Assessing the Robustness of Web Feature Services Necessary to Satisfy the Requirements of Coastal Management

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June 4, 2012

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Presentation Outline

- Background Information
  - Coastal Management Issues
  - Web-based GIS
  - Coastal Web Atlases
  - Web Services
  - Web Feature Services
- Research Questions
- Methods
- Results
- Discussion and Conclusion

Coastal ecosystems are extremely dynamic and inherently complex ecosystems

Photo source: Exxon Valdez Oil Spill Trustee Council GEM (Gulf of Alaska Ecosystem Monitoring and Research) project

There is no one factor, activity, or place for management to consider...

Traditional Management Strategies

Traditional Management Strategies

Ecosystem Based Management Strategies

Ecosystem Based Management Strategies

Building the Toolbox

- **Frenzy of tool development by institutions, organizations and agencies to help cope with these problems**

  What are some goals of these tools?

  - Incorporate a range of datasets;
  - Increase collaboration across stakeholders, jurisdictions, and spatial scales;
  - Evaluate management options[1]

One popular new tool being used is the coastal web atlas

(Center for Ocean Solutions 2011)[1]

What is a Coastal Web Atlas?

Photo sources: European Atlas of the Seas

A coastal web atlas is “a collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, and all of which are accessible via the Internet.”[2]

(O’Dea et al. 2007)[2]

Development of coastal web atlases (CWAs) has been driven by imperative coastal management and policy issues

Photo sources: International Coastal Atlas Network

Benefits of CWAs

- Easily accessible;
- Provide access to recent and up to date information;
- Serve as a data catalogue and portal for downloads;
- Incorporation of interactive tools and resources;
- Act as an educational resource;
- Assist with coastal and marine spatial planning[3]

(Wright, Dwyer, and Cummins 2011) [3]

Augmenting Coastal Web Atlases

- Geospatial Web Services
  - Modular applications that can be published, located, and invokes across the Web[4]
  - Perform various functions
    - Query, search, describe, identify, create, retrieve, etc.
  - Interface with a variety of applications and services

Photo source: Marine Metadata

Photo source: Ohio.gov

(Vasudevan 2001)[4]

Along with providing additional functions, web services also increase interoperability

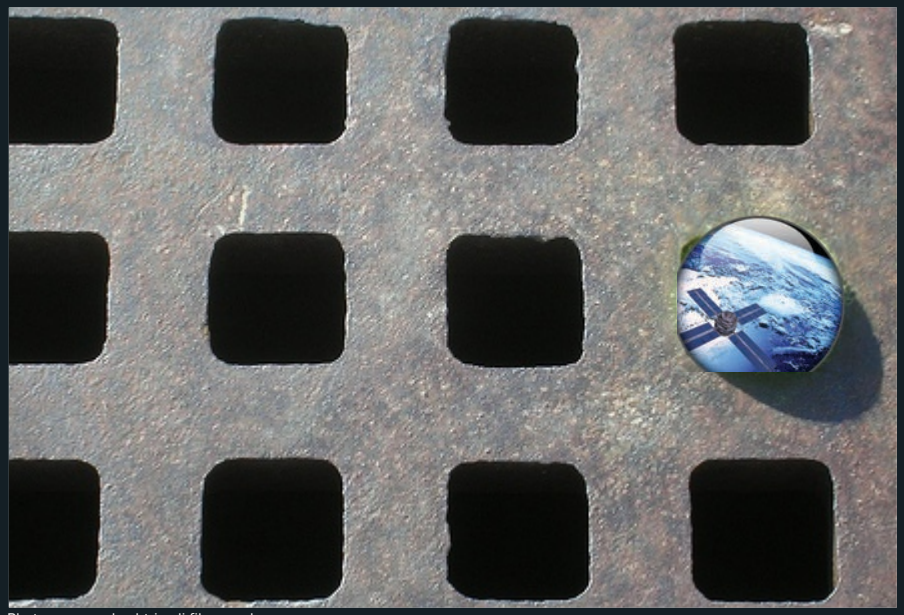


Photo source: akashtrivedi.files.wordpress.com

- Interoperability refers to the ability of heterogeneous systems or system components to communicate, exchange resources, or work together[5, 6]
  - So what exactly does that mean?

Allows Coastal Web Atlases to utilize data from different sources and formats for a wide range of functions

(Anderson and Moreno-Sanchez 2003)[5];(Lassoued et al. 2011)[6]

Open Geospatial Consortium (OGC)

Created numerous, interoperable, open-source geospatial web service standards[7]

Service Interface Standard	Input(s)	Output(s)	Client Functionality
Web Map Service (WMS)	Map (vector and/or raster datasets)	Image (GIF, JPEG, etc.)	Request only
Web Feature Service (WFS)	Vector datasets (points, lines, polygons)	XML data (or GML) that includes spatial, metadata, and attribute information	Request, query, and manipulate
Web Coverage Service (WCS)	Raster datasets (pixel-based or a feature bounded in space)	Encoded binary images (GeoTIFF, NetCDF, etc.) and metadata	Request and query

(Reed 2011)[7]

