

Washington's Grant Tracking System GIS Enhancement Project

Advanced Editing via the Internet

By

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ABSTRACT

PRISM is the Office of the Interagency Committee's (OIAC) mission critical database used by staff as well as constituents statewide to manage grant applications and funded projects. All phases of the grant process have been automated in PRISM beginning with applicants submitting their applications on-line, the grant evaluation process, and producing contracts for successful applicants. Agency staff uses PRISM to manage projects, track milestones, produce reports, letters and billings, document site inspections, and track compliance.

Using ArcGIS Server 9.2, the following GIS enhancements have been incorporated into the new PRISM .Net application: a custom-built mapping tool accessed from within PRISM for mapping of project boundaries and for maps and report generation; and a user-friendly interface where users don't have to be GIS experts to do a fairly accurate mapping and feature editing via the internet.

Background

The Office of the Interagency Committee (OIAC) is a unique agency that supports five boards whose work centers on providing leadership and funding for recreation, natural resource enhancements, salmon habitat protection and restoration, and conservation activities. Its various boards coordinate cross-organizational policy, strategies and education.

- Interagency Committee for Outdoor Recreation (IAC)
- Salmon Recovery Funding Board (SRFB)
- Governor's Forum on Monitoring Salmon Recovery and Watershed Health
- Washington Biodiversity Council
- Invasive Species Council

On average, the agency distributes \$240M per year to its constituents statewide.

Project Information System (PRISM)

All phases of the grant process have been automated in PRISM beginning with grant applicants submitting their applications, reports and supporting documents, as well as reviewing their project information on-line. Agency staff uses PRISM to manage projects, track milestones, produce reports, process billings, document site inspections, and track compliance. It's used to manage over 5,000 recreation and conservation projects that have been funded since 1965.

Business Rationale

Grant managers need accurate maps that show worksite and property boundaries when performing project site inspections. Accurate boundaries will help identify those sites where the use of the land has been changed (converted) to a use not in compliance with the Project Agreement between the agency and the project sponsor. Sponsors and the public could use this information to determine the level of protection that has been afforded to a specific property that was acquired or developed with agency assistance. Having this information readily available could help prevent sponsors from unknowingly converting properties.

Currently, GIS information is tracked as a single point for each project, no matter if it's a 20-mile long trail, a 5,000-acre acquisition, or the replacement of a single culvert. Tracking boundaries of worksites and properties, as polygons and polylines (as well as points), will allow the agency and others who use PRISM to see the extent of the investment made in providing recreation facilities and protecting Washington's natural resources. Over the last 41 years, the agency has funded nearly 5,000 projects including the acquisition, development, or restoration of trails, local and state parks, boat launches, salmon bearing streams, wildlife habitat, etc.

PRISM Map Objects Application

The Map Objects (MO) version of PRISM GIS was implemented in 1999 using ESRI Map Objects 2.0 and currently tracks point information stored in SQL Server in various formats. The mapping tools were not available to grant applicants and other stakeholders to map the location of the projects that they submitting for funding. Applicants provided project maps with their applications and agency personnel use those materials to map the locations of projects using the existing PRISM mapping tool.

Within the original PRISM MO application agency personnel were able to:

- Place points on PRISM online maps using map screen display or coordinates provided by sponsors. Each location is cross referenced to a long list of geographic areas, including counties, cities, watersheds, salmon recovery regions, public land survey, national forests, Ranger districts, water bodies, and many more.
- IT staff support basic mapping capabilities and extracts of worksite coordinates. The agency has only simple GIS tools, not expert-level tools or expertise for editing spatial data. The agency does not have in-house GIS technical staff.

PRISM was designed to run in a client/server database environment and required client PC's to connect to the server using TCP/IP connection via the internet. Listed below are the detailed hardware and software requirements included:

CPU	Pentium/120
RAM	16 MGS
Hard Disk Storage Space	50 MGS for IAC users 25 MGS for non-IAC users 1 GB for spatial data layers
Video	VGA 640x480 16 color
Operating System	Win 95/98/NT

Server Connection	TCP/IP connection via internet
PRISM Application Software	PRISM workbenches: Project, Fiscal, Group, Inventory Process
Screen to Database Connectivity	MDAC 1.5/Remote Data Objects (RDO)
Report to Database Connectivity	SQL server ODBC Database Drivers

Currently, PRISM is being migrated from Visual Basic 6.0 to the Microsoft .NET Framework 2.0. Selected tools include Visual Studio.NET 2005, C# Development Language, WinForms Smart Client, and Click Once deployment. The database will remain in SQL Server with Crystal Reports as the report writer. The new version of PRISM based on this new architecture was implemented in May 2007.

Vision for the New PRISM GIS

In an effort to bring PRISM's GIS application up to date and to support more robust GIS functionality, the following concepts were envisioned in 2005:

- Custom-built mapping tools accessed from within PRISM for mapping of project boundaries and for generating maps and reports of various project boundaries meeting selection criteria.
- A user-friendly interface where users don't have to be GIS experts to map and edit polygons, lines, and points via the Internet.

