

Enterprise Geodatabase Testing

Tools and Metrics

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April 2008

Presentation Roadmap

- **Why** test
- **What** to test
- **What** you need to test
- **T**est tools
- **R**esults (highlights)
- **R**esources



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:

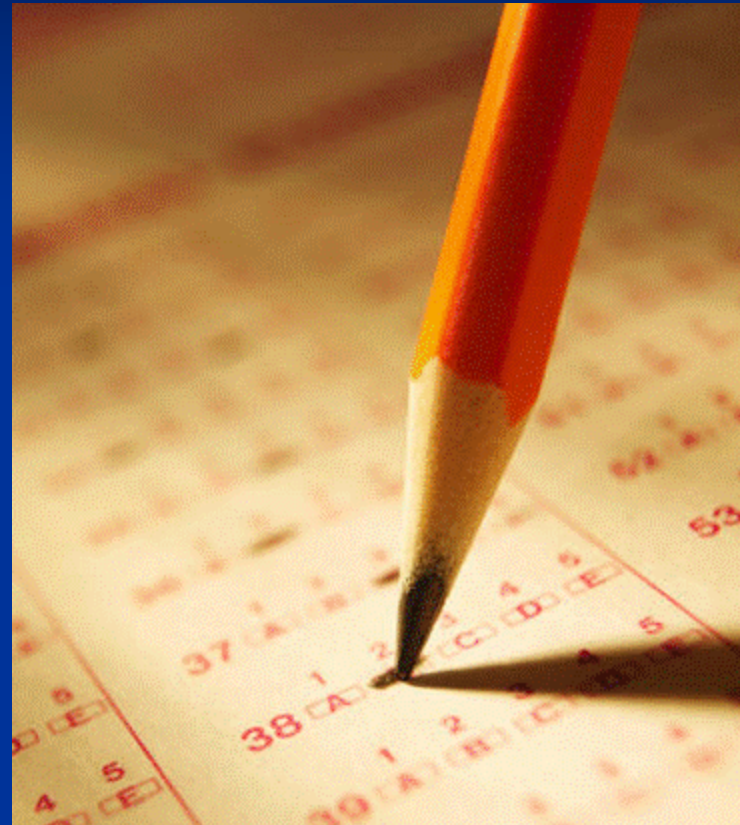
Up to petabytes of data (1,000 TBs)

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

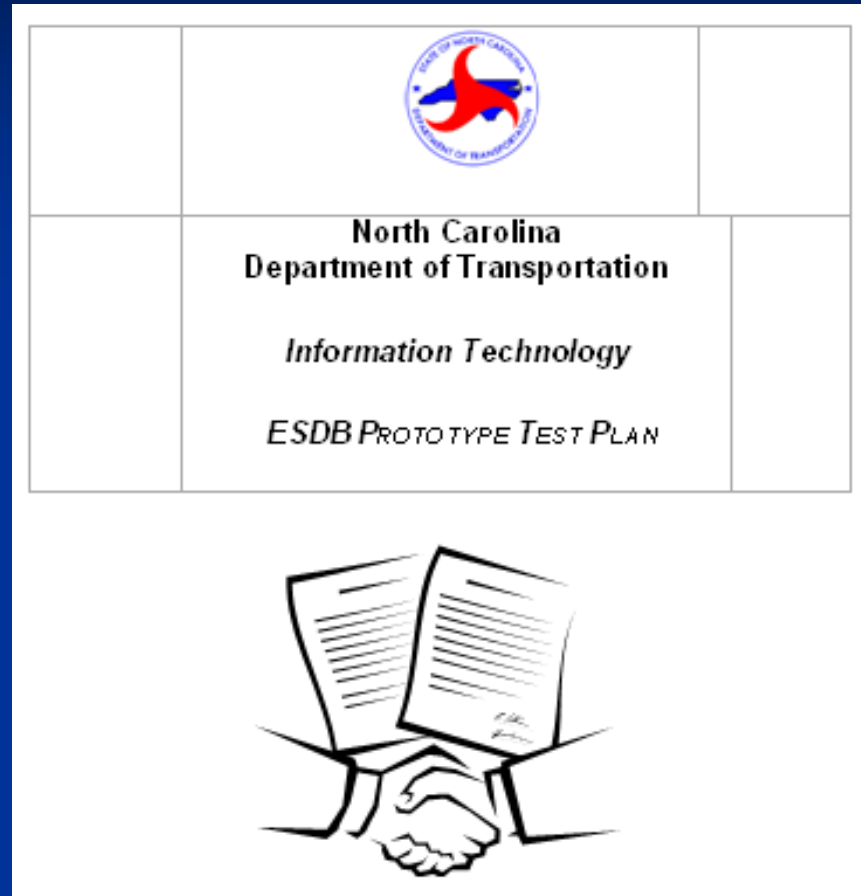
- Metrics / KPI
- Test parameters
- Tests to perform
- Test sequencing

■ 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 $\frac{1}{2}$ 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.