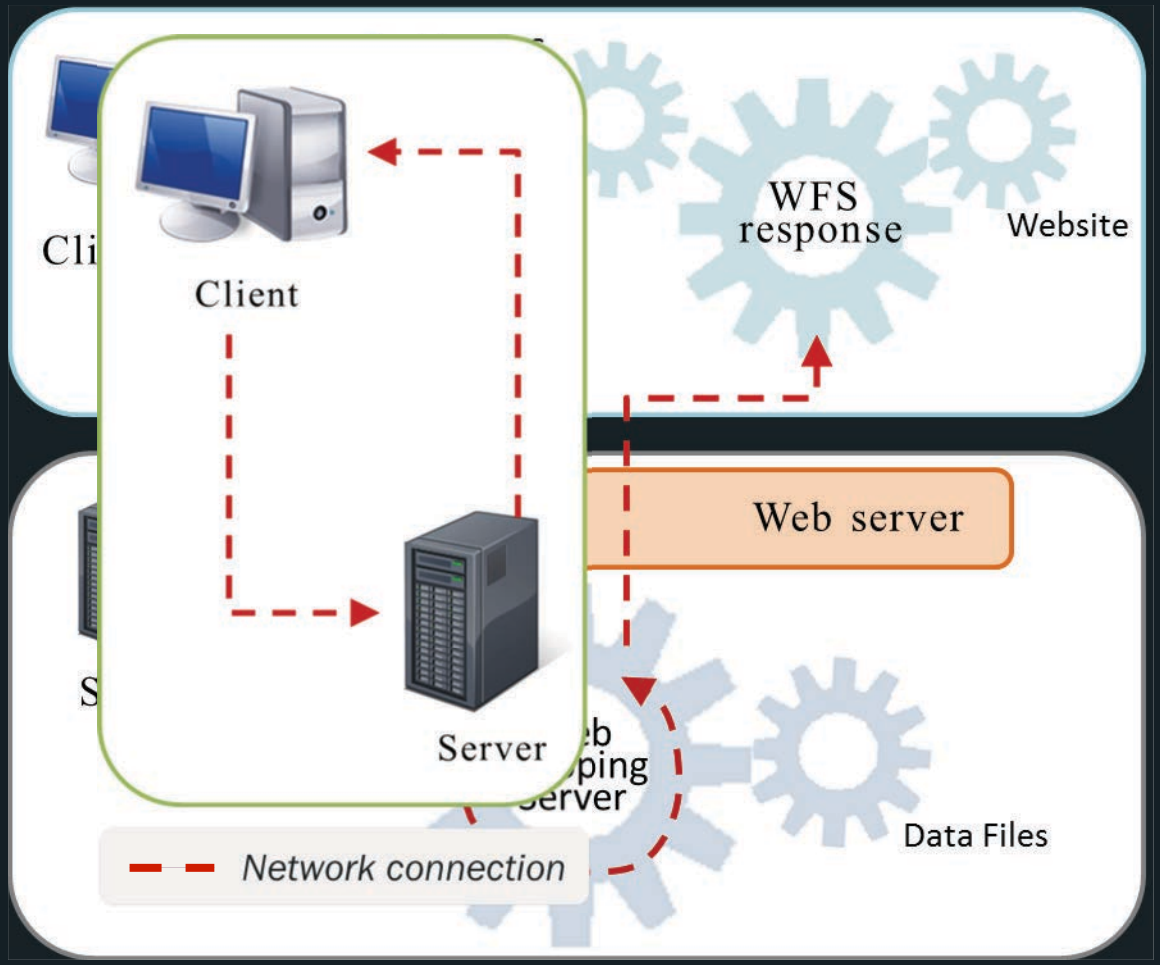
Web Services and Coastal Web Atlases:

Providing a "one-two punch" for coastal managers, policy makers, and scientists

- Numerous applications for web services and Coastal Web Atlases
- This study focuses on one approach:
  - A user's need to explore a specific management concern or question
    - Perform complex spatial queries with web feature services (WFSs) to extract relevant information

The core functions of web feature services, as well as Coastal Web Atlases and the Internet, operate based off a client-server architecture

The ability to create, author, and access web feature services requires additional components to be added to the basic client-server architecture



Web Feature Service User Requests

OGC WFS Standards allow 3 basic operation requests[8]:

1. Get Capabilities
2. Describe Feature Type
3. Get Features


```
<?xml version="1.0" encoding="ISO-8859-1"?>
- <WFS_Capabilities xsi:schemaLocation="http://www.opengis.net/wfs http://schemas.opengis.net/wfs/1.0.0/WFS-capabilities.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:ogc="http://www.opengis.net/ogc" xmlns="http://www.opengis.net/wfs" updateSequence="0" version="1.0.0">
    <!-- MapServer version 5.4.2 OUTPUT=GIF OUTPUT=PNG OUTPUT=JPEG OUTPUT=WBMP OUTPUT=SWF OUTPUT=SVG
    SUPPORTS=PROJ SUPPORTS=AGG SUPPORTS=FREETYPE SUPPORTS=ICONV SUPPORTS=WMS_SERVER
    SUPPORTS=WMS_CLIENT SUPPORTS=WFS_SERVER SUPPORTS=WFS_CLIENT SUPPORTS=WCS_SERVER SUPPORTS=GEOS
    SUPPORTS=RGBA_PNG INPUT=EPPL7 INPUT=POSTGIS INPUT=OGR INPUT=GDAL INPUT=SHAPEFILE -->
  - <Service>
      <Name>MapServer WFS</Name>
      <Title>Parcels of Iron County, WI</Title>
      <Abstract>This WFS contains spatial information for parcels in Iron County, Wisconsin. Includes acres (TOTACRES),
        total land value (TOTLAND) and total impervious value (TOTIMP) attributes for each parcel.</Abstract>
      <OnlineResource> http://webserverURLaddress/locationOfDataStoredAsWFS
                                                                    </OnlineResource>
    </Service>
  - <Capability>
    - <Request>
      - <GetCapabilities>
        - <DCPType>
          - <HTTP>
              <Get onlineResource=" http://webserverURLaddress/locationOfDataStoredAsWFS
                                                                    "/>
            </HTTP>
          </DCPType>
        - <DCPType>
          - <HTTP>
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                                                                    "/>
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        </GetCapabilities>
      - <DescribeFeatureType>
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            </HTTP>
          </DCPType>
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          - <HTTP>
              <Post onlineResource=" http://webserverURLaddress/locationOfDataStoredAsWFS
                                                                    "/>
            </HTTP>
          </DCPType>
        </DescribeFeatureType>
      - <GetFeature>
```
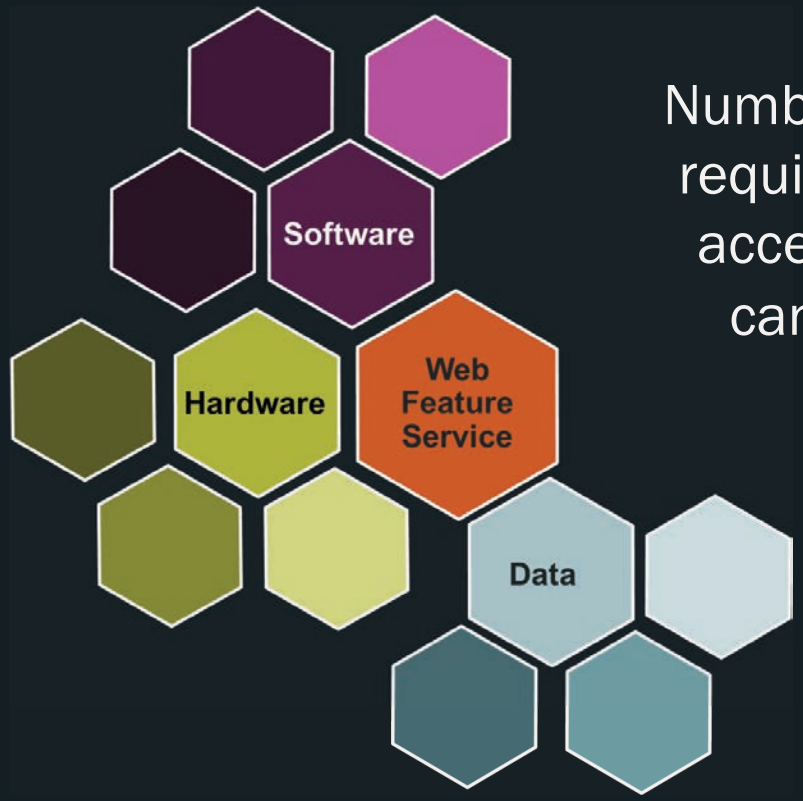


