Enterprise Geodatabase Testing
Tools and Metrics

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Presentation Roadmap

- **Why test**
- **What to test**
- **What you need to test**
- **Test tools**
- **Results (highlights)**
- **Resources**
Why Test?

1. Quantify **impact to existing resources**  
   Will ArcSDE inundate a shared network?

2. Justify **acquisition of new resources**

3. Comply **with IT architecture**

4. Educate **IT and GIS**  
   ESRI notions of tiers vs. standard IT notions of tiers

5. Reduce **Risk**  
   What configuration will work best in your unique environment?

6. Experiment **with processes and procedures**

7. Build **Relationships between IT and GIS**  
   Someone will have to support the system in production
Taming the Beast

GIS is one of largest applications for IT

**Network Traffic:**
Comparable in bandwidth to video conferencing

**Data:**
Up to petabytes of data (1,000 TBs)

**Computation:**
Computationally intensive
What to Test?

- Data Loading Procedures
- **Server load**
  - CPU + Memory
- **Network load**
  - bandwidth
- **Client response times**
  (end user experience)
- Database configuration
- ArcSDE parameters
Requirements (What you need to test)

- **Test Plan**
  - Metrics / KPI
  - Test parameters
  - Tests to perform
  - Test sequencing

- **Test Environment**
  - Hardware
  - Software
  - Data

- **People**
  - Test Team
  - HW / SW / DBA Support
  - Management Support
Test Plan: Metrics / KPI

- **KPI – Key Performance Indicator**
  - A metric in a particular context
  - Typically expressed as a ratio
  - Define before testing to determine Pass / Fail criteria

- **Client Response Time KPI**
  - e.g. 3 second map refresh 80% of the time

- **Choosing a KPI**
  - **Balance cost against business need**
  - Specifying ½ sec. map refresh 99.99999% of the time may result in significantly greater project cost
    - True business need or costly nice-to-have?
Test Plan: Test Parameters

- **Bandwidth**
  - 8 Mbps WAN
  - 100 Mbps LAN

- **ArcSDE Connection Type**
  - SDE Remote Connect
  - Direct Connect

- **User Activity Type**
  - Viewers
  - Editors
  - “Analysis” (raster loading / buffering)

- **Number of Users (1, 5, 25, 50)**
Test Plan: Levels

- **Level I: Batch Data Loading**
  - Test raster and vector data load times

- **Level II = Level I + Client Response Times**
  - Test client response times w/ArcMap
  - Test Oracle database server load

- **Level III = Level II + ArcIMS**
  - ArcIMS connections as proxy for concurrent ArcMap user sessions

- **Level IV: Thin Client Solutions**
  - ArcMap via Citrix and ArcGIS Server
## Test Plan: Tests & Sequencing

Defined tests with IDs. Parameters being tested. Duration, etc.

<table>
<thead>
<tr>
<th>Sess ID</th>
<th>TestID</th>
<th>Mbps</th>
<th>Con</th>
<th>ORA SVR</th>
<th>GDBT Users</th>
<th>GDBT Bw Req’d (Mbps)</th>
<th>Max GDBT users @ Mbps</th>
<th>WL Users</th>
<th>WL Agda</th>
<th>A-Script</th>
<th>Rast Loads</th>
<th>Date</th>
<th>Dur</th>
<th>Start</th>
<th>End</th>
<th>Purpose</th>
<th>GIFS</th>
<th>IMS CPU</th>
<th>MAX IMS CPU</th>
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<td>8</td>
<td>DC</td>
<td>test4</td>
<td>0</td>
<td>0.0</td>
<td>16</td>
<td>10</td>
<td>0</td>
<td>THINK time</td>
<td>800x500 Wake Zm2x</td>
<td>NONE</td>
<td>0</td>
<td>Dec05</td>
<td>5 mins</td>
<td>WebLoad + 1 Interactive WebLoad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4003</td>
<td>8</td>
<td>DC</td>
<td>test4</td>
<td>1</td>
<td>0.5</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>NONE</td>
<td>Rast Cat: Duplin (PC07)</td>
<td>1 Dec05</td>
<td>5 mins</td>
<td>1 Interactive GDBT + 1 raster load</td>
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<td>N/A</td>
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<td></td>
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<td>2.5</td>
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<td>10, no think time</td>
<td>500 Wake Zm2x</td>
<td>800x800 Wake Zm2x</td>
<td>NONE</td>
<td>0 Dec05</td>
<td>5 mins</td>
<td>+ WL. No raster loads.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>4006</td>
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<td>16</td>
<td>10, no think time</td>
<td>500 Wake Zm2x</td>
<td>800x800 Wake Zm2x</td>
<td>NONE</td>
<td>0 Dec05</td>
<td>5 mins</td>
<td>All GDBTs + WL. No raster loads.</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>4008</td>
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<td>800x800 Wake Zm2x</td>
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<td>10, no think time</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Test Environment: Hardware

