Agenda

- What is System Architecture?
- Design - System Architecture
  - Business
  - Data
  - Application
  - Technology
- Deploying - System Architecture
  - Scalability & Reliability
  - Performance
  - Security
  - Capacity Planning
  - Virtualization and Cloud
- Architecture Snapshots
- Summary
**What is System Architecture?**

*The Simple Definition*

- Provide optimal solutions specifying implementation information for 4 basic components
  - Users
  - Applications
  - Data
  - Network

![Diagram showing the components of a system architecture](image)
What is System Architecture?

Sounds Simple Enough

- Only 4 basic components
  - Why are we in this session then?

- The difficulty
  - Addressing two sets of extremely complex Enterprise Requirements

**Functional Requirements**
- Visualization
- Analysis
- Workflow Integration...

**Quality Attribute Requirements**
- Infrastructure
- Performance & Scalability
- Security ...

Organizations turn to Enterprise Architecture Frameworks as a roadmap.
Why is System Architecture important?

Helps address challenges faced by Energy Companies

- Global companies
- Integration with other vendors
  - standards play a key role
- Multiple data sources, projection and stewards
- “Real Time” information requirement from remote nodes
  - What is an appropriate replication mechanism?
  - Should deploy ArcGIS Server locally on each node?
  - Is Could a solution?
- Insufficient network bandwidth between nodes
- Costly software upgrades
- Integrating GIS fit within the Enterprise – role of IT
What is System Architecture?

Key Enterprise Architecture Areas

• Your Enterprise GIS Architecture is based on four* key areas:
  – Business Architecture - Business needs
  – Data Architecture - Data and workflow
  – Application Architecture - Applications utilized
  – Technology Architecture - Supporting infrastructure

• Each area provides key information for System Architecture

* Based on The Open Group Architecture Framework (Version 9), a mainstream IT framework
What is System Architecture?
Scope in an Enterprise Project

Project Phases

System Architecture

Design and Deployment are the next two sections of this presentation
Design – Focuses on Architecture Inputs and Decisions
Deployment – Focuses on Implementation Quality Attributes
Design - System Architecture
Design - System Architecture

Business Architecture
Design
Business Architecture

• **Identify**
  – Business strategy
  – Governance
  – Organization e.g. global vs. regional
  – Key business processes

• **Decisions**
  – Project Scope
    • One site, multiple sites, your whole org, interaction with other orgs…
  – Is the organization structured as centralized or de-centralized?
  – What are the key scenarios?
  – Migration
Design - System Architecture

Data Architecture
Design
Data Architecture

• Identify
  – Logical data assets
  – Physical data assets
  – Data management resources

• Decisions
  – How to address multiple data sources, projection and stewards
  – Is data going to be physically centralized or de-centralized?
    • If de-centralized, is replication necessary?
      – If replication is necessary, determine appropriate replication mechanisms
      – Is spatial versioning planned or non-simple spatial features?
        » If yes, then ArcGIS Server Replication might be a best fit
        » If no, then Relational database or disk hardware level replication might be best
Design - System Architecture

Application Architecture
Design
ArcGIS Server Conceptual Architecture

• Tiers
  – Client
  – Web
  – GIS
  – Data

Web Service Clients
ArcMap, ArcGIS Explorer, Gaia, etc.

ArcGIS Server
FGDB

Data

SOAP  REST  WMS  WCS  WFS  KML
Design
Application Architecture

• Identify
  – Individual application needs
  – Application interactions
  – Application relationships to the core business processes of the organization

• Decisions
  – First: Choose application types
  – Second: Choose corresponding ESRI applications

Use the Enterprise GIS Resource Center to help identify what is appropriate for your project
**Design**

**Application Architecture**

- Choose application type(s)
  - Application patterns are applicable cross platform and vendor solutions
  - MS Open Source Application Patterns