(Reed 2011)[8]

Web Feature Service Limitations



Number of integral components required to create, author, and access a web feature service can impact it's robustness

Robustness defined:

A web feature service's ability to provide accurate and precise data, on-the-fly, in a timely manner and in its entirety for a user, consistently

As the role of web feature services in CWAs increases its critical to understand what impacts a WFSs robustness and how that can impact a user

Research Questions

Q1. What components are necessary to create a robust web feature services that meets the demands of managers, decision-makers, and scientists to perform critical coastal spatial queries?

Q2. How does the robustness of a web feature service affect its performance in executing complex spatial queries?

Wisconsin Coastal Atlas

- Project funded by the University of Wisconsin Sea Grant[9]
- Seeks to provide maps, data, and decision support tools to address coastal hazards[9, 10]
- Developed upon the successful framework of the Oregon Coastal Atlas[9, 10, 11]

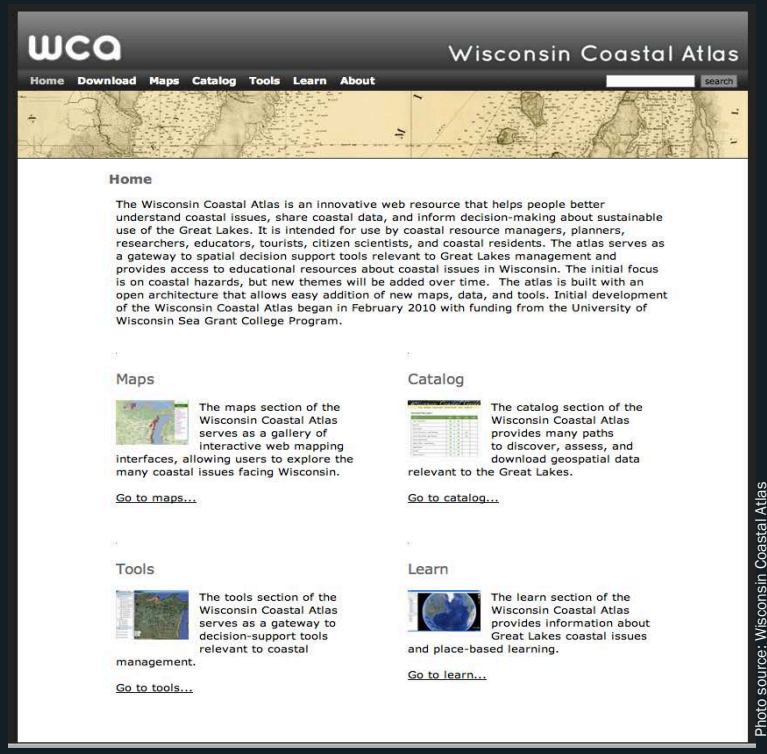


Photo source: Wisconsin Coastal Atlas

This research is a result of a collaboration between Oregon State University and the University of Wisconsin Sea Grant to evaluate the benefits and limitations of interfacing WFSs with the WCA

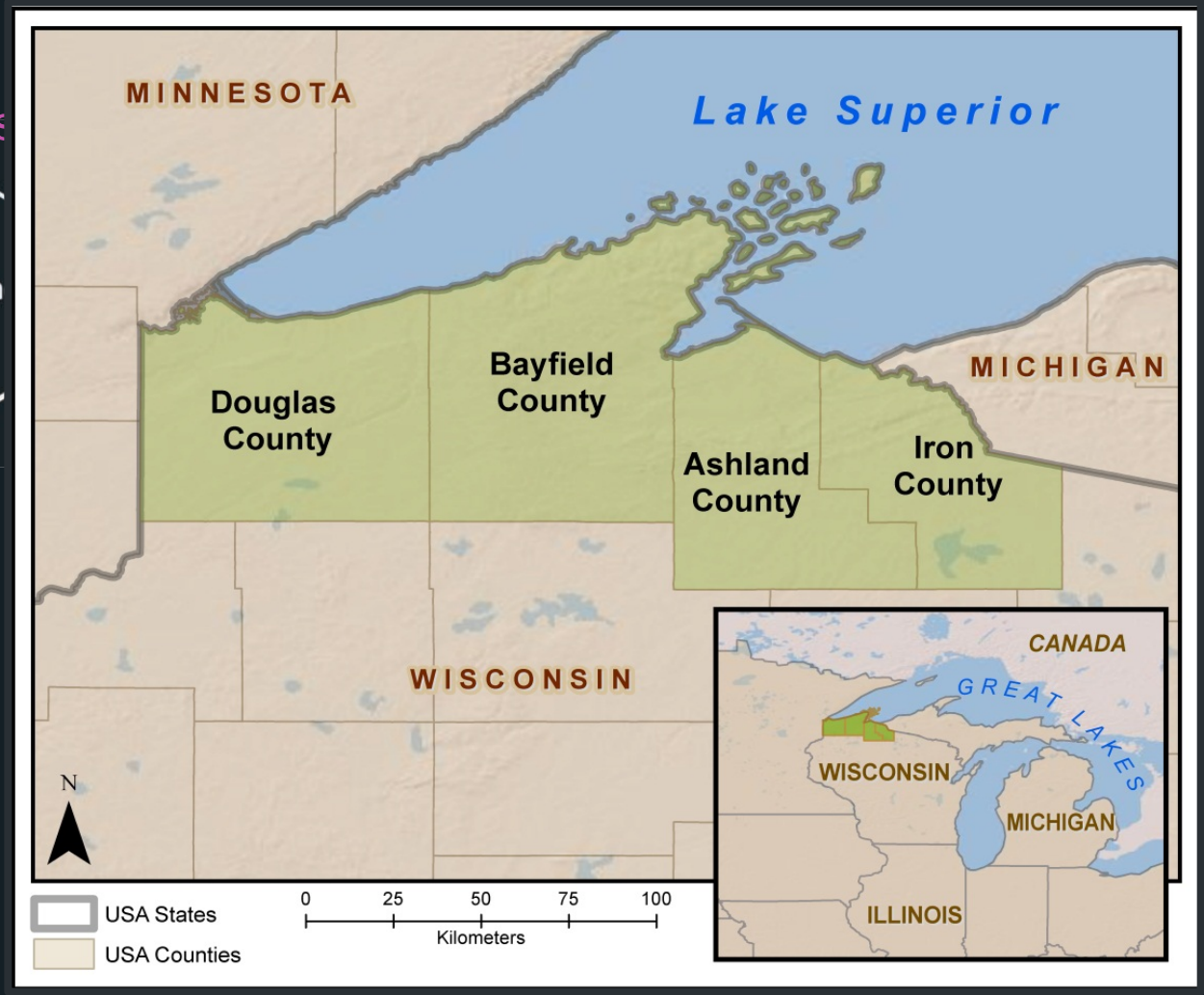
(Hart 2011)[9]; (Ventura et al. 2009)[10]; (Haddad, Bailey, Wright 2011)[11]