- **Server Room**
  - “Standard issue” servers
  - Sufficient to meet anticipated demand?

- **Test Lab (8 clients)**
  - (7) “Standard issue” client PCs
    - mix of CAD and GIS
  - (1) legacy laptop
  - 6 PCs shared 3 monitors
  - 1 PC with dedicated monitor
Test Environment: 

- ArcMap 9.2
- ArcSDE 9.2
- Oracle 10gR2
- ArcIMS 9.2
- ArcGIS Server 9.2
- Citrix Presentation Server
- RedHat Enterprise Linux (Oracle)
- Windows 2003 (other servers)
**Test Environment: Software > Test Tools**

- **Commercial Tools:**
  - Mercury LoadRunner – (up to 100K) $$$
  - Visual Studio Team Edition – (~20K) $$
  - ESRI’s Enterprise Test Harness – requires ESRI professional services contract ($?)

- **Pros:**
  - Provide the most functionality

- **Cons:**
  - Steep learning curve
  - Cost of tool more than entire test budget?
Test Environment: Software > Test Tools

**Free tools:**

- **Geodatabase Performance Toolset (GDBT)**
  - Generate load against ArcSDE via ArcMap
  - Collect client response times

- **WebLoad**
  - Generate load against ArcIMS (or any web app)
  - Developed by a founder of Mercury Interactive

- **OpenSTA**
  - Not selected for this project

- **DummyNet**
  - Bandwidth Impairment
  - Runs on FreeBSD (Unix)
Geodatabase Performance Toolset (GDBT)

- **ArcGIS Desktop extension**
- **In ArcMap:**
  - Appears as a Toolbar
  - Simulate ArcMap user activity
  - Monitor client response time
- **In ArcCatalog:**
  - Appears as a Tab
  - Visualize state tree
  - Monitor edits in delta tables
  - Tweak spatial indexes
  - Etc.
GDBT: Pros and Cons

PROS:
- Reliable map display generator
  - Simulate viewers
- Reliable Update Features function:
  - Simulate editors
- Being updated for a future release
- Free of cost

CONS:
- No official support
- Bugs
- Some functions don’t work
  - Create New Features
- One instance per PC
- Can’t set test durations
  - # of operations only
GDBT Scripting: Simulating ArcMap Viewers

[Image of a script task configuration tool with highlighted options: Display Generator, Scale, Count, Generate display commands, and Generate random display commands.]

- Output Script: D:\\1-dana\1-ArcMap92-Test\\Untitled.txt
- Log File: D:\\1-dana\1-ArcMap92-Test\\gdbtest.log
- Configuration: Simple Setup
- Type: Display Generator
- Scale: 10000
- Count: 5
- Generate display commands
- Generate random display commands
GDBT: 10 Random Displays

DSP_MAPSCALE=50000
DSP_MAP_AOI=2153707.02,708360.21;2173194.87,733403.61
DSP_RANDOMEXTENTS=10
THINKING_TIME=1
GDBT: 10 Fixed Displays

Fixed Displays unrealistic due to database caching?
Mostly used Random Displays
**GDBT: Update Features limitations**
## GDBT Assumptions: “Think Time”