<table>
<thead>
<tr>
<th>Application type</th>
<th>Benefits</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mobile Applications</strong></td>
<td>• Can support handheld devices.</td>
<td>• Input and navigation limitations</td>
</tr>
<tr>
<td></td>
<td>• Provide availability and ease of use for out-of-office users</td>
<td>• Limited screen display area</td>
</tr>
<tr>
<td></td>
<td>• Can support offline and occasionally connected scenarios.</td>
<td></td>
</tr>
<tr>
<td><strong>Rich Client Applications</strong></td>
<td>• Can leverage client resources.</td>
<td>• Deployment complexity; however, a range of installation options are available, such as Windows Installer, and XCOPY</td>
</tr>
<tr>
<td></td>
<td>• Provide better responsiveness, rich UI functionality, and improved user experience.</td>
<td>• Can be challenging to version over time</td>
</tr>
<tr>
<td></td>
<td>• Provide highly dynamic and responsive interaction.</td>
<td>• Platform-specific</td>
</tr>
<tr>
<td></td>
<td>• Can support offline and occasionally connected applications.</td>
<td></td>
</tr>
<tr>
<td><strong>Rich Internet Applications (RIA)</strong></td>
<td>• Provide the same rich UI capability as rich clients.</td>
<td>• Larger application footprint on the client machine compared to a Web application</td>
</tr>
<tr>
<td></td>
<td>• Provide support for rich media and graphics display.</td>
<td>• Restrictions on leveraging client resources compared to a rich client application</td>
</tr>
<tr>
<td></td>
<td>• Simple deployment and the distribution capabilities (reach) of Web clients.</td>
<td>• Requires deployment of or Microsoft Silverlight™ run time on the client</td>
</tr>
<tr>
<td><strong>Services Applications</strong></td>
<td>• Provide loosely coupled interactions between client and server.</td>
<td>• No UI support</td>
</tr>
<tr>
<td></td>
<td>• Can be consumed by different and unrelated applications.</td>
<td>• Client is dependent on network connectivity</td>
</tr>
<tr>
<td></td>
<td>• Supports interoperability.</td>
<td></td>
</tr>
<tr>
<td><strong>Web Applications</strong></td>
<td>• Has broad reach, and a standards-based UI across multiple platforms.</td>
<td>• Dependency on network connectivity (must be connected all of the time)</td>
</tr>
<tr>
<td></td>
<td>• Offers ease of deployment and change management.</td>
<td>• Difficulty in providing a rich UI</td>
</tr>
</tbody>
</table>

SMS, Flex
Design
Choose Application Architecture

Example: ArcGIS API for Flex

• Tiers
  – Client
  – Web
  – GIS
    • ArcGIS SOM and ArcGIS SOC

• Management Interfaces
  – ArcCatalog
  – ArcGIS Services Directory
  – ArcGIS Server Manager

• Processing Loads
  – Notice Presentation Layer offloaded to client
  – Cache balance on client and server
Design - System Architecture

Technology Architecture
Design
Technology Architecture – key decisions

• Identify
  – IT infrastructure
  – Middleware needs
  – Networks
  – Standards

• Decide
  – Choose an Architectural Style and standards
  – Where Virtualization should be utilized
  – How to best minimize Network loads
  – What storage mechanisms to utilize
Design
Technology Architecture

- **Storage Mechanisms**
  - **SAN**
    - Provides optimal performance, availability and scalability
    - Common for RDBMS and Vector data
  - **NAS**
    - SAN typically does not allow concurrent access of multiple servers to file based storage on one LUN
    - Common for File Based imagery
  - **DAS**
    - Utilize local disks on web application servers with read-only File Geodatabases
    - Fast performance
Design
Technology Architecture – use virtualization when appropriate

• Primary virtualization technologies utilized by ESRI customers

  – Application Virtualization
    • Useful for scenario of:
      – Centralized Data
      – Distributed Users
      – User functional requirements demand Rich Client Applications
    • Common supporting products include
      – Windows Terminal Services
      – Citrix – Provides additional Enterprise management capabilities

  – Hardware Virtualization
    • Useful for scenario of:
      – Multiple servers are not heavily utilized
      – Facilitates server consolidation
    • ArcGIS Server now fully supported
      – Testing indicates 20-30% performance/throughput degradation due to high I/O demands of GIS imagery and functions
      – 60% degradation has been observed so testing is key to identifying your needs
Deployment - System Architecture
Deployment
Ensure Performance, Scalability and Reliability Service Level Agreement (SLA)

- Performance
- Scale up vs. Scale out
- Distributed vs. Non-Distributed
- Load balancing vs. Clustering
Performance, Scalability & Reliability
Distributed vs. Non-Distributed

Single Machine Scenario
- **Install ArcGIS Server close to data sources**
- **Only distribute components where necessary**
  - This provides best performance
- **Distribution may be necessary for**
  - Security policies, physical constraints, shared business logic, and scalability
- **Design architecture to leverage Elasticity of the Cloud Computing**

Multiple Machine Scenario
Scalability & Reliability

Scale Up vs. Scale Out

• **Scale Up – Get a Bigger Server** *(AFTER TUNING)*
  - Common recommendation for Relational Database Servers
  - Look at scale-up options first if availability requirements not high
  - **Pros**
    - Simple option with no additional maintenance costs
  - **Cons:**
    - Single point of failure
    - Windows limit is roughly 100 ArcSOC processes

• **Scale Out – Get more Servers**
  - Common recommendation for Web and ArcGIS Application Servers
  - **Pros**
    - Increases load capacity, protects against hardware failures, and ArcGIS products designed to scale out on multiple tiers.
  - **Cons**
    - Additional administrative and equipment costs
Scalability & Reliability