Methodology

Perform Two Phases of Analysis to Address the Research Questions

Res

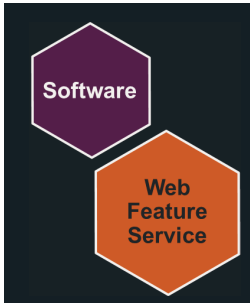
Compon



Data sources include Ashland County, Bayfield County, Douglas County, Iron County, Wisconsin Coastal Atlas, and ESRI

Web Feature Service Components

Evaluate popular software, hardware, and data components to determine the impact each component has on WFS robustness



Software Components

- Numerous open source and proprietary server and client software applications
- Results in a broad range of effects on WFS robustness
- This study will focus on evaluating three popular web mapping servers and desktop GIS applications

Web Mapping Servers

MapServer, GeoServer, and ArcGIS for Server 10.0

(henceforth referred to as ArcServer)

Python Script

Web Mapping Server

MapServer

GeoServer

ArcServer

County Dataset

Ashland

Bayfield

Douglas

Iron

OGC WFS Operation Request
(*n*= 30)

Get Capabilities

Describe Feature Type

Get Feature

Desktop GIS Application

Quantum GIS, gvSIG, and ArcGIS

Desktop GIS Application

Quantum GIS

gvSIG

ArcGIS

Web Mapping Server

MapServer

GeoServer

ArcServer

County Dataset

Ashland

Bayfield

Douglas

Iron

OGC WFS Operation Request
(*n*= 10)

Get Capabilities

Describe Feature Type

Get Feature

Hardware Components

User's Network Speed Capabilities

Python Script

High Network Speed
1,000 Mbps

Low Network Speed
15 Mbps

Web Mapping Server

MapServer

GeoServer

ArcServer

County Dataset

Ashland

Bayfield

Douglas

Iron

OGC WFS Operation Request
(*n*= 30)

Get Capabilities

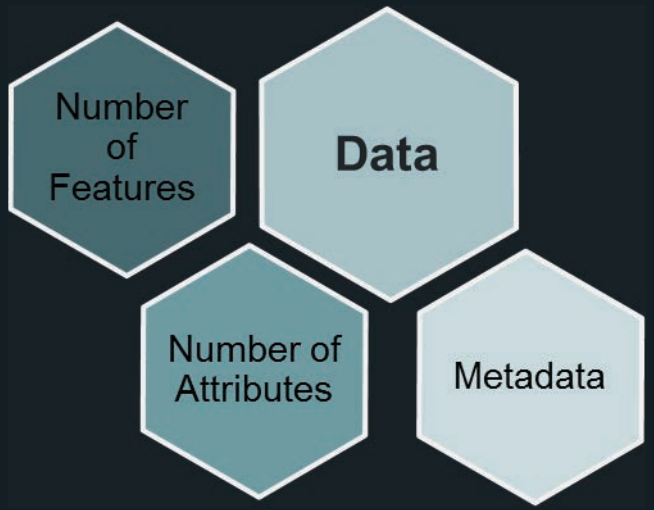
Describe Feature Type

Get Feature

Data Components

Impacts of data features, attributes, and metadata

- Due to WFSs distributed nature, the amount of data can impact a WFS's reliability and timeliness
- Study focuses on three components that can be changed to determine their influence on WFS robustness



Number of Features

Representations of real world items

Desktop GIS Application

Quantum GIS

gvSIG

ArcGIS

Web Mapping Server

MapServer

GeoServer

ArcServer

County Dataset

Ashland
9,192 Features

Bayfield
32,843 Features

Douglas
47,224 Features

Iron
1,059 Features

OGC WFS Operation Request (*n*= 10)

Get Feature

Number of Attributes

Attributes are data or characteristics of a feature

Desktop GIS Application

Quantum GIS

gvSIG

ArcGIS

Web Mapping Server

MapServer

GeoServer

ArcServer

County Dataset

Douglas
47,224 Features
33 Attributes

Douglas
47,224 Features
6 Attributes

OGC WFS Operation Request (*n*= 10)

Get Feature

Metadata

Data about data

Python Script

Web Mapping Server

MapServer

GeoServer

ArcServer

County Dataset

Douglas
No Metadata

Douglas
Basic Metadata

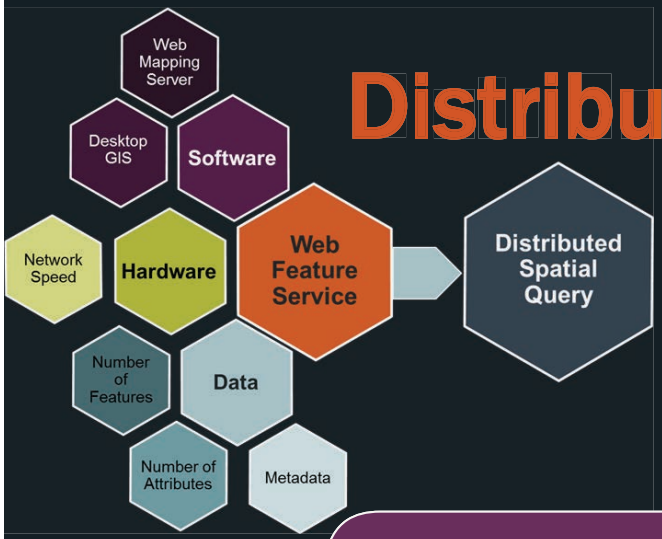
Douglas
Mandatory FGDC Metadata

Douglas
Full FGDC Metadata

OGC WFS Operation Request (*n*= 30)