<table>
<thead>
<tr>
<th>Total Concurrent Users</th>
<th>Users Simulated per PC</th>
<th>Total DPM Required per PC*</th>
<th>Think Time in seconds**</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>60</td>
<td>1</td>
</tr>
</tbody>
</table>

GDBT Script Assumptions Table (6 DPM User Productivity Rate)
* Number of users simulated per PC multiplied by 6 DPM
** Total DPM required per PC divided by 60 seconds (1 minute)
Assumptions: “Think Time”

- **PC1**: DPM: 6, TT: 10.0, # users: 1
- **PC2**: DPM: 6, TT: 10.0, # users: 1
- **PC3**: DPM: 6, TT: 10.0, # users: 1
- **PC4**: DPM: 6, TT: 10.0, # users: 1
- **PC5**: DPM: 6, TT: 10.0, # users: 1

= 5 concurrent users

- **PC1**: DPM: 12, TT: 5.0, # users: 2
- **PC2**: DPM: 12, TT: 5.0, # users: 2
- **PC3**: DPM: 12, TT: 5.0, # users: 2
- **PC4**: DPM: 12, TT: 5.0, # users: 2
- **PC5**: DPM: 12, TT: 5.0, # users: 2

= 10 concurrent users

- **PC1**: DPM: 60, TT: 1.0, # users: 10
- **PC2**: DPM: 60, TT: 1.0, # users: 10
- **PC3**: DPM: 60, TT: 1.0, # users: 10
- **PC4**: DPM: 60, TT: 1.0, # users: 10
- **PC5**: DPM: 60, TT: 1.0, # users: 10

= 50 concurrent users
Other Assumptions

- **Editor to Viewer ratio:** 1:5 (20% / 80%)
- **Map Scale for Displays:**
  - Vector – 10K and 100K
  - Raster – 2K and 5K
- **Symbology / layers / scale-dependencies:**
  - Used standard technician’s MXD in GIS Unit
- **User Levels:**
  - Low = 5 users
  - Moderate = 10 users
  - High = 25 users
  - Peak = 50 users
Area of Interest: Vector (~7)

- AOIs with little “dead space” due to scripting automation
- Contiguous selection of counties vs. loading all data for all counties

```
“DSP_MAP_AOI=1569565.46,626299.67,1921106.50,929299.43”
```
Areas of Interest: Raster (~6)

- Plugged text for AOIs into GDBT scripts

```
“DSP MAP AOI=2060102.13,80458,22;2374417.33,351372.15”
```
GDBT: Client Response Time Monitoring
(A window into the user experience)
### GDBT: Client Response Time Data Collection

#### Interactive GDBT

**PC# 2, pg. 1 of 2**

- **Lev. 3, Ses. 5, Date: 12/5/07**

Note: Please collect times to 2nd decimal place.

#### Client Response Time Data Collection

<table>
<thead>
<tr>
<th>Test_ID</th>
<th>Samp_Num</th>
<th>FetchTime</th>
<th>DrawTime</th>
<th>TotalDisplayTime</th>
<th>COMMENTS</th>
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<tr>
<td>5002</td>
<td>1</td>
<td>0.53</td>
<td>0.74</td>
<td>0</td>
<td>start 12:52</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.53</td>
<td>1.07</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.04</td>
<td>0.79</td>
<td>0</td>
<td></td>
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<tr>
<td></td>
<td>4</td>
<td>0.04</td>
<td>0.74</td>
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<td>5</td>
<td>0.04</td>
<td>0.44</td>
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<tr>
<td></td>
<td>6</td>
<td>0.216</td>
<td>1.17</td>
<td>0</td>
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<tr>
<td></td>
<td>7</td>
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<td>1.36</td>
<td>0</td>
<td></td>
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<tr>
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<td>8</td>
<td>0.12</td>
<td>1.06</td>
<td>0</td>
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<tr>
<td></td>
<td>9</td>
<td>0.04</td>
<td>0.47</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>5003</td>
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<td>0.33</td>
<td>0.74</td>
<td>0</td>
<td>start 12:53</td>
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<tr>
<td></td>
<td>2</td>
<td>0.33</td>
<td>1.07</td>
<td>0</td>
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<td>0.74</td>
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<td>10</td>
<td>0.04</td>
<td>0.47</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

