ArcGIS Enterprise Systems: Designing, Testing and Monitoring

Jim VanOstenbridge, jvanostenbridge@esri.com
Martin Hamann, MHamann@esri.com
Andrew Sakowicz, asakowicz@esri.com
Agenda

• Esri’s Solution Architecture Practice
• Overview of System Tools
• System Test and System Monitor Case Study
Esri’s Solution Architecture Practice

- GIS platform strategy
- Align resources to realize intended business outcomes
- Develop initial impressions of SLAs
  - Performance
  - Scalability
  - Availability
- Develop Solution Road Map
  - Recommendations
  - Prescriptive activities
Best Practice: Leverage System Tools

- Defined: software tools to help plan, test and monitor a system implementation.
- Maintain SLA’s
- Transparency into system
- Tune system stability & availability
- Identify “bottlenecks”
- Reduce risks
- Optimize spend
- Improved capacity planning
Definitions
Performance

- Speed, e.g. response time (seconds)
Scalability

- The ability to increase output and maintain acceptable performance
Capacity

- The maximum level of output the system can produce, e.g.
- X cars/sec
- X maps/sec

At capacity

Over capacity
Bottleneck

- Resource(s) limiting the performance or capacity

Think of:
- Lanes - as CPU processor
- Toll - as ArcGIS Server instances
- Cars - as map requests
Process and Tools
Process and Tools
System Tools download

- [http://www.arcgis.com](http://www.arcgis.com)
- **owner:**EnterpriseImp
- Show ArcGIS Desktop Content
Relationship between System Tools

System Designer

User Load
CPU%

System Monitor

Capacity models

Performance Tests

System Test
System Tools framework
System Tools are not just tools

Tool
Patterns
Discipline
Infrastructure
Capacity Planning
Provide sufficient hardware resources

Most systems are CPU bound

GIS Systems are bound by:

1. CPU - typically
2. Memory – when large number of services
3. Disk – Image Service, Synchronization
4. Network – low bandwidth deployment
5. Poorly configured virtualization can result in 30% or higher performance degradation

Most well-configured and tuned GIS systems are CPU bound.
## Infrastructure

### Memory requirements

Wide ranges of memory consumptions

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<thead>
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<td>500 MB</td>
</tr>
<tr>
<td>ArcSOC Image</td>
<td>20 MB</td>
<td>1,024 MB</td>
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<tr>
<td>ArcSOC GP</td>
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<td>2,000 MB</td>
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<tr>
<td>XenApp Session</td>
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<tr>
<td>Database Session</td>
<td>10 MB</td>
<td>75 MB</td>
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<tr>
<td>Database Cache</td>
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<td>200 GB</td>
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System Designer
Solution Architecture design methodology

- Gathering requirements
- Designing
- Capacity: CPU, Network, Memory
- Reporting
Demo
System Designer
Performance Testing
Testing process

- Application
- GIS Services
- Infrastructure: Hardware and Software
Required skill set
Configuration, Tuning, Testing
System Test Tool features
GIS Test Automation

• ArcGIS Services
  - Mapping
  - Feature Service
  - OGC
  - Geocoding
  - Image Service
  - Network Analyst
  - Geoprocessing
  - Tile Cache

• Application Testing

• Discipline relevant report
## Test tools feature comparison

<table>
<thead>
<tr>
<th>Tool</th>
<th>Cost</th>
<th>Learning Curve</th>
<th>OS Metrics</th>
<th>GIS Data Generation</th>
<th>GIS Test Automation</th>
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<tbody>
<tr>
<td>Load Runner</td>
<td>High</td>
<td>High</td>
<td>Windows/Linux</td>
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<td>Visual Studio</td>
<td>Medium</td>
<td>High</td>
<td>Windows</td>
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<tr>
<td>JMeter</td>
<td>Free</td>
<td>High</td>
<td>Requires additional plugin</td>
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<tr>
<td>System Test</td>
<td>Free</td>
<td>Low</td>
<td>Windows/Linux</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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</table>

*Tech Support by Esri PS as part of consulting support*
Performance testing

Value

- Identify bottlenecks
- Determine system capacity
- Demonstrate performance SLA
Demo
System Test
System Monitoring
Monitoring Enterprise GIS
Challenges

- Multiple administrators
- Multiple disparate monitoring/diagnostic tools
- Data collected in a reactive fashion: on demand and for limited time
- Correlation of data with different timestamp is difficult
- ArcGIS administrators do not have access to all tools, data and reports
- Challenging to quickly identify the root cause and take appropriate measures
Standards for effective GIS monitoring