Get Feature

Distributed Spatial Queries



Analysis to identify land parcels within 1,000 feet of the Lake Superior shoreline with county parcel data with full features, 6 attributes per feature, and FGDC Metadata

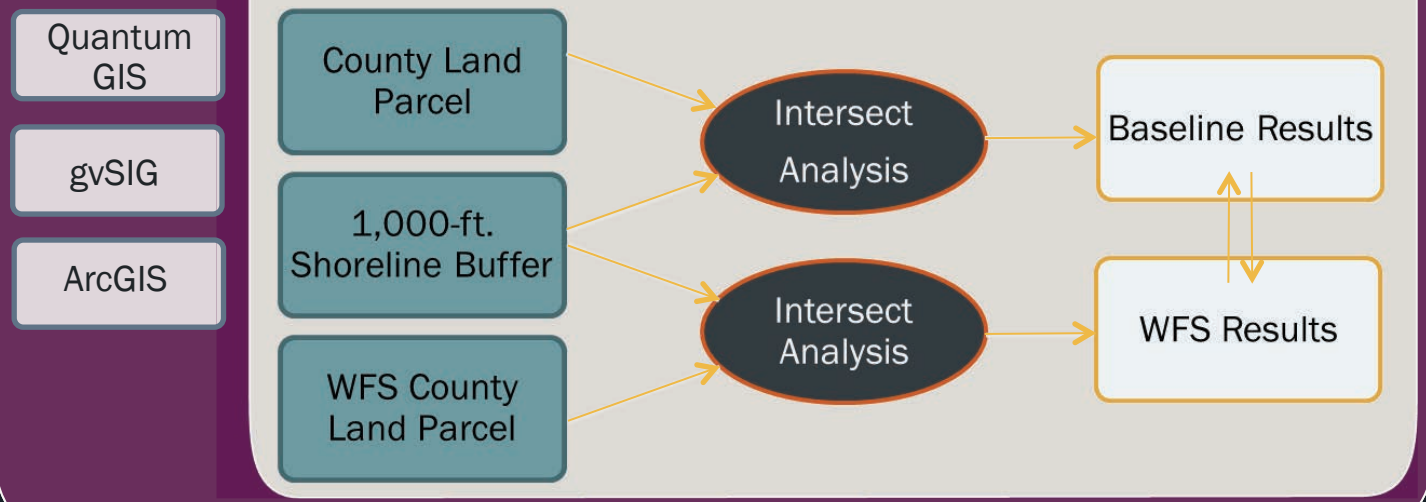
Desktop GIS Applications

Quantum GIS

gvSIG

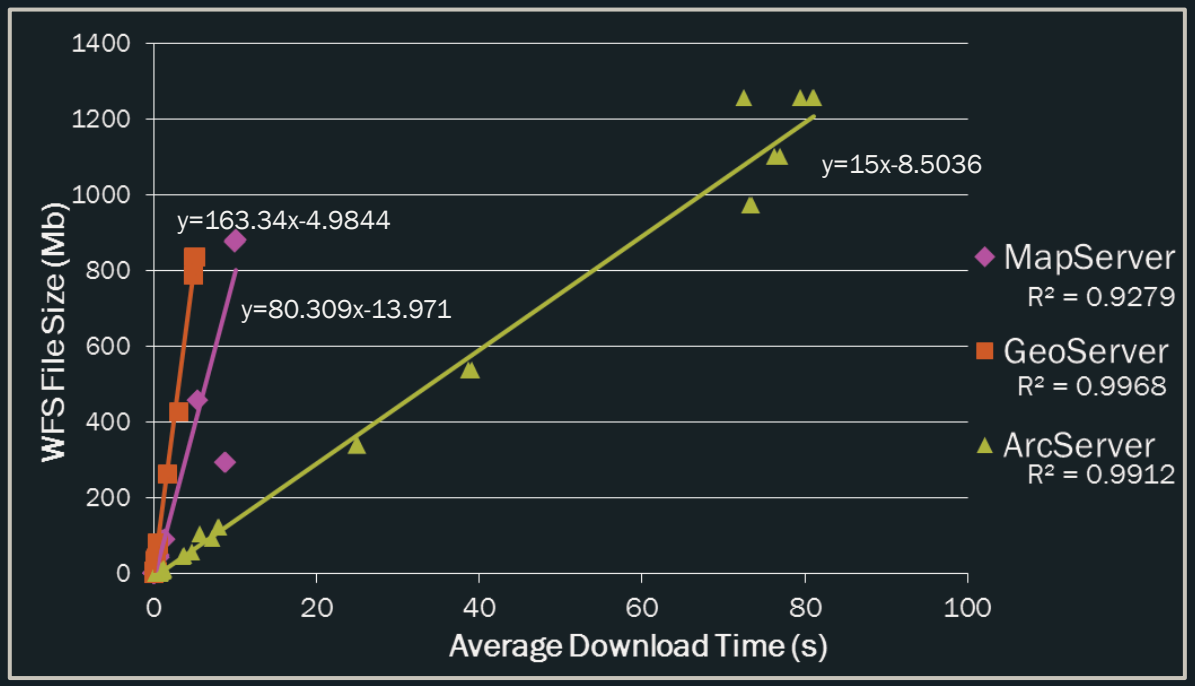
ArcGIS

Analysis



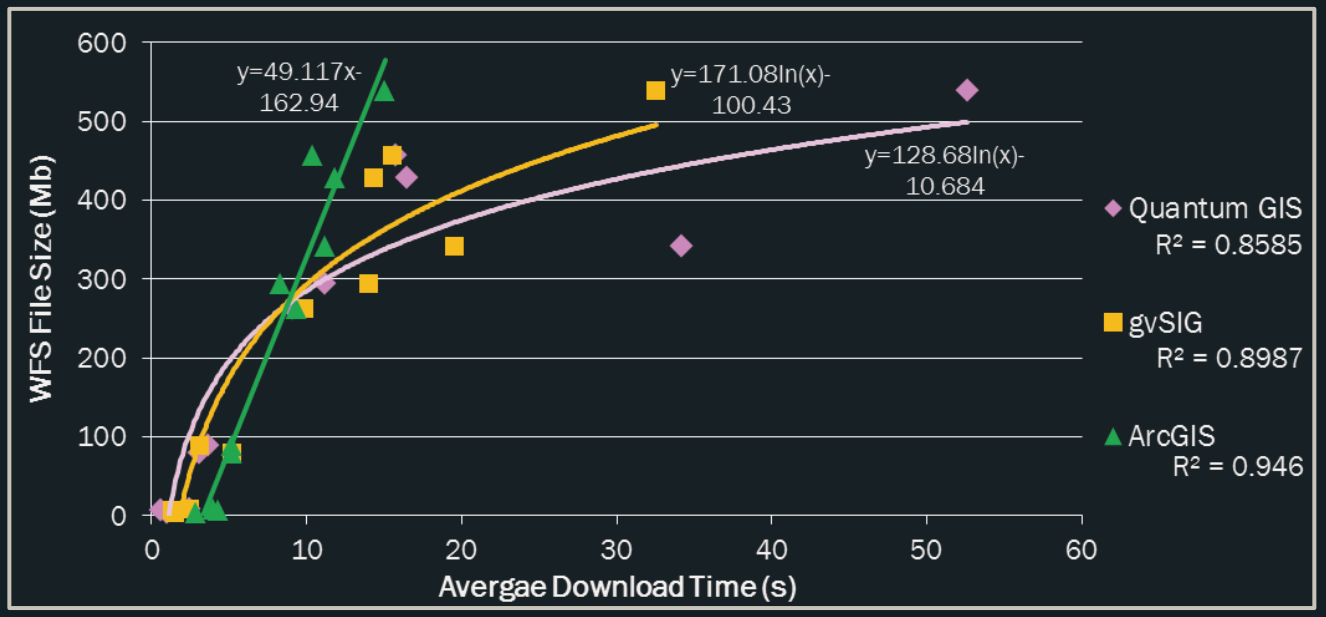
Web Mapping Server Results