#### Log File Analysis

**Log File: S002_GDBTEST.log**

- **12:49:07 - THinking_TIME=10**
- **12:49:07 - DSP_RANDOMEXTENTS=10**
- **12:54:21 - Display times (sec):**
- **12:54:21 - End script [D:\SDF_TEST\LEVEL2\SCRIPTS\rcrn_dsmp_user_vec_100k.txt]**
- **12:54:21 - ***** Summary *****

#### Summary Statistics

- **Min = 0.234375, Max = 2.71875, Avg = 0.4765625**

#### Additional Information

- **Operation**
  - Total Duration
  - DSP_RAN
  - DISPLAY
  - THINKING TIME
  - DSP_RANDOMEXTENTS

<table>
<thead>
<tr>
<th>Operation</th>
<th># Edits</th>
<th>Total Time (secs)</th>
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<tbody>
<tr>
<td>Total Duration</td>
<td>1</td>
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<tr>
<td>DSP_RAN</td>
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<td>0</td>
</tr>
<tr>
<td>DISPLAY</td>
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<td>0</td>
</tr>
<tr>
<td>THINKING TIME</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>DSP_RANDOMEXTENTS</td>
<td>1</td>
<td>314.34</td>
</tr>
</tbody>
</table>
WebLoad

- Free Open Source Software Tool (FOSS)
- Created by a founder of Mercury Interactive
- Load Testing, Functional Testing, and Monitoring
- Used to generate load against ArcSDE via ArcIMS site
- One machine can simulate hundreds of virtual users
  - Similar to ESRI’s Enterprise Test Harness?
WebLoad: Components

- **WebLoad IDE**
  - Record scripts (“agendas”) using a web browser
  - Stored as JavaScript (tweakable)

- **WedLoad Console**
  - Run scripts as tests
WebLoad IDE: Agenda

http://www.virginiadot.org/projects/protim.asp
http://gis.virginiadot.org/website/vdotgis_ext/defaultLoad.htm
http://gis.virginiadot.org/website/vdotgis_ext/Run.htm
http://gis.virginiadot.org/website/vdotgis_ext/jsForm.htm
http://gis.virginiadot.org/website/vdotgis_ext/Authorize.htm
http://gis.virginiadot.org/arcims_path/ims?ServiceName=vdotgis_ext&ClientVersion=4.0&Form=1&Encode=False
http://gis.virginiadot.org/arcims_path/ims?ServiceName=vdotgis_ov&ClientVersion=4.0&Form=1&Encode=False
http://gis.virginiadot.org/website/vdotgis_ext/viewer.htm
http://gis.virginiadot.org/website/vdotgis_ext/blank.htm
http://gis.virginiadot.org/website/vdotgis_ext/TOCFrame.htm
http://gis.virginiadot.org/website/vdotgis_ext/MapFrame.htm
http://gis.virginiadot.org/website/vdotgis_ext/yellow.htm
http://gis.virginiadot.org/website/vdotgis_ext/toolbar.htm
http://gis.virginiadot.org/arcims_path/ims?ServiceName=vdotgis_ext&ClientVersion=4.0&Form=1&Encode=False
http://gis.virginiadot.org/website/vdotgis_ext/toc.htm
http://gis.virginiadot.org/website/vdotgis_ext/toc.htm
http://gis.virginiadot.org/website/vdotgis_ext/splash.htm
Sleep
http://gis.virginiadot.org/arcims_path/ims?ServiceName=vdotgis_ext&ClientVersion=4.0&Form=1&Encode=False
http://gis.virginiadot.org/website/vdotgis_ext/toc.htm
WebLoad > WebLoad Console > Load Profile

Concluding Load Size: 5
Starting Load Size: 1
Time of each interval: 1
Load to increase each interval: 2
WebLoad > Monitoring > View - Chart