Load Balancing vs. Clustering

Load Balancing

- Requests distributed across all healthy servers
- Enhances performance, availability, and scalability of services such as ArcGIS Web App servers, and read-only stores

Failover Cluster

- Upon failure, standby server takes over
- Provides high availability and scalability for read/write stores such as databases
- ArcGIS SOM cluster can provide HA without burden of 2 SOMs to maintain
Deployment

Performance

- Selecting Services
- Caching
Performance
Selecting Services

- Different geospatial services have different loads on your systems
  - This table summarizes the relative performance of services
  - If performance is high, then a fast result is returned with less system overhead

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Performance</th>
<th>Considerations</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map Service Dynamic (MXD)</td>
<td>Medium</td>
<td>See below Map Service Performance Factors</td>
<td>REST Export Map</td>
</tr>
<tr>
<td>Map Service Dynamic (MSD)</td>
<td>Medium</td>
<td>Typically faster than Mxd; especially with complex document with only vector data</td>
<td>N/A</td>
</tr>
<tr>
<td>Map Service Cached</td>
<td>Low</td>
<td>Format (IE: PNG for vector; JPEG for raster)</td>
<td>REST Export Map</td>
</tr>
<tr>
<td>Map Service Cached+Dynamic</td>
<td>Medium</td>
<td>Cache base map layers and use dynamic services for a few dynamic layers</td>
<td>N/A</td>
</tr>
<tr>
<td>Geocoding</td>
<td>Low</td>
<td>Batching will improve performance</td>
<td>N/A</td>
</tr>
<tr>
<td>GeoData</td>
<td>High</td>
<td>Dependent upon volume of replication updates</td>
<td>N/A</td>
</tr>
<tr>
<td>Geometry</td>
<td>Low</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Geoprocessing</td>
<td>High</td>
<td>Dependent on complexity of the task. In general, RAM or Solid State Disks may improve performance</td>
<td>N/A</td>
</tr>
<tr>
<td>Globe</td>
<td>High</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Image</td>
<td>Low</td>
<td>Dependent on compression type, e.g. JPEG, PNG</td>
<td>REST Export Image</td>
</tr>
<tr>
<td>Mobile</td>
<td>Low</td>
<td>Synchronization dependent upon number of edits</td>
<td>N/A</td>
</tr>
<tr>
<td>Network Analysis</td>
<td>High</td>
<td>Dependent upon data format. SOC is the fastest. RAM or Solid State Disks may improve performance</td>
<td>REST Solve</td>
</tr>
<tr>
<td>WMS</td>
<td>Medium</td>
<td>Optimize map documents. Slightly slower than REST ExportMap</td>
<td>N/A</td>
</tr>
<tr>
<td>WCS</td>
<td>Variable</td>
<td>Dependent on output image type</td>
<td>N/A</td>
</tr>
<tr>
<td>3rd party services</td>
<td>Variable</td>
<td>Can impact overall performance and should be evaluated</td>
<td>N/A</td>
</tr>
<tr>
<td>WES</td>
<td>Medium</td>
<td>Ability to construct efficient query filter</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Design
Technology Architecture – Optimize network loads

• How to best minimize Network loads
  – ArcGIS Server should be installed close to the data sources
  – Visited tiles are cached in a browser
  – Map Service vs. Query tasks
  – JPEG vs. PNG
  – Bandwidth accelerators
  – Optimize content delivery, e.g. AKAMI
Design
Technology Architecture – optimize network loads

- Estimate Network loads
  - Identity available infrastructure bandwidths
  - Plan for infrastructure upgrades as necessary and balance with adjusting workflows and services utilized

<table>
<thead>
<tr>
<th>Network Load Factors by Application Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Architecture</td>
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<tr>
<td>---------------------------</td>
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<tr>
<td>Rich Client Applications</td>
</tr>
<tr>
<td>Rich Client Applications via Citrix (Image)</td>
</tr>
<tr>
<td>Rich Client Applications via Citrix (Vector)</td>
</tr>
<tr>
<td>Web Applications (Dynamic)</td>
</tr>
<tr>
<td>Web Applications (Cached)</td>
</tr>
<tr>
<td>Mobile Applications</td>
</tr>
<tr>
<td>Services (REST)</td>
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<tr>
<td>Services (SOAP)</td>
</tr>
</tbody>
</table>
Security

ArcGIS Component Locations

- Web Server
- GIS Server
- Data
- Internet (HTTP)
- Mobile Device
- Web Application
- Rich Client Applications
  - ArcGIS Explorer
  - ArcGIS Desktop
  - ArcGIS Engine