The specific user requirement and general design concepts for PRISM GIS were documented during various working sessions with the agency grant managers and key external groups. These sessions were held in 2005 - 2006 and resulted in a detailed set of user interface design specifications and some 75 detailed required and high priority functional requirements. The requirements were grouped into the following categories:

General
Map Panel
Navigation
Tool Bar
Map Printing

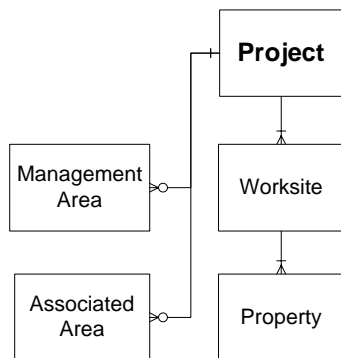
Data Layers
Queries
PRISM Application Interface
Editing Tools

The following list provides a general concept of the enhanced application:

- A new Mapping Module to be invoked from within the newly migrated PRISM.NET WinForms system.
- Use of polygons and lines, as well as points, to represent project worksites and properties.
- The storage and display of multiple levels of boundaries to represent project location, which can include worksites, properties, and management areas.
- Making the mapping module available to all PRISM users and grant applicants/sponsors (via the Internet) who can draw boundaries and place points during the application phase, with quality assurance by staff.
- The use of aerial photos, U.S. topography maps and other base layer information for better placing of project worksites.

- Enhanced selection and display of project data on maps. Enhanced display of background layers and labels.
- Allowing grant applicants/sponsors to generate and print some standard maps from PRISM.
- An infrastructure to support more advanced GIS functionality in the future, such as editing, versioning, vertical integration, coincidental layers, and advanced analysis.

Overview of PRISM Project Data Hierarchy



Worksite: Area where grant funds are being spent. Includes property being acquired; areas being planned, assessed, or studied; and locations where on-the-ground activities occur such as development, restoration, and maintenance.

Property: Area of ownership. Its boundary can contain one or more parcels. Properties identify the land to be acquired or show ownership of the lands being developed, restored, and maintained.

Management Area: Area defined as part of the contractual agreement between Managing Agency and the Project Sponsor that requires the Sponsor to ensure the continued availability, maintenance, and protection of facilities or habitat lands acquired or developed with funding assistance.

Associated Area: Area adjacent to or associated with project worksite(s). These areas are defined in existing GIS layers that can be used to help map worksites and properties and/or show a project's relationship to existing recreation/conservation lands. Examples include State Parks, National Parks, Conservation Areas, and other public lands managed for recreation or conservation purposes.

Existing and Projected PRISM Usage

It was understood from the beginning of the PRISM migration project that an enhanced hardware and software architecture would be needed. The usage estimates were based on previous grant cycles, what grant managers have observed over the years, and projected increases in pass-thru funding for various grant programs.

Existing PRISM Usage Statistics

- 40 Internal Staff
- 30 - 350 External Users
- Peak Usage has seen 150 concurrent Users
- PRISM Logs 50 transactions per hour (not all transactions are tracked)
- Read-Only Access hasn't been tracked

Projected PRISM Usage Statistics

- Function: Editing over the Internet (add/modify/commit) for polygon, lines and points

- Data Sizing: 4 terabyte of data in ARCSDE format
- General Usage: up to 40-users/day editing
- Concurrent Usage: Peaks up to 20-30 users editing/day during a 2-month period

GIS Architectural Considerations

The support of editing of spatial information online poses an interesting challenge to designers and developers, especially if one wishes to do so in a cost-effective manner.

The PRISM design team looked at numerous options for handling the editing of spatial data as well as the other significant requirements, including aerial photos. Three proposed scenarios were proposed for moving the PRISM to the Microsoft .NET environment.

Architectural Consideration 1: A Sole ArcIMS solution

The first scenario considered revolves around the use of ArcIMS for map serving as well as the development of a bridge for the editing of spatial data online. The development effort would consist of implementing a custom control, to be consumed in a WinForms application (PRISM.NET) as well as in an ASP.NET application. This map control would package-up the client-side functionality of ArcIMS into a reusable control, taking into account basic map navigation and querying to more functionality, such as editing (required for the application).

Sponsors would use PRISM.NET to launch the map view for visualization, querying and editing. Editing would be performed on points, lines and polygons in a similar manner to how Points are edited presently in the PRISM application; namely, the user would select the type of spatial object edited (point, line, polygon) and enter a point or series of points. At the end of the editing session, the point, or collection of points, is passed to the PRISM database in SQL Server (for temporary or permanent storage) and then immediately (through stored procedures and ARCSDE command line commands) stored as a feature class in the PRISM Geodatabase, making the spatial information immediately available via the ArcIMS map service.

OIAC staff would have the same ability to perform simple edits to point, line and polygon spatial information via the same kind of interface. All other mapping navigation functionality would be enabled, such as dynamic zoom, panning and identify.