PM@GIS223108L Processor:% Processor Time:_Total
Time: 160.000
Current Slice Average (Current Value): 24.302

<table>
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<tr>
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<th>Measurement Name</th>
<th>Measurement Type</th>
<th>Value</th>
<th>Scale</th>
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<td>Total</td>
<td></td>
<td>Load Size</td>
<td>Current Slice Sum (Current Value)</td>
<td>0.363</td>
<td>50.000</td>
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<td>PM@GIS223108L</td>
<td>Memory:Available MBytes</td>
<td>Current Slice Average (Current Value)</td>
<td>70.000</td>
<td>100.000</td>
<td></td>
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<tr>
<td>PM@GIS223108L</td>
<td>Processor:% Processor Time:_Total</td>
<td>Current Slice Average (Current Value)</td>
<td>8.502</td>
<td>50.000</td>
<td></td>
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</table>
WebLoad: Assumptions Influence Results

- Tested against NCDOT ArcIMS App (TIMS)
- 800 x 500 GIF
- No imagery
- ArcMap Image Service
- AOI + Map Scale chosen for higher density of features
- 10 pans / ran in a loop
- User Productivity – 6 DPM

Any one of these choices could influence performance / capacity
WebLoad: Image Dimension vs. Scale vs. AOI

First Agenda:
- 400 x 250
- Zoomed in tight
- Johnston County
- **File size:** \(~9K\)

Final Agenda:
- 800 x 500
- Zoomed out
- Wake County Beltline
- **File size:** \(~98K\)
WebLoad: ArcIMS Capacity Calculations

(Total # of images / duration of test in mins) / 6 DPM
= effective concurrent users

Example:
- 1,000 GIFs produced
- 5 minute test run
- 6 Displays Per Minute user productivity
- 1000 GIFS / 5 mins = 200 total Displays Per Minute
- 200 total DPM / 6 DPM user productivity = ~ 33 effective concurrent users
WebLoad: Our Results

Utilizing:

- ArcIMS “spatial servers” running on a single server
- Webserver (IIS) running as a virtual server on different machine (NCDOT standard practice)
- Servlet engine = Servlet Exec

Can support (within chosen KPI):

- ~40 users per server (6 Displays Per Minute)
- ~23 users per server (10 Displays Per Minute)

For more users:

- Scale horizontally (add more servers)
- Distribute “spatial server” processes to these servers
Citrix Presentation Server

- **Low bandwidth solution**
  - ~8 Mbps shared WAN from GIS Unit to Server Building

- **Publish ArcGIS Desktop to a powerful, centralized server**

- **More efficient than a web page**
  - Thin client / ICA Protocol
  - Sends only mouse clicks, keyboard strokes, and *portions* of a screen that change

- **Stability over a WAN**
  - Many dropped packets vs. LAN
  - Lose connection and reattach to ArcMap session still running on Citrix
GIS Users per Citrix Server?

- Memory required per GIS user?
  - Economics
  - ArcGIS Desktop on standalone PC = ~2G recommended

- What is a typical GIS user?
  - ArcMap session +
  - ArcCatalog session (sometimes)

  = (1) GIS User

- Limitations:
  - Unable to install GDBT (registry issues)
  - Used VBA script to cycle through features
Memory per GIS User on Citrix

<table>
<thead>
<tr>
<th>Product</th>
<th>Action</th>
<th>Server RAM (MB)</th>
</tr>
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<tbody>
<tr>
<td>ArcMap 9.2</td>
<td>Raster MXD with browse script running</td>
<td>120</td>
</tr>
<tr>
<td>ArcCatalog 9.2</td>
<td>Previewing raster data with ArcToolbox enabled</td>
<td>110</td>
</tr>
<tr>
<td>One ArcGIS Desktop User (ArcMap + ArcCat)</td>
<td>N/A</td>
<td>230</td>
</tr>
</tbody>
</table>

Table 12: Memory Utilization for One ArcGIS Desktop 9.2 User

● **Bottom line:**
  - ~15-20 users per server (4G RAM/quad-core)
  - To support more users per server, add more RAM
  - Isolate analysis users on separate Citrix server
ArcGIS Server: More Thin Client Solutions