- Many excellent monitoring tools on the market
- Few provide GIS dashboards
- System Monitor can be used as reference implementation
Enterprise GIS effective monitoring

“PIECE” of mind with System Monitor

- Proactive
- Integrated
  - Dashboards across all tiers
- End-to-End
  - All tier monitoring
- Continuous
  - %Coverage provided
- Extendable
  - Custom queries

Key Performance Indicators:

<table>
<thead>
<tr>
<th></th>
<th>% Coverage</th>
<th>% Uptime</th>
<th>% Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100.00</td>
<td>100.00</td>
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<tr>
<td>6</td>
<td>100.00</td>
<td>98.75</td>
<td>0.00</td>
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</tbody>
</table>
Monitoring

Value

- Proactive validation:
  - Configuration
  - Resource Utilization
  - Usage Trends
  - Performance SLA
  - Uptime SLA
Demo
System Monitor
Use Cases

Applied use of System Monitor and Test tools
Demo
Simulate CPU spike (e.g. Antivirus scan)
Demo
Simulate ArcGIS user load

Table:

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>System</th>
<th>Category</th>
<th>Name</th>
<th>Instance</th>
<th>Value</th>
<th>Type</th>
<th>Validation</th>
<th>Alerting</th>
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</thead>
<tbody>
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<td>asakowicz_SampleWorldCities</td>
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<td>0.17</td>
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</table>
Case Study
Introduction

• Purpose – provide a practical case study describing how the System Monitor and System Test esri resources can be leveraged when implementing complex mission critical GIS platforms

• Case Study – Implementation of a GIS (Platform as a Service) PaaS in a large federal agency with mission critical user communities
  - Objectives, requirements, and unique challenges
  - High level architecture(s) and organizational context
  - System Monitor and System Test use case examples
Implementation Overview

• Private cloud service model – enable sponsors to efficiently provide content as standards based GIS services on appropriate infrastructure.

• COTS and Open Source technology

• Highly Available (HA) infrastructure
Implementation Overview

- Mature service features
  - Service Level Agreement (SLA)
  - Documented on-boarding procedures
  - Cost Sharing Model

- Dedicated GIS and IT support staff
Operational Environment and Organizational Considerations

- All GIS server systems are RHEL VMs (including RDBMS)

- Virtual environment is configured and managed using Puppet Labs software

- Domain expertise, system accesses, and roles are split between multiple organizations.
Challenges - GIS vs IT Roles

- The IT organization SA’s manage the infrastructure; VM’s, Puppet catalogs, classes, and scripts, software installation and licensing, web servers, and RDBMS including all tasks requiring root or DBA privileges. Windows domain admins are in a separate group.

- The GIS support team interact with the GIS site(s) through the ArcGIS Desktop applications, or the ArcGIS Server Manager or Admin rest endpoints. The GIS team has some limited access to the RHEL ‘Compute Farm’ data ingestion servers through SSH shell connections.
Technical Challenges – Complexity, the Usual Suspects

- High availability
- Fault Tolerance
- Scalability in a context of event driven traffic spikes
- Performance
- Security
- Interoperability
- Integration with existing policy and practice
- Infrastructure Environment
Technical Challenges – Project Specific

- Time enabled services based on continuously updating data feeds
- Scientific and environmental data sources require pre-processing to enable or optimize for dissemination as GIS web services
- These narrow performance optimization options (e.g. caching)
## Representative Services and Update Cycles