In this scenario, there would be no difference in the user experience between sponsors and OIAC staff.

Architectural Consideration 2: A Hybrid ArcIMS / ArcGIS Server Solution

The second scenario considered revolves around the use of ArcIMS for map serving, fed through the ArcGIS Server. The sponsors will have the same editing scenario outlined in Consideration 1 for the editing of spatial data online. The development effort would consist of implementing a custom control, to be consumed in a WinForms application (PRISM.NET) as well as in an ASP.NET application. This map control would package-up the client-side functionality of ArcIMS into a reusable control, taking into account basic map navigation and querying to more functionality, such as editing (required for the application).

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OIAC staff would have the extended ability of a richer editing experience through ArcObjects controls via ArcGIS Server for the direct editing of the feature class in the Geodatabase. All other mapping navigation functionality would be enabled, such as dynamic zoom, panning and identify.

In this scenario, there would be a significant difference in the editing user experience between Sponsors and OIAC staff. IAC Staff would have a higher fidelity editing experience to Sponsors; however, this really isn't seen as a limitation, since the pay-off will be in better server resource usage. By this, we mean that ArcIMS will be utilized to a greater extent for basic mapping and those functions within ArcGIS Server will be utilized mainly for OIAC editing functions.

Architectural Consideration 3: An ArcGIS Server Solution

The third scenario considered was comprised solely of an ArcGIS Server solution. The sponsors would have advanced editing functionality for editing of spatial data online. The development effort would consist of implementing ArcObjects controls, to be consumed in a WinForms application (PRISM.NET) as well as in an ASP.NET application. This map control would extend ArcObjects as well as the .NET browser control into a reusable control, taking into account basic map navigation and querying to more functionality, such as editing (required for the application).

Sponsors would use PRISM.NET to launch the map view for visualization, querying and editing. Editing would be performed on feature classes within the PRISM Geodatabase. There would be no need to go through any other mechanism or SQL Server table for editing. The spatial information would be immediately available to users via the ArcGIS Server interface.

OIAC staff would have the same extended editing ability.

In this scenario, there would be no difference in the editing user experience between Sponsors and OIAC staff. The possible exception to this would be based on the credentialing of users.

Selected Architecture and Phased Development of the PRISM GIS

Due to the complexity of the project and the use of the newer server technology, an iterative approach to system development and testing was used. This phased approach to development saw the initial tools for OIAC staff and grant applicants being built and tested in ArcGIS Server

9.2 using out of the box functionality. In testing ArcGIS Server out of the box functionality within the PRISM environment, performance appeared satisfactory, and the next phase of development was undertaken.

After some discussion with the two PRISM application development consultants, the PRISM Database and GIS Project Managers and the agency's Information Technology Manager, it was decided that the risks and benefits in the Architectural Consideration #3: *An ArcGIS Server Solution* was considered the appropriate solution, given the requirements, but also provided the greatest challenge.

The technical decision was presented for review and approval to the Project Steering Committee, comprised of IT managers from for Washington state agencies: Dept. of Fish & Wildlife; Office of Financial Management; Utilities and Transportation Commission; and the Dept. of Information Services.

The project plan will follow a phased implementation with the project close out and delivery set for May 30, 2007. The phases of the project are broken down into five categories:

- ArcGIS Server Performance Testing
- Discovery and Design
- Development and Testing
- Deployment
- Project Close-Out and Delivery

The next phase of development consisted of customization of ArcGIS Server to meet the goals and requirements of OIAC.

Risk Assessment

Tackling any applications development during a major new software release heightens the level of risk that is typically encountered during any applications development effort. During the initial planning, design and development phases, the project managers and consulting staff compiled a list of 20 high, medium and low level risks that would need to be managed and monitored. Listed below are examples of some of the documented high level risks that needed to be addressed and a mitigation plan implemented.

Documented High Level Risks
The editing approach, allowing Sponsors to enter project locations, is fairly new and unproven.
ESRI technical staff had concerns about our approach of embedding an asp.net application within a WinForms application.
ArcGIS Server (9.1) had performance issues and the risk is that the new version (9.2) will perform the same.
The GIS technology is new and unproven.
System response time could be slower than current or acceptable levels.

Documented High Level Risks
The interface between the new GIS module and PRISM may not be as seamless as envisioned.
Some desired features might not be possible within budget and within tight time frame.
Hardware and software development estimates came from ESRI in 2004; costs may have risen.
May not be able to meet the May implementation date.
Combining both the new PRISM 2007 plus the new Mapping Module may be too much for one implementation.

Performance Testing

A rapid development of a simple ArcGIS Server out-of-the-box editing application was implemented and loaded for user testing in March 2007.

Early on, the agency committed to the implementation of blade server technology in the production environment. This was implemented and initial performance testing was conducted in the new production environment.

By the end of January 2007, the first testing of the out-of-the box application was conducted to see if the performance of the mapping application could handle the complex geometry in a timely fashion. Along with testing the application performance, testing was also done on how well the application performed while accessing orthoimagery data via an external IMS Image Service provided by the Dept. of Fish and Wildlife.