- Intention to generate load using:
  - ArcGlobe service via ArcGIS Explorer
  - Published MXD service via Internet Explorer

- Unable to generate load against ArcGIS Server with WebLoad
  - Web 2.0 complexity
  - May be possible using OpenSTA
ArcGIS Server: Manual Testing

- Only 3 testers in lab during this session
- Manual browsing of ArcGlobe Service
- Manual browsing of Published Map Service
- **Observation:** Published Map Service used about 2X more CPU on database server
  - ArcGlobe service caching on both client and service
Output Products and Benefits

- **Detailed project report**
  - Contains technical recommendations for ArcSDE implementation

- **Build documents**
  - ArcSDE, ArcGIS Server, ArcIMS, Citrix

- **Revised Test Plan**
  - May be used as a template for future projects

- **Strengthened Relationships with IT**

- **Educated IT Staff**
Test Results: Highlights

- Direct Connect faster than SDE Remote Connect by ~1/3 (36%)
- Isolate Analysis GIS users on separate Citrix server
  - Three-ring buffer operation consumed 25% of server’s CPU resources & consumes more RAM
- Standard NCDOT servers sufficient to meet anticipated need
- Proved inadequacy of 8 Mbps WAN connection for Enterprise GIS
Further Work

Output from prototype = input to next project
(implementing ArcSDE)

Need to research:

- Versioned work flows
  - Performance will be different
- Automate load against ArcGIS Server services
- Tuning
  - Spatial indexes
  - Oracle
  - ArcIMS / ArcGIS Server
- Citrix
  - Plotting, getting data on/off servers, etc
Lessons Learned

- **Testing isn’t easy**
  - Tools have deficiencies
  - Learning how to test is part of the process

- **Making test assumptions isn’t easy**
  - “Average” map display (scale, num + type of layers, etc)

- **Testing can be a highly iterative process**
  - Test Plan evolved as we went along

- **Testing will save time and money in production**
  - ArcSDE no longer a mystery / fear factor to IT
  - Established specific needs beyond sizing charts
Resources

- **DummyNet (Bandwidth Impairment):**
  - http://www.dummynet.com/

- **Geodatabase Performance Toolset (GDBT):**
  - Google for “GDBT”

- **WebLoad (ArcIMS Load Testing):**
  - http://www.webLoad.org

- **OpenSTA (ArcGIS Server Load Testing?):**
  - http://www.openSTA.org

- **ESRI’s System Design Strategies White Paper**

- **ESRI Support Forums**
  - http://support.esri.com
Thank You. Questions?

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Additional Material

Logs
D:\SDE-TEST\Level2\Scripts\"gdbtest.log"
\LOGS
\LOGS\PERFMON

LEVEL 3
PC01
Update Features
PC02
Interactive (GDBT)
Display 100K scale
Vector
+ Webload Image
100K Users
TIMS
PC03
Display 2K scale
R+V
PC04
Display 5K scale
R+V
PC05
Raster
Batch load (Jolyn)
R+V
PC06
Raster
Batch load (Duplin)
R+V
Remote Desktop
GDBT
Vector
PC07
GDBT
Scripts
PC08
Laptop
Interactive
TIMS (Internet Explorer)
GDRT Scripts = PC1, 3, 4, 5, 8
Additional Material

**HP DL 380 G5**
- Dual-Core Intel Xeon 5150 Processor (2.66 GHz, 1333 FSB)
- 4MB L2 Cache
- Smart Array P400 Controller with 512MB write cache
- 2 Embedded NC373i Gigabit Network Adapters
- Redundant power supply
- Hot plug 2.5" SAS Drives
- 4 GB of PC2-5300 DDR2 memory

**Itanium 64**
- Dual-core Itanium® 2
- Level 1 cache: 32 KB
- Level 2 cache: 1 MB
- Level 3 cache: 12 MB
- Smokin' Fast

**Diagram**
- Itanium 64
- EVA6000 SAN
- 300 GB