<table>
<thead>
<tr>
<th>Service</th>
<th>Update Frequency</th>
<th>Performance Workflow</th>
<th>Nominal Map/Image requests (Est)</th>
<th>Peak Map/Image requests (Est)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watches\Warnings and Advisories</td>
<td>1 minute \ 10 minutes</td>
<td>Light Vector</td>
<td>10K Hr</td>
<td></td>
</tr>
<tr>
<td>Daily Global Precipitation</td>
<td>Daily</td>
<td>Light Raster</td>
<td>1K Hr</td>
<td>10K Hr</td>
</tr>
<tr>
<td>Radar (1x1 km base reflectivity)</td>
<td>5 minutes</td>
<td>Light Raster</td>
<td>20K Hr</td>
<td>200K Hr</td>
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<tr>
<td>HRRR</td>
<td>15 minutes \ 1 hour</td>
<td>Heavy Raster</td>
<td>UNK</td>
<td>UNK</td>
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<tr>
<td>Hurricane Tracks/Wind/Surge</td>
<td>10 minutes or less</td>
<td>Light Vector</td>
<td>1K Hr</td>
<td>100K Hr</td>
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<td>AHPS gauges</td>
<td>15 minutes</td>
<td>Light Vector</td>
<td>1K Hr</td>
<td>10K Hr</td>
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<tr>
<td>Flood Outlook Product</td>
<td>Daily</td>
<td>Light Vector</td>
<td>1K Hr</td>
<td>10K Hr</td>
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<tr>
<td>CPC Weather Hazards</td>
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<td>10K Hr</td>
<td>100K Hr</td>
</tr>
<tr>
<td>Quantitative Precipitation Forecast (QPF)</td>
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<td>Light Vector</td>
<td>1K Hr</td>
<td>10K Hr</td>
</tr>
<tr>
<td>Weather Features</td>
<td>Daily</td>
<td>Light Raster</td>
<td>1K Hr</td>
<td>10K Hr</td>
</tr>
<tr>
<td>Sea Surface Temp</td>
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<td>1K Hr</td>
<td>10K Hr</td>
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<tr>
<td>NDFD Wind Velocity Forecasts</td>
<td>1 hour</td>
<td>Light Raster</td>
<td>1K Hr</td>
<td>10K Hr</td>
</tr>
</tbody>
</table>
Data ingestion workflow for (gridded) scientific datasets

1. Poll/Pull Data
2. Extract Raster Bands, Project, Scale, Classify
3. Extract Metadata Headers
4. Add to Mosaic Dataset
5. Update Mosaic Dataset Metadata Fields

Data Ingestion workflow for time-stamped vector datasets

1. Poll/Pull Data
2. Extract, Project, and Generalize (if applicable)
3. Extract and Apply Forecast Date/Time (Issue and valid times)
4. Add Current Features
5. Purge Stale Features
System Monitor/Test Value Proposition

- Provide shared situational awareness for GIS support roles that may not typically have access to server infrastructure and associated monitoring software managed by IT organization.

- Complement monitoring tools used by the IT organization. Simplify cross correlation of GIS domain specific settings, platform infrastructure resource constraints and/or events, and user load.
System Monitor/Test Value Proposition

• Provide empirical basis for tuning service configuration and underlying resource requirements to maximize overall system performance while taking into consideration:
  - System memory and CPU resources
  - Number of Services
  - Min/Max instances per service
  - Individual service complexity (resources required per running instance / web request)
  - Service criticality, usage patterns and load

• Auditable logs to document SLA compliance and support formal service onboarding process
The availability for both the GIS and IT teams to System Monitor KPI can help isolate the ‘signatures’ associated with adverse conditions associated with resource constraints, improper configurations, or component failures. This in turn can translate into:

- Timely decision support to enable anticipation of and/or rapid response to events
- Standardized and simplified role based procedures (SOPs) and situational responses.
- Expedited identification of the appropriate change requests and support ticket items based on empirical, thresholds, and alerts.
System Test - Standard Procedure for Onboarding GIS Services

- Services are worked collaboratively between the content sponsor and the GIS support team on the Development Tier where cartography, data ingestion, and required service capabilities are defined.

- Service configurations graduate to the QA site where the service catalog mirrors the Production site(s). Once deployed on the QA site the service is subjected to load testing using the System Test application.
System Test - Standard Procedure for Onboarding GIS Services

- Service specific System Monitor KPI collectors are configured

- If test results are acceptable they are entered as benchmark artifacts in the program CM repository and the service is queued for Production.
If unit test performance is not acceptable in terms of response time, code, and content; further analysis is performed to isolate problematic layers, cartographic configurations, or underlying RDBMS queries.

This may include leveraging additional tools such as mxdperfstat and/or PerfQAnalyzer.
# System Test – Results as CM Artifacts

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## System Test Results

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<tbody>
<tr>
<td></td>
<td>Transactions/Sec</td>
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<tr>
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<td>Request Response Time</td>
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<td>7</td>
<td>Requests/Sec</td>
</tr>
<tr>
<td>8</td>
<td>Passed Requests</td>
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<tr>
<td>9</td>
<td>Failed Requests</td>
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<td>% Failed Requests</td>
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<td>11</td>
<td>HTTP 5xx Requests</td>
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<tr>
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<td>HTTP 4xx Requests</td>
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<td>HTTP 200 Requests</td>
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<td>15</td>
<td>Avg. Content Length</td>
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</table>

### Table of Contents (Chart Layouts)

- Transaction Response Time
- Transactions/Sec
- Request Response Time
- Requests/Sec
- Request Status
- % Processor Time (CPU)
- % Idle Time (Disk)
- Available Bytes (Memory)
- Network Throughput (Network)
- Individual Transaction Response
- Avg. Content Length (in Bytes)
- Key Indicators
### System Test Results

#### Request Response Time vs. Step Load

- **Request Response Time**: [Graph showing the relationship between request response time and step load.]