Pooled and Non-Pooled Application Services:

1. The general map display application was developed and implemented in a pooled environment and is accessed from the main PRISM tool bar.
2. The editing application was developed and implemented in a non-pooled environment and is accessed from project application and summary screens.

Two Server Load / Capacity Test				Three Server Load / Capacity Test			
IACGIS02				IACGIS02			
Time	CPU Usage	RAM	SOC	Time	CPU Usage	RAM	SOC
9:30	N/A	304 MB	N/A	10:05	9%	333 MB	3
9:35	43%	486 MB	4	10:10	4%	422 MB	4
9:40	30%	544 MB	6	10:15	N/A	N/A	N/A
9:45	53%	680 MB	7	IACGIS03			
9:50	2%	788 MB	9	Time	CPU Usage	RAM	SOC
9:55	14%	870 MB	11	10:05	29%	353 MB	3
10:00	1%	1 GB	12				

10:05	11%	999 MB	13
IACGIS03			
Time	CPU Usage	RAM	SOC
9:30	N/A	273 MB	N/A
9:35	43%	397 MB	3
9:40	8%	513 MB	6
9:45	21%	567 MB	7
9:50	53%	650 MB	9
9:55	59%	728 MB	10
10:00	2%	848 MB	11
10:05	2%	877 MB	12
Time	Pooled Services	Non-Pooled Services	Total # of Active Instances
9:30	3	1	<i>4</i>
9:35	4	1	<i>5</i>
9:40	7	5	<i>12</i>
9:45	7	7	<i>14</i>
9:50	7	10	<i>17</i>
9:55	7	14	<i>21</i>
10:00	7	16	<i>23</i>
10:05	7	18	<i>25</i>

10:10	1%	396 MB	4
10:15	N/A	N/A	N/A
IACGIS05			
Time	CPU Usage	RAM	SOC
10:05	50%	324 MB	3
10:10	8%	335 MB	3
10:15	N/A	N/A	N/A

Time	Pooled Services	Non-Pooled Services	Total # of Active Instances
10:05	2	7	<i>9</i>
10:10	3	8	<i>11</i>
10:15	3	9	<i>12</i>

10:10	1%	396 MB	4
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10:15	N/A	N/A	N/A
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IACGIS03

9:30	N/A	273 MB	N/A
9:35	43%	397 MB	3
9:40	8%	513 MB	6
9:45	21%	567 MB	7
9:50	53%	650 MB	9
9:55	59%	728 MB	10
10:00	2%	848 MB	11
10:05	2%	877 MB	12

IACGIS05

10:05	50%	324 MB	3
10:10	8%	335 MB	3
10:15	N/A	N/A	N/A

Time	Pooled Services	Non-Pooled Services	Total # of Active Instances
9:30	3	1	4
9:35	4	1	5
9:40	7	5	12
9:45	7	7	14
9:50	7	10	17
9:55	7	14	21
10:00	7	16	23
10:05	7	18	25