Diagram showing the network connections and server locations, including DMZ, Local Area Network (LAN), and Web Users.
Deployment

Capacity Planning

- Initial Capacity Planning Guidance
- Single Workflow Modeling
- Enterprise Workflow Modeling
- Load Testing
High-level capacity guidance

Useful when user and business needs not clearly delineated
Deployment
Model Driven Capacity Planning

- Single Workflow Modeling
  - Simple Capacity Calculator
  - Non-Distributed server model
  - Benchmark comparisons
  - See Enterprise Resource Center

- Enterprise Workflow Modeling
  - Capacity Planning Tool (CPT)
  - Modeling includes
    - Multiple workflows
    - Multiple Servers and tiers
    - Network loads

- Load-Testing
  - Collect your own statistics and model
    - See Enterprise GIS Resource Center for guidance
  - Enterprise Implementation Services Team
    - Collect statistics for your environment and provide recommendations
Architecture Snapshots
Architecture Snapshots
Geocentric - Shell Oil

User Application interfaces

Corporate Portal (User-customisable)

‘Light’ users

Specialist Apps (Business/GeoScience)

Power Users

Find & Retrieve

Geoparsing & Geocoding

Search (spatial, text, natural language)

Browse (folders, categories)

GIS Catalog (Metadata per layer)

Corporate Memory

Business Catalog (Central Asset Register)

Documents

Library Records

Federated DBs

Imagery

Federated DBMSs

Internet (search, trade journals, hosted services)
Architecture Snapshot
County Implementation

[Diagram showing network architecture with labels for Internet, Users/Services, Passive Systems Failover Site, DMZ, Reverse Proxy Web Server, Web/Application Server, Database Server, Production Internal System, and Dev/Staging Server.]

Active Systems Primary Site
Reverse Proxy Web Server
2 Core – 2+ GHz

DMZ

DMZ

Reverse Proxy Web Server
2 Core – 2+ GHz

Production Internal System

Web/Application Server 1 & 2
ArcGIS Server 9.3 & IIS

Database Server
MS SQL 2005

10TB SATA Data
Rasier/Cache File Share

iSCSI SAN

Database Server

1.8TB SAS Disks
SQL Server Vectors

Database Server

MS SQL 2005

10TB SATA Data
Rasier/Cache File Share

iSCSI SAN

Database Server

1.8TB SAS Disks
SQL Server Vectors

Database Server

ArcGIS Desktop

Users

10 Mbps

10 Mbps
Architecture Snapshots
Geospatially-Enabled - Sears

GIS Based Service Area Planning
Forecasted Demand Available Fleet

Customer Request
Home Delivery OR
Home Product Repair

Capacity Area Management System (CAMS)
Assign Technicians to work areas

Sears Enhanced Home Delivery System (EHDS)
Nationwide Geocoding and Route Optimization

Warehouse Optimization
Routing forklifts

Customer Service
Delivery Vehicle departs to your home to Deliver Merchandise
Service Technician Departs to your home for Product Repair

Computer Aided Routing System (CARS)
Geocoding and Route Optimization

Mobile Mapping
In-Vehicle Navigation

Nationwide Geocoding and Routing
GPS
In-Vehicle Navigation
Route Management
Mobile Workstation
ArcObject
Architecture Snapshot
AcGIS Server on Amazon Cloud
Architecture Snapshot
AcGIS Server on Amazon Cloud – building map cache
Architecture Snapshot
AcGIS Server on Amazon Cloud – building map cache
• ESRI will be posting Reference Implementations to the new Enterprise GIS Resource Center

• Located in the Implementation Gallery

• Reference Implementations are a mechanism to communicate deployment best practices
  – Goal is to also provide performance and security validation for Reference Implementations
Summary
Summary

- Remember the 4 basic components of System Architecture
  - User, Application, Data, and Network

- Architecture is an iterative process
  - Use your key scenarios to validate proposed alternatives

- Enterprise solutions fail if Quality Attributes not addressed
  - System Architecture addresses Quality Attribute Requirements

- Patterns and Best Practice References are your friend
  - Application Architecture Patterns
  - Architecture Styles
  - Reference Implementations
  - Capacity Planning Guides

Check out the Enterprise GIS Resource Center for the technical answers you need to provide optimal solutions
References

• **ESRI Enterprise GIS Resource Center Website**
  – Focused Enterprise GIS Technical Solutions
  – [http://resources.esri.com/enterprisegis/](http://resources.esri.com/enterprisegis/)

• **MS Open Source Application Architecture Pattern Guidance**
  – [http://www.codeplex.com/AppArch](http://www.codeplex.com/AppArch)

• **TOGAF – An Enterprise Architecture Framework**

• **ESRI Project Center Website**
  – Guidance for managing an Enterprise GIS project