- Variations in the creation of each WFS and the WFS XML structure retuned for each request
  - Impacted file size, download time, overall download speed
- No change in the overall data characteristics of each WFS



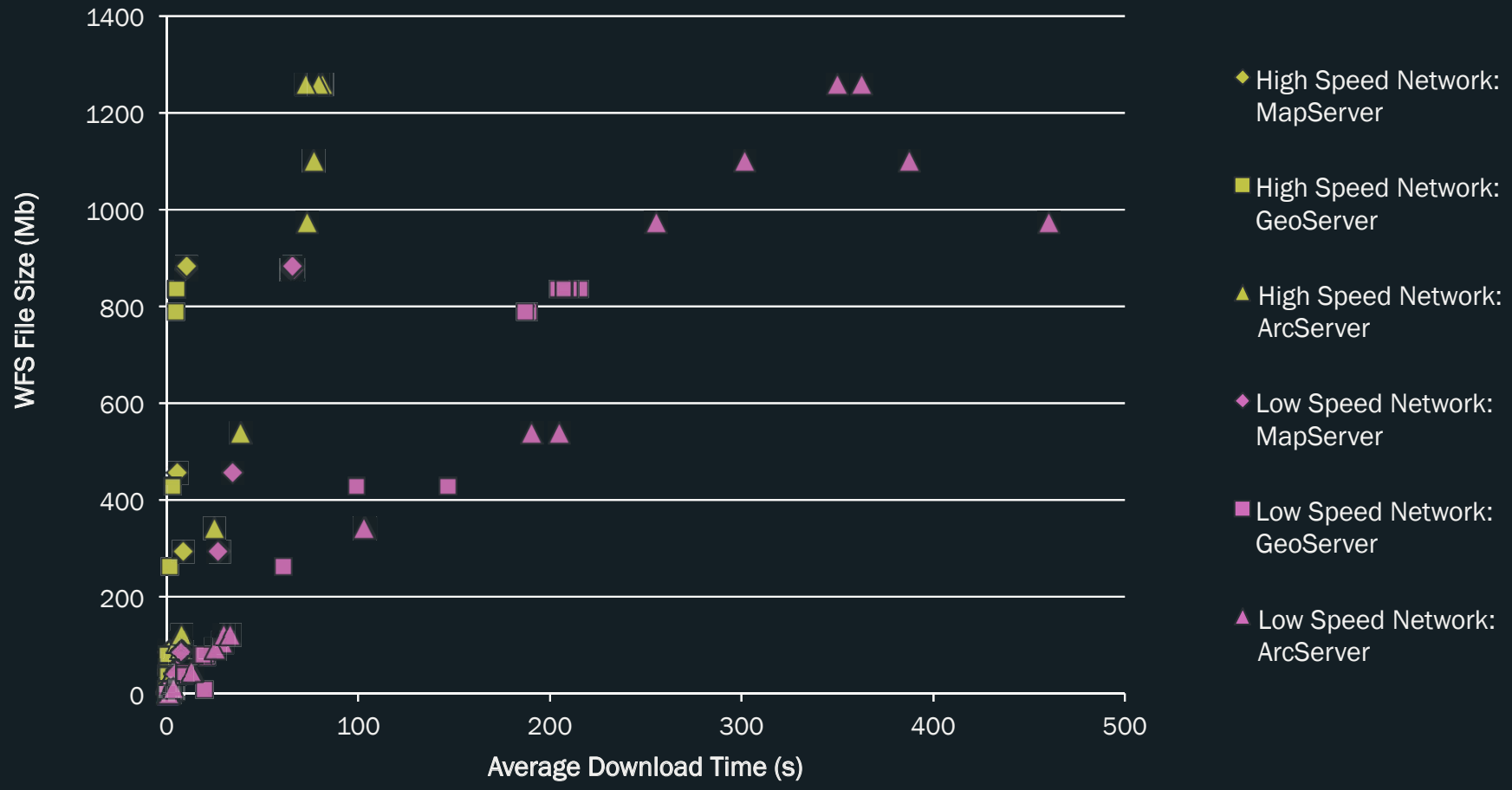
Desktop GIS Application Results

- Variations in the creation of WFS requests, download time, and overall download speed
- No change in the overall data characteristics of each WFS or downloaded file size