Sess ID	TestID	Mbps	Con	ORA SVR	GDBT Users	GDBT Bw Req'd (Mbps)	Max GDBT users @ Mbps	WL Users	WL Agda	A-Script	Rast Loads	Date	Dur	Start	End	Purpose	GIFS	AVG IMS CPU	MAX IMS CPU
4	4001	8	DC	test4	0	0.0	16	10, no think time	800x 500 Wake Zm2x	NONE	0	Dec05	5 mins			WebLoad + 1 Interactive WebLoad			
4	4003	8	DC	test4	1	0.5	16	0	NONE	Rast Cat: Duplin (PC07)	1	Dec05	5 mins			1 Interactive GDBT + 1 raster load	N/A	N/A	N/A
4	4004	8	DC	test4	5	2.5	16	10, no think time	500 Wake Zm2x	NONE	0	Dec05	5 mins			+ WL. No raster loads.			
4	4006	8	DC	test4	10	5.0	16	10, no think time	800x 500 Wake Zm2x	NONE	0	Dec05	5 mins			All GDBTs + WL. No raster loads.			
4	4008	8	DC	test4	25	12.5	16	10, no think time	800x 500 Wake Zm2x	NONE	0	Dec05	5 mins			All GDBTs + WL. No raster loads.			
4	4009	8	DC	test4	50	25.0	16	10, no think time	800x 500 Wake Zm2x	NONE	0	Dec05	5 mins			All GDBTs + WL. No raster loads.			

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: Software

- 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

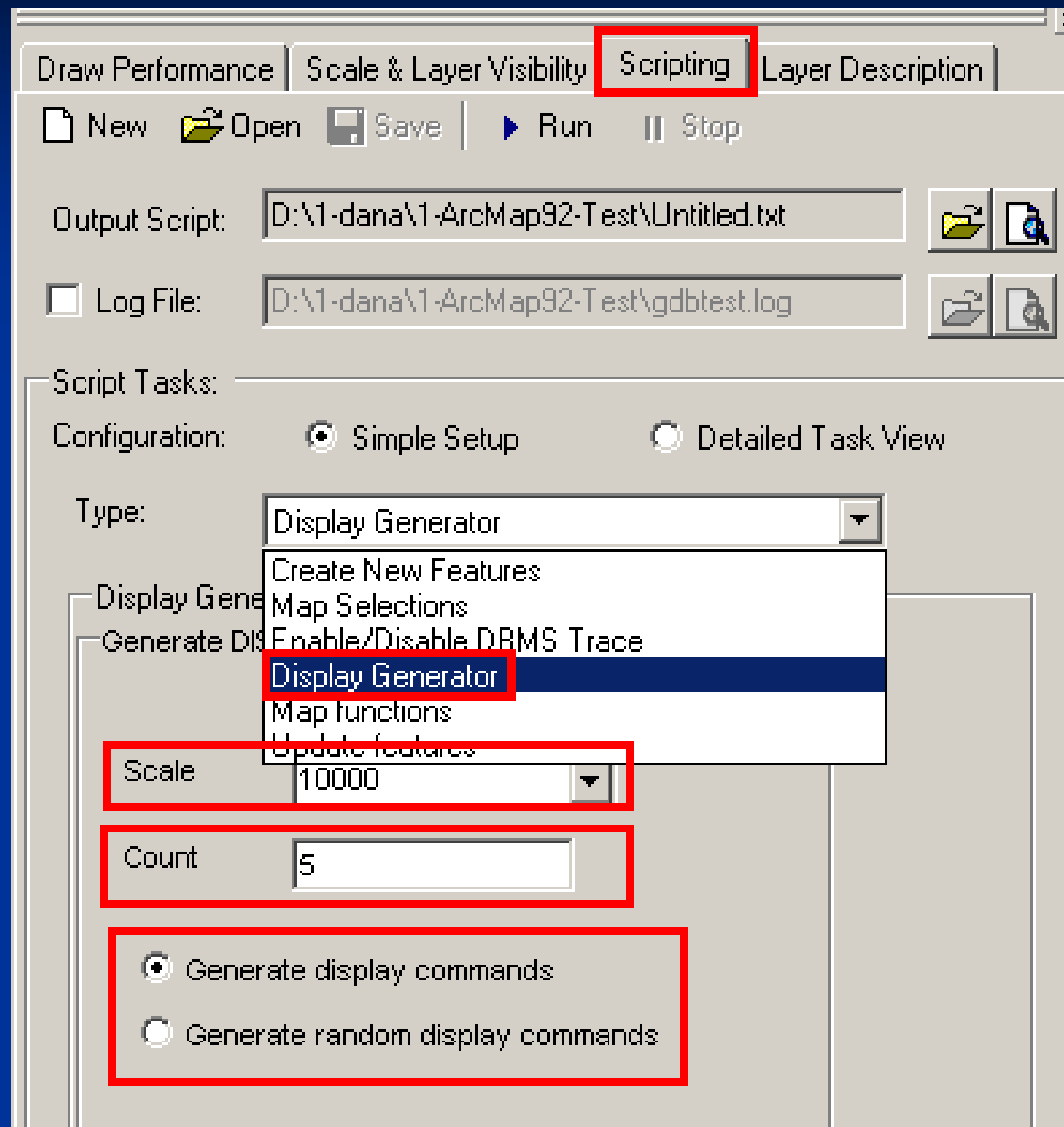
PROS:

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

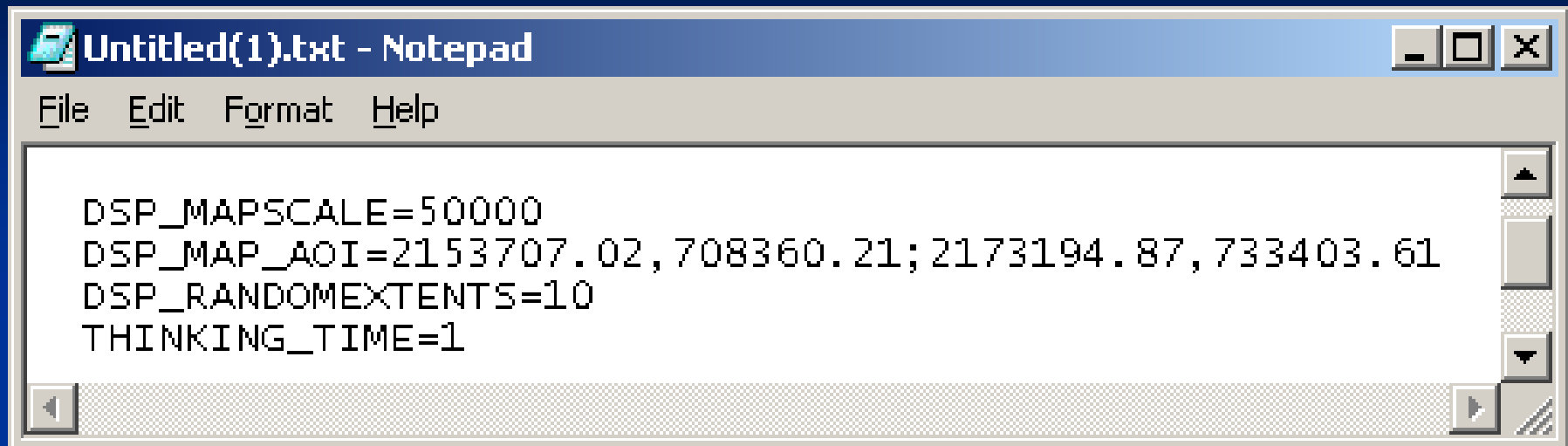
CONS:

- 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

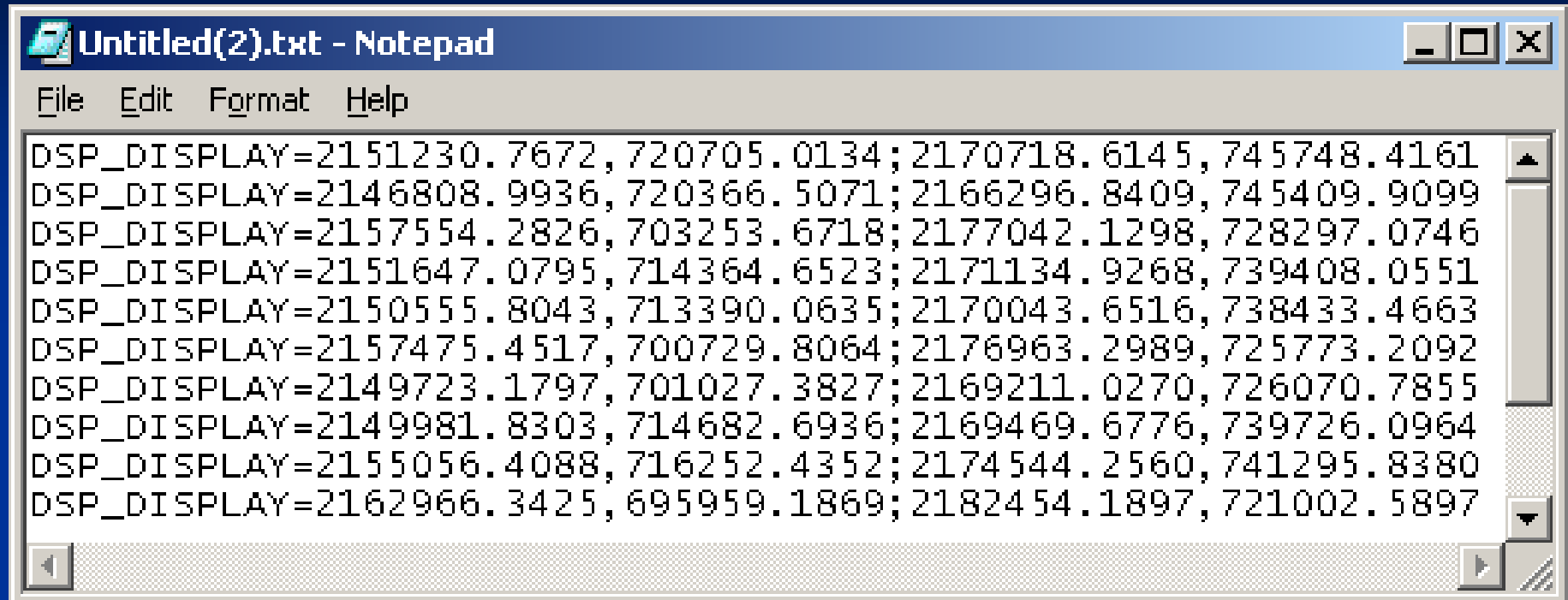


GDBT: 10 Random Displays



```
Untitled(1).txt - Notepad
File Edit Format Help
DSP_MAPSCALE=50000
DSP_MAP_AOI=2153707.02, 708360.21; 2173194.87, 733403.61
DSP_RANDOMEXTENTS=10
THINKING_TIME=1
```

GDBT: 10 Fixed Displays



```
Untitled(2).txt - Notepad
File Edit Format Help
DSP_DISPLAY=2151230.7672,720705.0134;2170718.6145,745748.4161
DSP_DISPLAY=2146808.9936,720366.5071;2166296.8409,745409.9099
DSP_DISPLAY=2157554.2826,703253.6718;2177042.1298,728297.0746
DSP_DISPLAY=2151647.0795,714364.6523;2171134.9268,739408.0551
DSP_DISPLAY=2150555.8043,713390.0635;2170043.6516,738433.4663
DSP_DISPLAY=2157475.4517,700729.8064;2176963.2989,725773.2092
DSP_DISPLAY=2149723.1797,701027.3827;2169211.0270,726070.7855
DSP_DISPLAY=2149981.8303,714682.6936;2169469.6776,739726.0964
DSP_DISPLAY=2155056.4088,716252.4352;2174544.2560,741295.8380
DSP_DISPLAY=2162966.3425,695959.1869;2182454.1897,721002.5897
```

Fixed Displays unrealistic due to database caching?

Mostly used Random Displays

GDBT: Simulating Editors with Update Features

The screenshot displays the ArcGIS Desktop interface with the **Feature Class Properties** dialog box open. The dialog box is configured for the feature class **NC1.DBO.Roads_WakeDurOrange_EDIT**. The **Feature in extent** field is highlighted with a red circle and contains the value **5586**. Below this, several actions are listed with their respective counts, each highlighted with a blue box:

- Move geometry**: 56
- Move node**: 0
- Add Vertex**: 56
- Split**: 56
- Delete**: 56
- Update Attributes**: 56