#### % Processor Time (CPU) vs. Step Load

- **% Processor Time (CPU)**: [Graph showing the relationship between % processor time and step load.]

#### Transactions/Sec vs. Step Load

- **Transactions/Sec**: [Graph showing the relationship between transactions per second and step load.]

### Tables

#### Request Response Time @ nco-vs-gismgmt1

<table>
<thead>
<tr>
<th>Step Load</th>
<th>Avg. Value</th>
<th>Std. Deviation</th>
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#### % Processor Time @ nco-vs-gismgmt1

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<td>80</td>
<td>15.110</td>
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<tr>
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<td>15.647</td>
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#### % Processor Time @ vm-lnx-esri-qa2

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#### Transactions/Sec @ nco-vs-gismgmt1

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<td>100</td>
<td>35.965</td>
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Testing and Monitoring of GIS Server(s) – Test Scenarios

• Normal operation under simulated load
• Shutdown and start up of one or more read only slave(s)
• Failover to warm stand by master
• Shutdown / restart up of one or more GIS servers
Testing and Monitoring of GIS Server(s)

• Initial KPI and Thresholds – RDBMS Server(s)
  - HTTP collector for selected services
    - Response Time > 2 seconds (will vary)
    - Response Code  <> 200
    - Response Length (will vary)
  - System
    - CPU > 70%
    - Memory > 80%
## ArcGIS Server Monitoring

### AGIS Operations

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<th>Name</th>
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<th>Type</th>
<th>Type</th>
<th>Errors</th>
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<th>Busy Time per Tr (sec)</th>
<th>Transactions</th>
<th>Max</th>
<th>Busy</th>
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### HTTP Service Monitoring

#### CPC Weekly SST Anom

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#### CPC Weekly SST Total

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## Service Level KPI Overviews