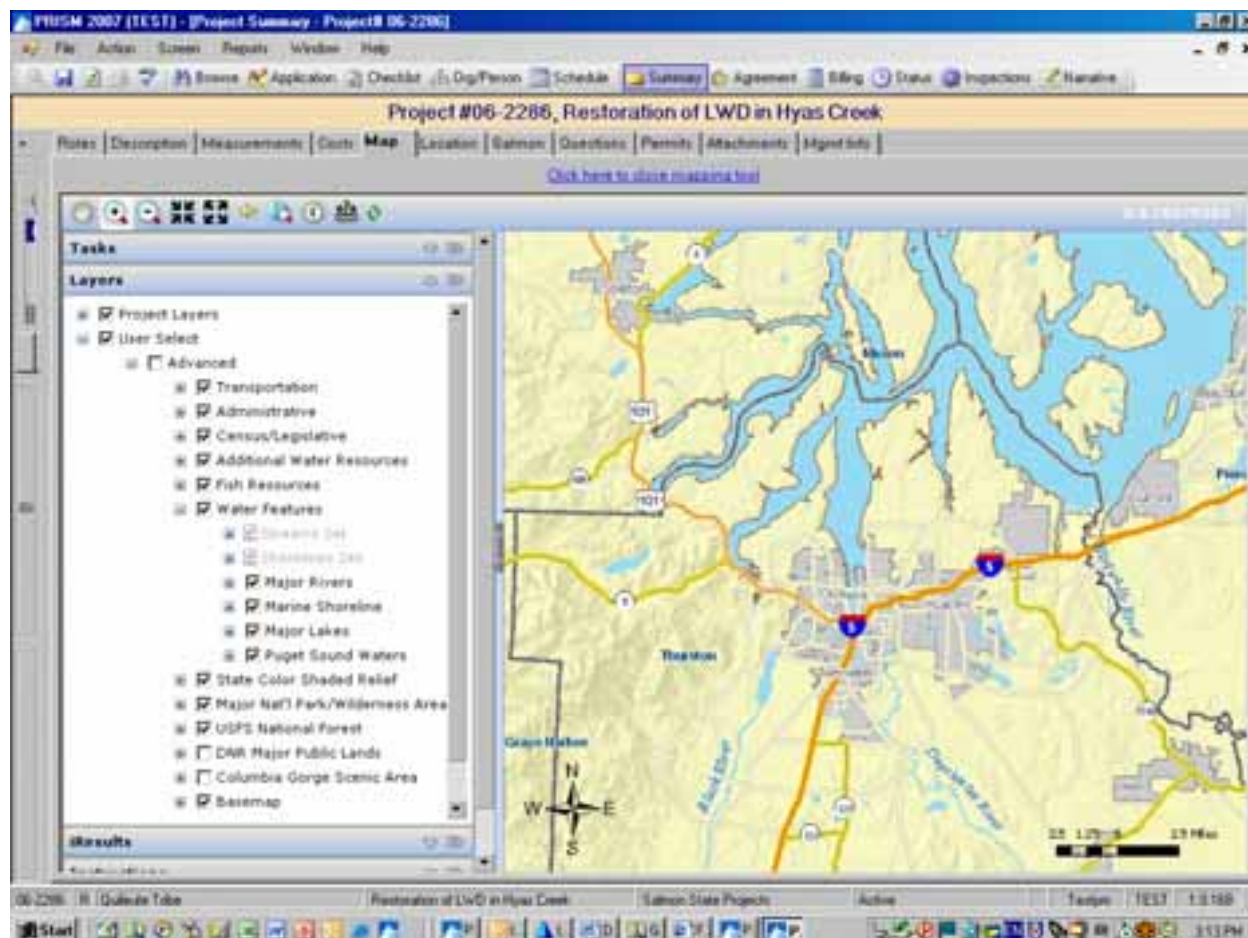
Time	Pooled Services	Non-Pooled Services	Total # of Active Instances
10:05	2	7	9
10:10	3	8	11
10:15	3	9	12

Feedback from the users was also gathered during the concurrent testing to see if the general direction and functionality would meet their initial needs. By in large, the test results were positive.

Resulting Architecture Changes

After overcoming some initial load balancing issues, and based on the results from the ArcGIS Server performance testing, the final approval to implement an ArcGIS Server application was given the go-ahead. But it was also suggested by the consultants that a third server be added to the new production environment to improve performance and load balancing. This decision was based on the usage statistics generated during the initial testing.

PRISM GIS Mapping Application



Data

Staff identified 84 data layers that had to be added to the new PRISM GIS application. Of those 84 layers, 30 layers had been used in the previous PRISM Map Objects mapping application. The major additions were base layers used for map reference – shaded relief, USGS topography maps, NOAA marine charts, major public lands and the new 2006 WA National Agriculture Image Program (NAIP) data. This resulted in the implementation of a SAN storage solution with 5+ Terabytes of vector and raster data in ArcSDE.