Hardware Results

User's Network Speed Capabilities

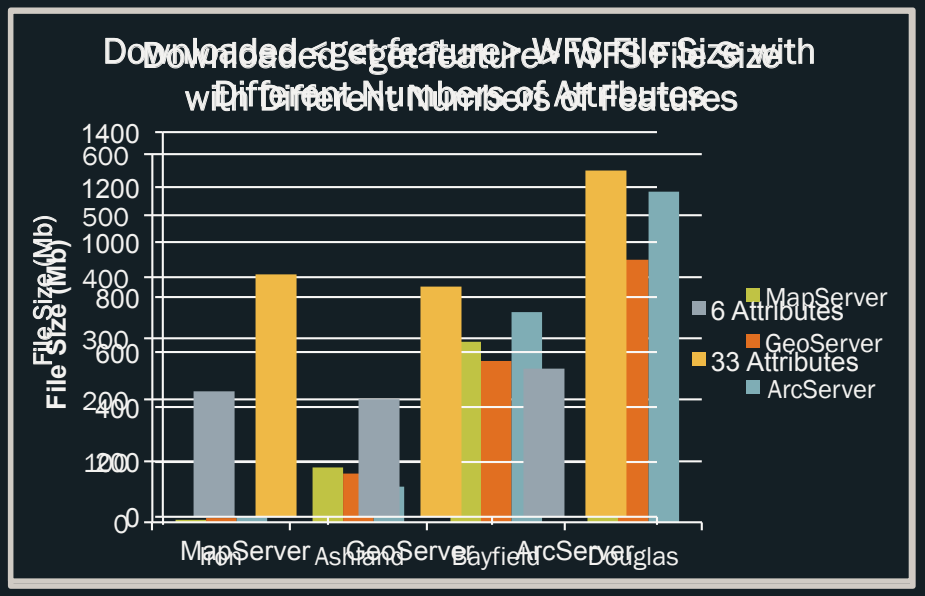


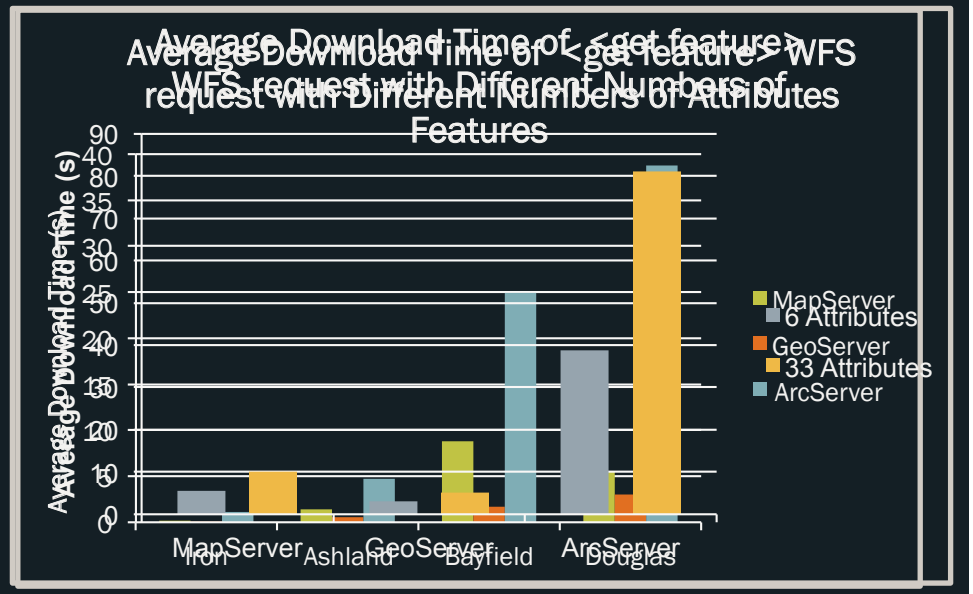
Data Component Results

Number of Features and Attributes

- Number of features and attributes mainly impacts a WFS file size and download time
- Accurate return of features and attributes for each test