### Key Performance Indicators:

| Rank | % Coverage | % Uptime | % Alert | Host                     | Counter Type                | Agent          | Samples | Calculated Samples | Expected Samples | Alert |
|------|------------|----------|---------|-------------|---------------------------|---------------------------|---------------|---------------|----------------|----------------|-------|
| 1    | 81.25      | 82.05    | 0.00    | httpsゲース    | http                      | NCO-VS-QISGMT1            | 160           | 240           | 190            | 0              |       |
| 2    | 81.25      | 81.03    | 0.00    | 123456789   | http                      | NCO-VS-QISGMT1            | 130           | 240           | 190            | 0              |       |
| 3    | 81.25      | 100.00   | 0.00    | cpx_cmapsh_du_305deg   | http                      | NCO-VS-QISGMT1            | 247           | 240           | 195            | 0              |       |
| 4    | 81.25      | 74.36    | 0.00    | cpx_drought_monitor   | http                      | NCO-VS-QISGMT1            | 145           | 240           | 195            | 0              |       |
| 5    | 81.25      | 85.10    | 0.00    | cpx_forecast_8_10_day_precip | http                      | NCO-VS-QISGMT1            | 166           | 240           | 195            | 0              |       |
| 6    | 81.25      | 87.69    | 0.00    | cpx_forecast_8_10_day_temp | http                      | NCO-VS-QISGMT1            | 171           | 240           | 195            | 0              |       |
| 7    | 81.25      | 83.05    | 0.00    | cpx_forecast_8_14_day_precip | http                      | NCO-VS-QISGMT1            | 162           | 240           | 195            | 0              |       |
| 8    | 81.25      | 83.08    | 0.00    | cpx_forecast_8_14_day_temp | http                      | NCO-VS-QISGMT1            | 162           | 240           | 195            | 0              |       |
| 9    | 81.25      | 100.00   | 0.00    | cpx_gauge_anomaly_daily_total_precip | http                      | NCO-VS-QISGMT1            | 266           | 240           | 195            | 0              |       |
| 10   | 81.25      | 43.59    | 0.00    | cpx_gfs_precip_anomaly_001 | http                      | NCO-VS-QISGMT1            | 85            | 240           | 195            | 0              |       |
| 11   | 81.25      | 52.31    | 0.00    | cpx_gfs_precip_anomaly_002 | http                      | NCO-VS-QISGMT1            | 103           | 240           | 195            | 0              |       |
| 12   | 81.25      | 66.67    | 0.00    | cpx_monthly_drought Outlook | http                      | NCO-VS-QISGMT1            | 130           | 240           | 195            | 0              |       |
| 13   | 81.25      | 69.23    | 0.00    | cpx_monthly_precipforecast | http                      | NCO-VS-QISGMT1            | 135           | 240           | 195            | 0              |       |
| 14   | 81.25      | 67.18    | 0.00    | cpx_monthly_precip_forecast | http                      | NCO-VS-QISGMT1            | 151           | 240           | 195            | 0              |       |
| 15   | 81.25      | 84.10    | 0.00    | cpx_monthly_temp_forecast | http                      | NCO-VS-QISGMT1            | 164           | 240           | 195            | 0              |       |
| 16   | 81.25      | 86.67    | 0.00    | cpx_monthly_temp_forecast | http                      | NCO-VS-QISGMT1            | 169           | 240           | 195            | 0              |       |
| 17   | 81.25      | 78.46    | 0.00    | cpx_seasonal_drought Outlook | http                      | NCO-VS-QISGMT1            | 153           | 240           | 195            | 0              |       |
| 18   | 81.25      | 81.03    | 0.00    | cpx_seasonal_precip_forecast | http                      | NCO-VS-QISGMT1            | 150           | 240           | 195            | 0              |       |
| 19   | 81.25      | 79.49    | 0.00    | cpx_seasonal_temp_forecast | http                      | NCO-VS-QISGMT1            | 150           | 240           | 195            | 0              |       |
Testing and Monitoring of PostgreSQL RDBMS HA Cluster Test Scenarios

- Normal operation under simulated load
- Failover to warm stand by master
- Shutdown of one or more read only slave(s)
- Addition or start up of read only slave(s)
Initial KPI and Thresholds – RDBMS Server(s)

- Processor utilization > 70%
- Memory utilization > 80% of physical
- Storage utilization > 80% of storage capacity
- Average Disk Seconds / Read > 10ms
- Average Disk Seconds / Write > 10ms
Continuous Update Services – Data Ingestion Tier

QA – Integration Test Site

Web

GIS

RDBMS

Data Ingestion

Production Sites

ArcGIS Server Site A

ArcGIS Server Site B

Web Servers

GIS Servers

RHEL 6.5

AGS 10.2.2

GIS Management

ArcGIS Desktop

Winn2008 R2

GIS Admins

System Monitor

System Test

Winn2008 R2

Data Ingestion

'Compute Farm'

RHEL 6.5

AGS 10.2.2

File Systems:

- Common Data
- Config Stores
- Data Ingest Staging/Logs

System Admins
Data Ingestion Process Description

- Data scripts/processes run against configuration tables in RDBMS that define groups of servers concurrently updating specific sets of source data.
- Each process logs process/status metrics to the ‘cluster’ table every 60 seconds.
Data Ingestion Process Description

- System Monitor can in turn be configured with DB/Query counters against ingest process tables to track data ingestion process status and associated resource usage.
Monitoring of Data Ingestion Processes - Scenarios

- Compute Node shutdown (one and/or all)
- Unexpected shutdown/exception in data ingestion program/process
- Master database failover to warm standby
- Missing data in common data repository
Monitoring of Data Ingestion Processes - KPI

- Compute Node(s) overall CPU, memory
- Number of running data ingest processes
- Number of RDBMS connections (master)
- For each data ingest process:
  - Process run status
  - Server CPU, memory
  - Process memory
  - Time elapsed since last data update (in units as configured for that data source)
  - Number of features/images added and/or deleted during the last update
  - Available disk space on ‘data staging’ folders/mounts
Looking Forward

Continue refinement of KPI’s, thresholds, and alerts

• Continue tuning service performance based on KPI findings

• Isolate and document KPI event/condition ‘signatures’ and identify appropriate responses, procedures, CR’s and support tickets, etc.

• Identify appropriate integration points with NCO’s existing monitoring/alerting systems and associated response protocols
Don’t forget to complete a session evaluation form!