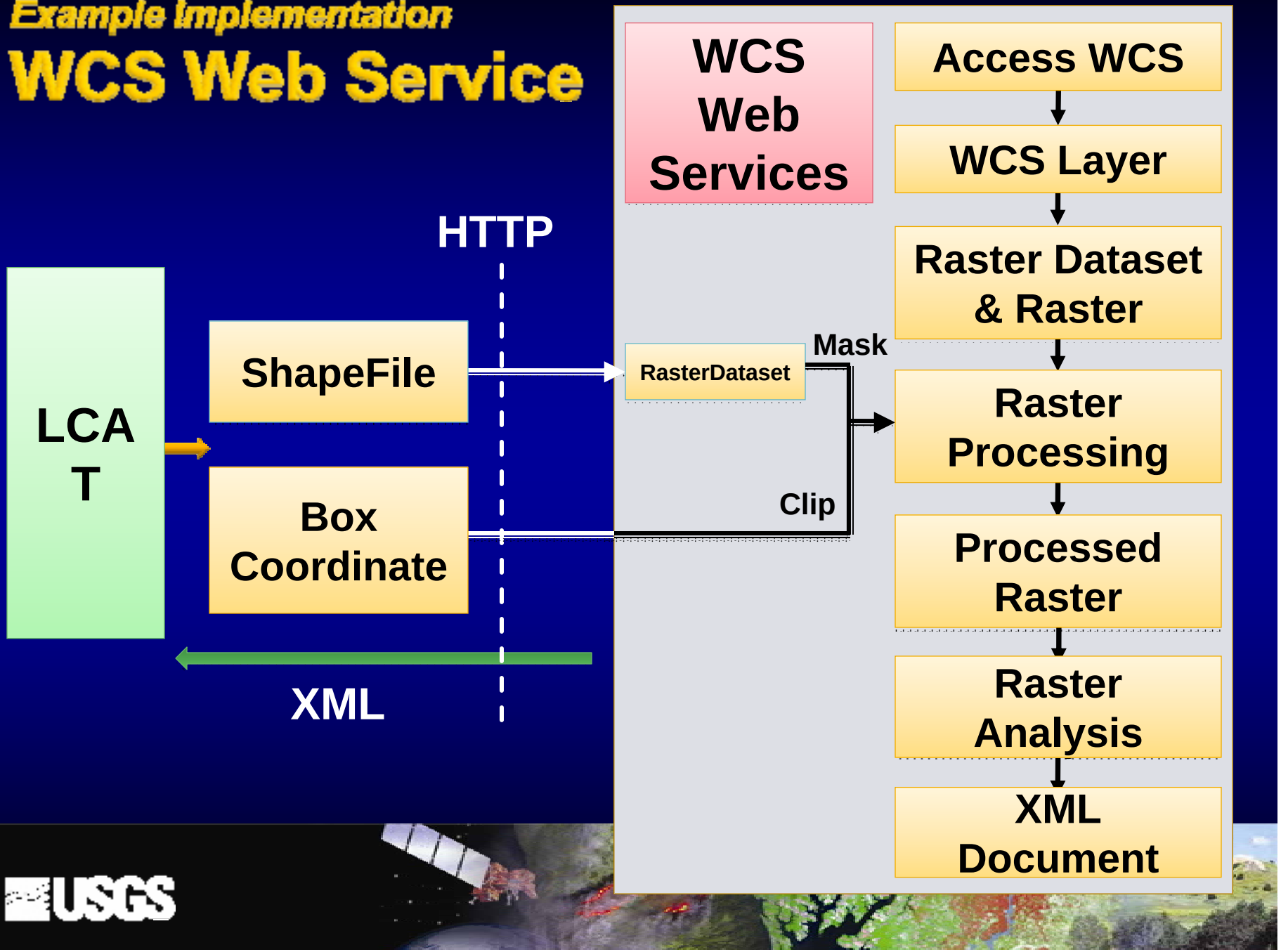
Example Implementation

WCS Web Service



Example Implementation

WCS Web Services

WCS Web Service Return XML Document:


```
<?xml version="1.0" encoding="utf-8" ?>
- <NewDataSet>
- <WCSImageAttributes>
  <Value>11</Value>
  <Color>73,109,163</Color>
  <Frequency>39860</Frequency>
  </WCSImageAttributes>
- <WCSImageAttributes>
  <Value>21</Value>
  <Color>224,204,204</Color>
  <Frequency>230039</Frequency>
  </WCSImageAttributes>
    … …
  <PixelStatistics>
    <TotalPixelCount>141
4557</TotalPixelCount>
    </PixelStatistics>
- <RasterFilePath>
    <FilePath>C:\Temp\ex
toutputImg1011.tif</File
Path>
    </RasterFilePath>
    </NewDataSet>
```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ArcObjects WCS & Raster Bugs/Shorts

- Doesn’t support MapServer WCS full Url
  - Solution: write a wrapper
- Doesn’t support MapServer TileIndex
  - Solution: input a real image file path in the map file

```
LAYER
      NAME "Landcover_2001"
      STATUS OFF
      TYPE RASTER
      DUMP TRUE
      DATA "/ms4w/Apache/htdocs/mapserver_data/landcover13_1.tif"
      #TILEINDEX
"C:/ms4w/Apache/htdocs/mapserver_data/2001_landcover.shp"
      #TILEITEM "LOCATION"
      #TILEITEM "BLocation"
      PROJECTION
        "init=epsg:4326"
      END
      …….
END
```

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ArcObjects WCS & Raster Bugs/Shorts cont…

- When do raster operation such as mask extraction, colormap of the original raster is removed

ArcObjects WCS Road Map*

9.2

- WCS on MapService
- WCS on ImageService
- WCS on GeoDataService
- 1.0.0, 1.1.0, 1.1.1
- GetCapabilities
- DescribeCoverage
- GetCoverage
- "Make WCS layer" GP tool

9.3

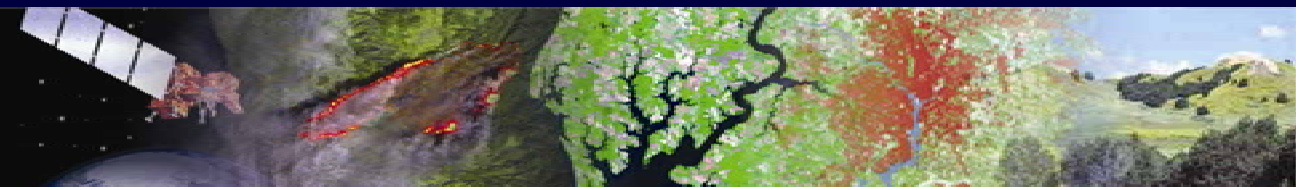
- bug fixes
- updated "Make WCS layer" GP tool

9.3.1

- add WCS on Optimized MapServer
- bug fixes

9.4 +

* Satish Sankaran, Leveraging the OGC Capabilities of ArcGIS Server , 2009 ESRI User Conference



Future Work

- WCS vs OPenDAP?
  - OGC WCS gets more support from popular software venders such as ESRI, MapServer, GeoServer
  - However, NASA, NOAA have huge volume NetCDF data which OPenDAP supports
- GDAL extension for WCS?
  - Develop custom function such as polygon extraction in GDAL with C/C++
  - MapServer uses GDAL to support WCS
- ERDAS Imagine support?
  - ERDAS Imagine has supper strong image processing features
  - IMAGINE Developers' Toolkit, C/C++ API

Questions and Contact Information

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