Number of Features

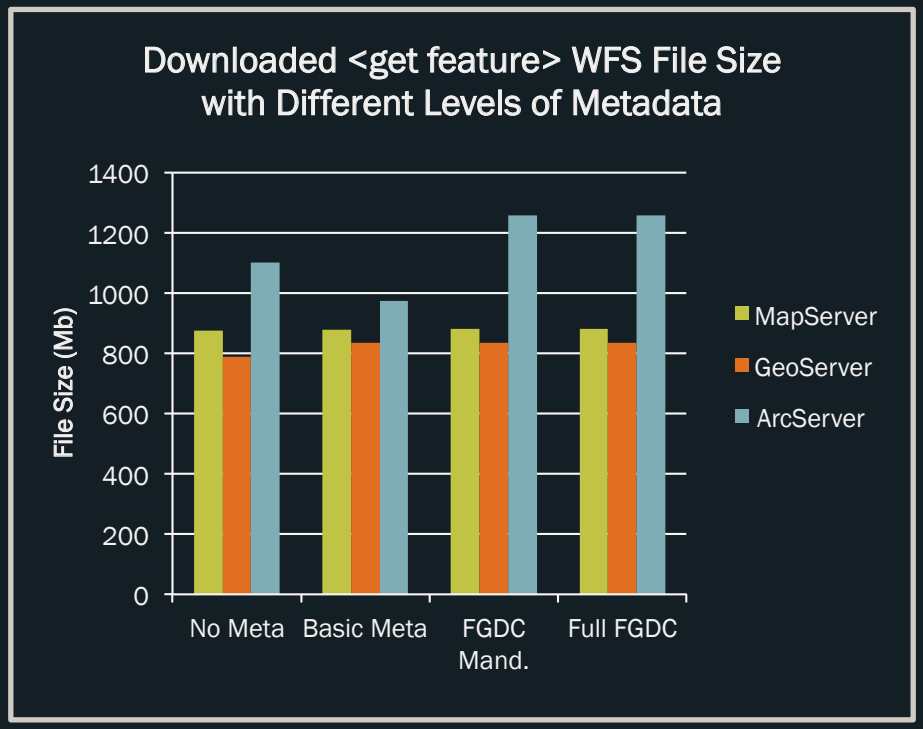


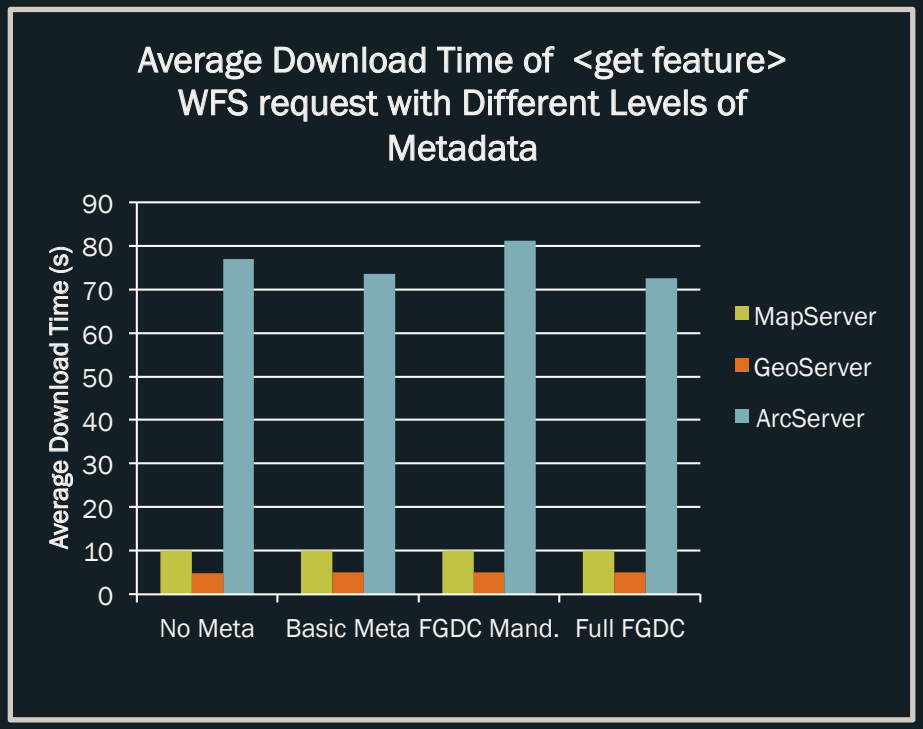


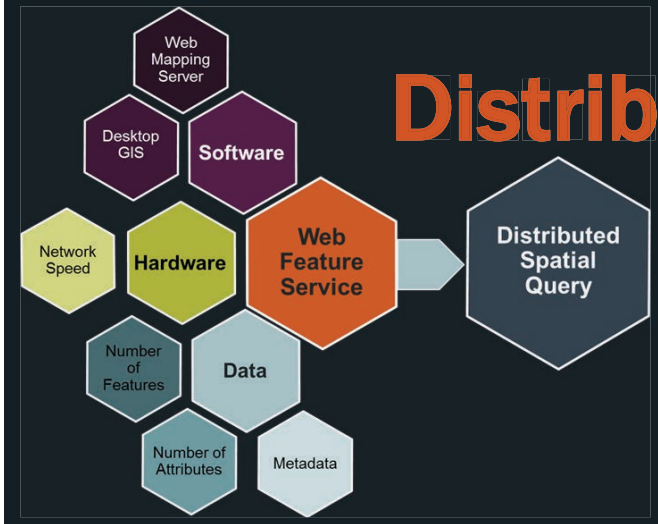
Data Component Results

Metadata

- No effect on the number of features or attributes downloaded
- No or small variation in file size and download time between all levels of metadata







Distributed Spatial Queries Result

- No effect on the results of the spatial query
- Only impacts were on the user: such as tool location and tool parameters

County	Number of selected features	Total Value (dollars)
Ashland	1,787	158,419,410
Bayfield	2,441	108,622,950
Douglas	1,671	39,260,500
Iron	91	780,500

Implications of Results

- Study suggests that all components had an impact on WFS robustness
  - Predominantly impacted by server software and network speed
  - Greatest impacts were on WFS file size and download time
- Selecting WFS components should be based off a potential users needs
- Robustness of a WFS did not affect the accuracy of a distributed spatial query

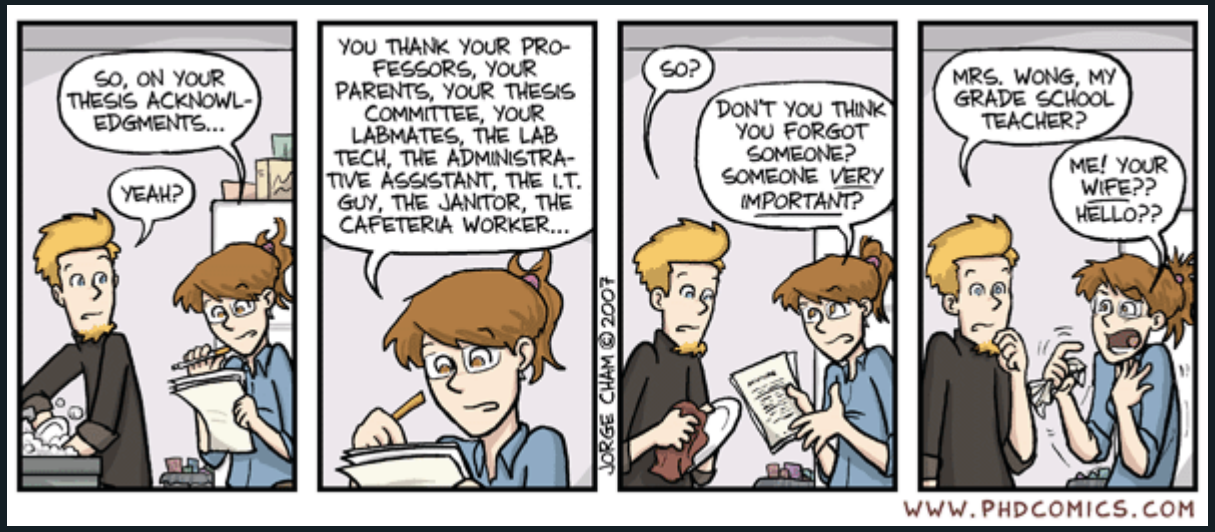
Photo source: Jim Bauer

Conclusion

- Web Feature Services:
  - Reliable, on-the-fly spatial coastal datasets
  - Flexible
  - Utilized in a variety of coastal management applications
  - Increase the use of a Coastal Web Atlas

Photo source: Wisconsin Coastal Management Program

Acknowledgements



A special thanks to my advisor, Dr. Dawn Wright, and my graduate committee, Dr. Julia Jones and Dr. David Hart. Thanks to Dr. Jim Graham for his help with web services and python scripting. Huge thanks for the support from my follow Rogues in Davey Jones Locker and well as my OSU cohort, and friends scattered across the U.S. Thank you to my family for endless support and encouragement. And a most grateful thanks to my husband, David, for his endless support and help during this entire process

Questions?

Photo source: Wisconsin Coastal Management Program

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