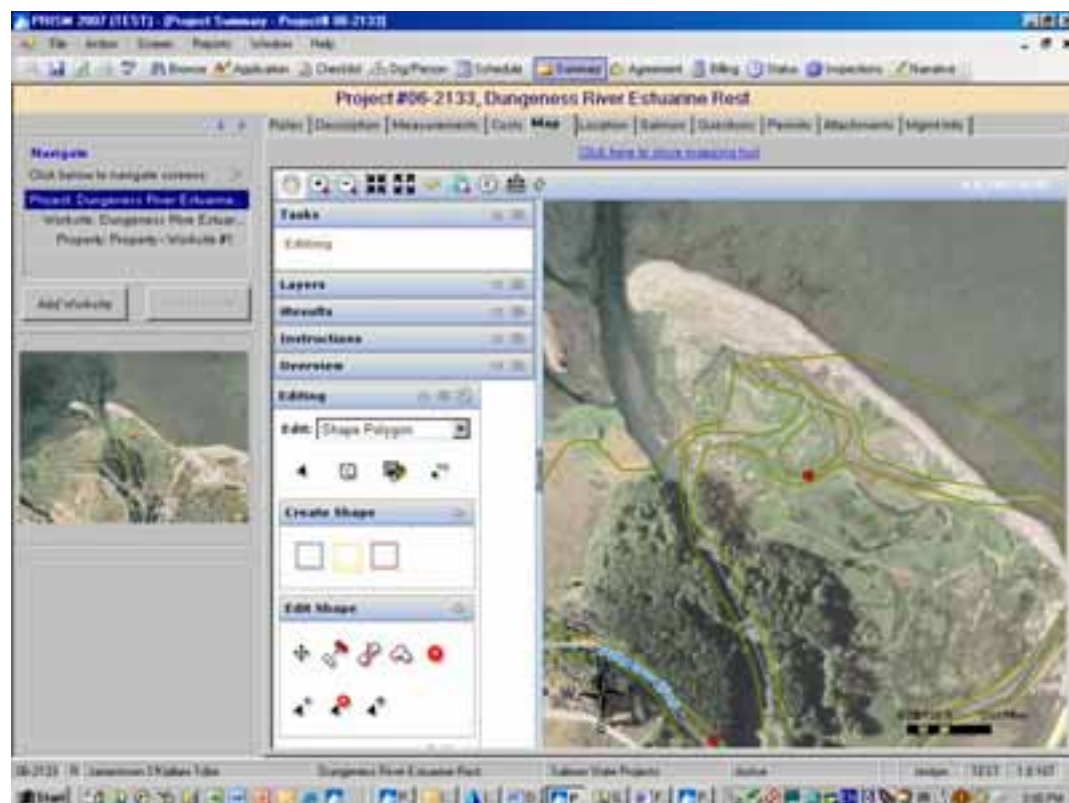
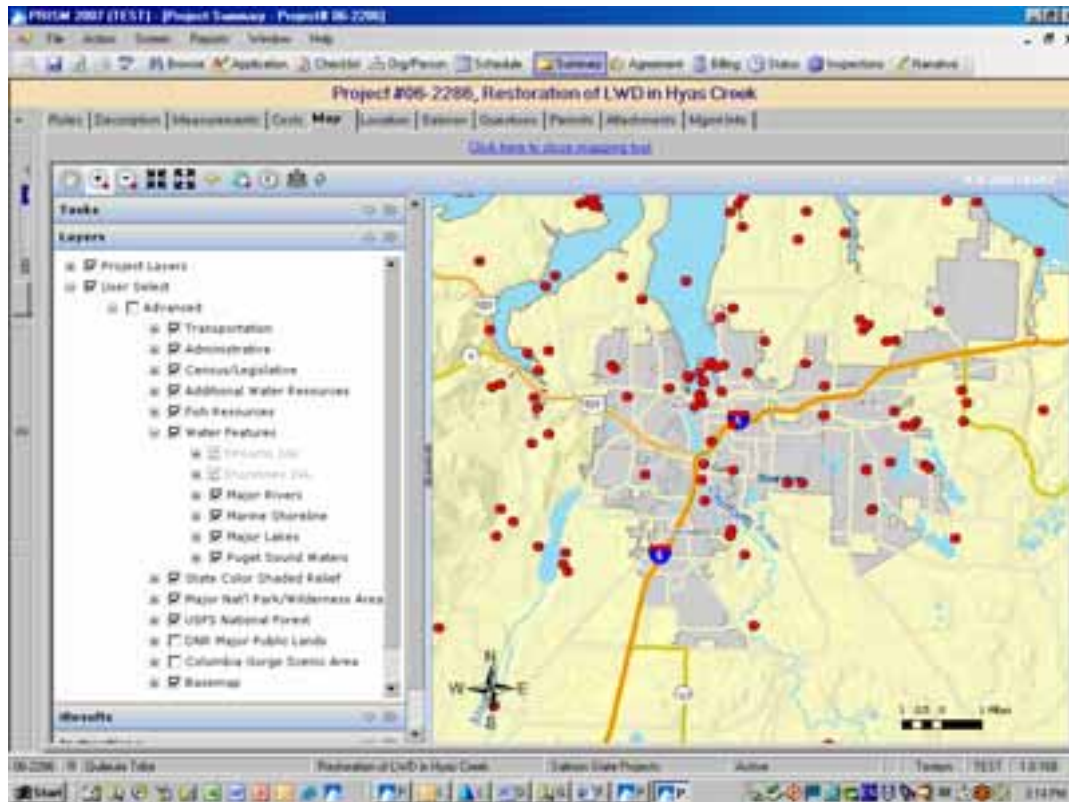
To improve map display performance, 20 + data sets were cached in a separate map service. Among these are included:

24K Railroad
Interstate Highways
Major Streets
Streets
Water Points 24k
Streams 24k
Shoreline 24k

Major Rivers
State Shoreline
Marine Shoreline
Major Lakes
Puget Sound Waters
County
City Limits

City Limits Boundary
Major Nat'l
Parks/Wilderness
USFS National Forests
Major Nat'l Parks
USFS National Forests
Shaded Relief

Map Design and Layout



Custom Functionality

PRISM is a WinForms application consuming an ArcGIS Server mapping service, hence much of the initial work centered on the coupling and communication strategy between the PRISM and the ArcGIS Server service and between the PRISM database (SQL Server) and the geodatabase.

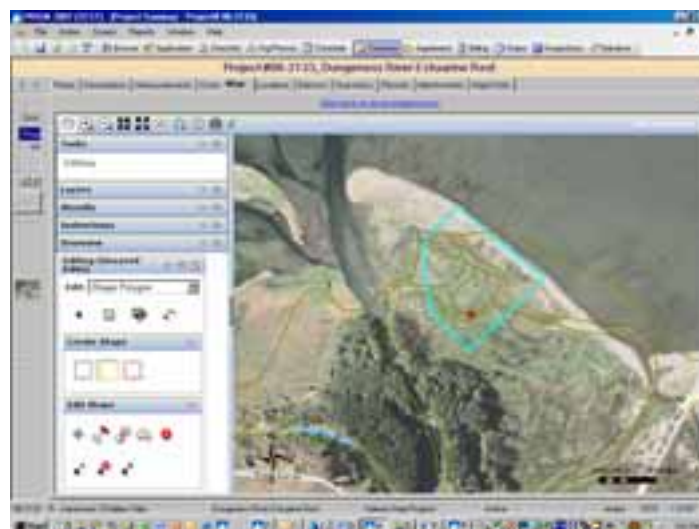
Initial custom map navigation tools were built to overcome the delineation between PRISM in a WinForms application and the PRISM ArcGIS Server mapping application. The Winform portion of PRISM needed to be aware of the state of the ArcGIS Server mapping application and vice versa, for navigation and editing.

Events raised within PRISM needed an effective communication path to trigger either events or procedures from within ArcGIS Server. Some of these were handled through the use of passed parameters to the URL of the ArcGIS Server service. Others were handled through the use of stored procedures within SQL Server and ArcSDE.

With the release of service pack 2 for ArcGIS Server more functionality was exposed to developers for control over the editing interface and editing events. Functions were created to synchronize the PRISM database and the geodatabase upon the close of the editing session, as well as performing specialized queries to populate PRISM tables with queried information during editing sessions. Ancillary, though no less important, was the development of stored procedures within the PRISM database called from within ArcGIS Server for the maintenance of the geodatabase upon the start of an editing session.

Also, during the close (and save) of an editing session with ArcGIS Server was the saving of mapping images to the PRISM database for use in other parts of the overall PRISM application, where up-to-date maps are needed, but no map interaction is necessary.

The mixture of a Winform application consuming ArcGIS Server mapping and custom functionality provided unique challenges to the development team, although as server centric architectures increasingly become the norm, 'hybrid' systems, such as PRISM will be easier to implement and serve as a compelling solution.



GIS Network, Hardware and Software Architecture

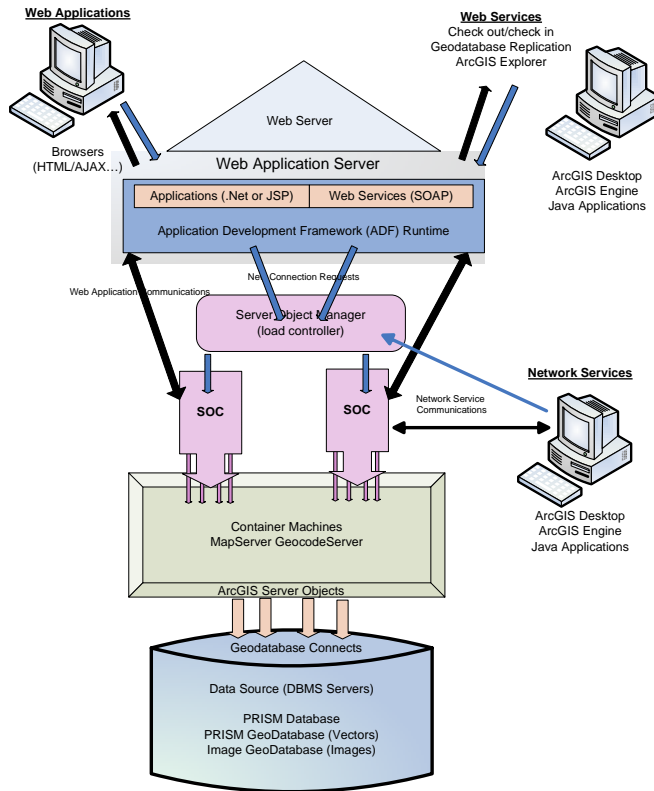
The agency decided to use a three-tier platform configuration with separate map servers. The 3-tier configuration includes a web server, map server/container machine, and a data server. We decided to use a 3-tier configuration with the Service Manager located on the Web Server. This configuration was chosen because it provides the simplest three tier configuration and it provides a scalable architecture.

Our production environment includes a single Web server which acts as the Web Application Server and provides ADF runtime services and load balancing as the Server Object Manager. The map server/container machine layer supports three Server Object Container machines to meet the required site capacity. The Service Manager load balancing is provided by the GIS service manager which resides on the web server tier. Our development, test and demo environments are set up to mirror the production environment, but the middle tier currently supports only two Server Object Container machines.

Setting up the environments was particularly difficult for our agency because we were starting from scratch with the new ArcGIS Server products (ArcGIS Server 9.2). Our production environment is comprised of five HP Blade Servers with Windows Server 2003 (E), ArcGIS Server 9.2 (SP2), and SQL Server 2005 (ArcSDE 9.2, SP2) connected to an HP External Storage Array Network. Our development environment consists of four HP Proliant Servers with Windows Server 2003, ArcGIS Server 9.2 (SP2, and SQL Server 2005 (ArcSDE 9.2, SP2) connected to different drives on the HP External Storage Array Network. We used the EDN software disks for the development network which we believe added a few unexpected and undocumented problems in setting up the web application server. These problems were not encountered when using the production ArcGIS Server 9.2 software. Considering the budget we had to work with, the timeline we were given, and the newness of the ArcGIS Server 9.2 product, we are happy with the choices we made on the three-tier platform configuration, the hardware selected, and the software we decided to use. The application has not been fully implemented into the production environment, but our users seem happy with the initial testing.

Please see the following network configurations diagrams for more information.

5/1/2007



Web Applications. The Web server manages the interface between external client and the Web application server environment. ArcGIS Server provides an ADF runtime that is executed with a .NET or J2EE Web app server. Apps can be deployed within the ADF that consume ArcGIS Server course and fine-grained ArcObjects components and support browser HTML clients. Web service catalogs can be deployed within the ADF that connect Web client desktop apps directly to services provided by ArcGIS Server. ArcGIS Server provides a rich environment for support Web client apps and service environments.

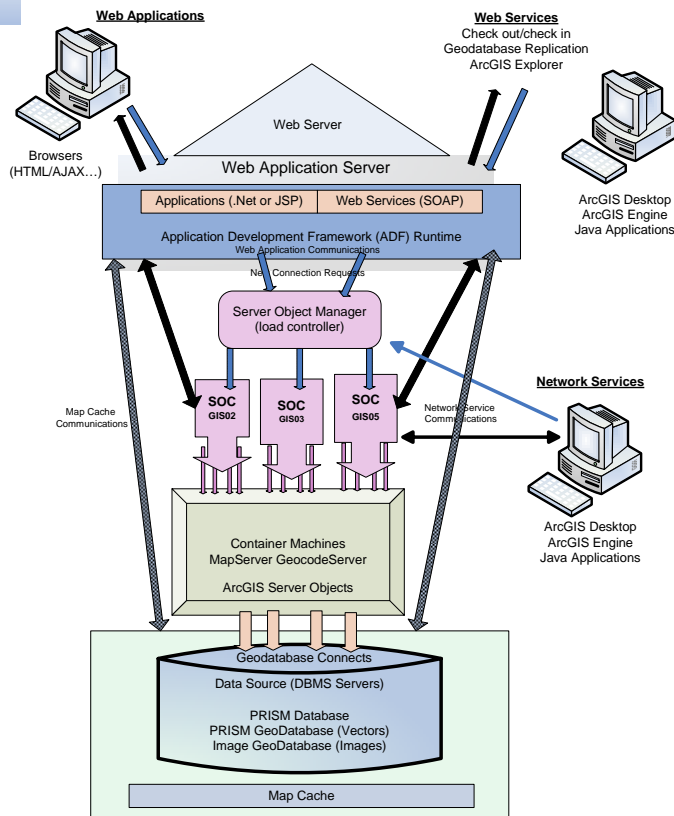
Service Manager. The ArcGIS Server Object Manager assigns inbound application service requests to appropriate ArcGIS Server Object Containers. A SOC is deployed to support each published service config. The SOM performs initial SOC startup deployment, transaction instance SOC assignment, and SOC instance load balancing and deployment management based on the published service configs. Client apps can access ArcGIS Server objects directly through the SOM network interface without the Web server interface.

Spatial Services. ArcGIS Server architecture includes a Server Object Container that supports course and fine-grained ArcObjects technology. Course grained objects are deployed with each ArcGIS Server release. Additional custom objects can be developed and deployed within the SOC C++ development Environment.

Data Source. The ArcGIS Server objects can access local shapefile, image, and SDE data sources. The service objects support query processing for local shapefile and image data sources. The SDE DBMS support query processing for SDE data sources. An SDE for Coverages interface is provided to support access to ArcInfo coverage files.

OIAC Production Environment ArcGIS 9.2 Server Components

5/1/2007



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Specific Technical Challenges Encountered

The mixture of developing a WinForms application to consume an ArcGIS Server application provided the largest technical challenge to the development team. As mentioned, the state of each application needed to be known by the other, in order to work as an integrated whole.

Stored procedures and SQL Tables, built on the fly, aided in keeping one application informed of what the other was doing, or more specifically, what the user was doing.

These challenges exposed the need for developer control (or knowledge) of rather finely-grained ArcObjects within the ArcGIS Server WEB.ADF. As additional service packs were released, more exposure was given the development team to tap into the editing model, for example.

Response time for the mapping was a significant technical challenge. The robust map built for the PRISM project needed to be responsive, hence the need for a thoughtful choice in what portions of the map were to be pooled and what other portions of the map may need to be in non-pooled services. From there, appropriate levels of caching were performed, so that the resulting mapping environment could have a close approximation to the responsiveness users expect from other mapping environments, such as those developed upon ArcIMS.

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