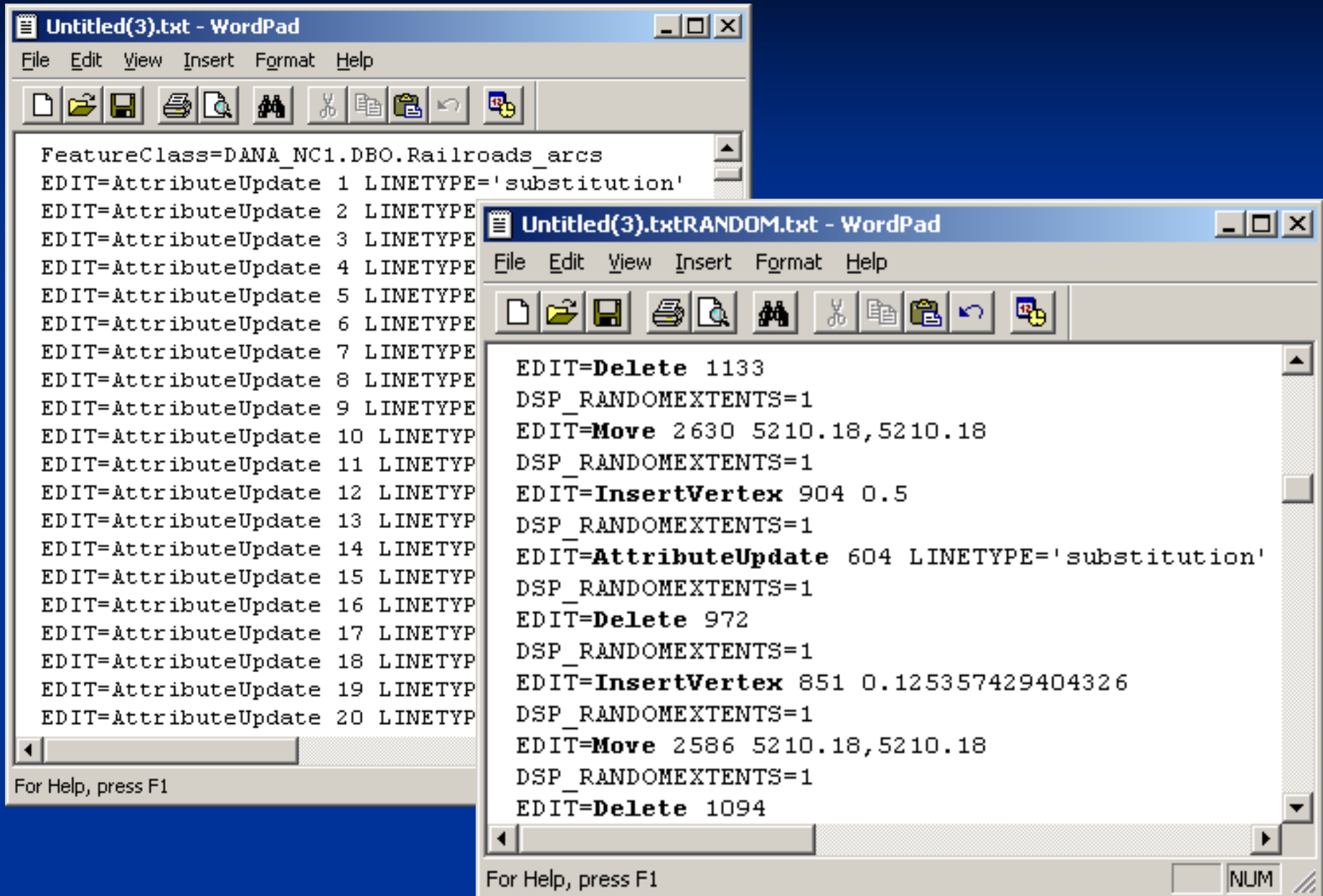
The **Expressio** field is also highlighted with a blue box and contains the expression **MSLINK=9999**. The **OK** and **Cancel** buttons are visible at the bottom of the dialog box.

In the background, the **Update Features** tool configuration is visible. The **Type** is set to **Update features**. A table shows the feature class and the number of features:

FeatureClass	# Features
NC1.DBO.Roads_WakeDurOrange_EDIT	5586

At the bottom of the interface, the **XOffset** is set to **588.14** and the **Sample percent** is set to **1**, which is also highlighted with a red circle.

GDBT: Update Features limitations



GDBT Assumptions: “Think Time”

Total Concurrent Users	Users Simulated per PC	Total DPM Required per PC*	Think Time in seconds**
5	1	6	10
10	2	12	5
25	5	30	2
50	10	60	1

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

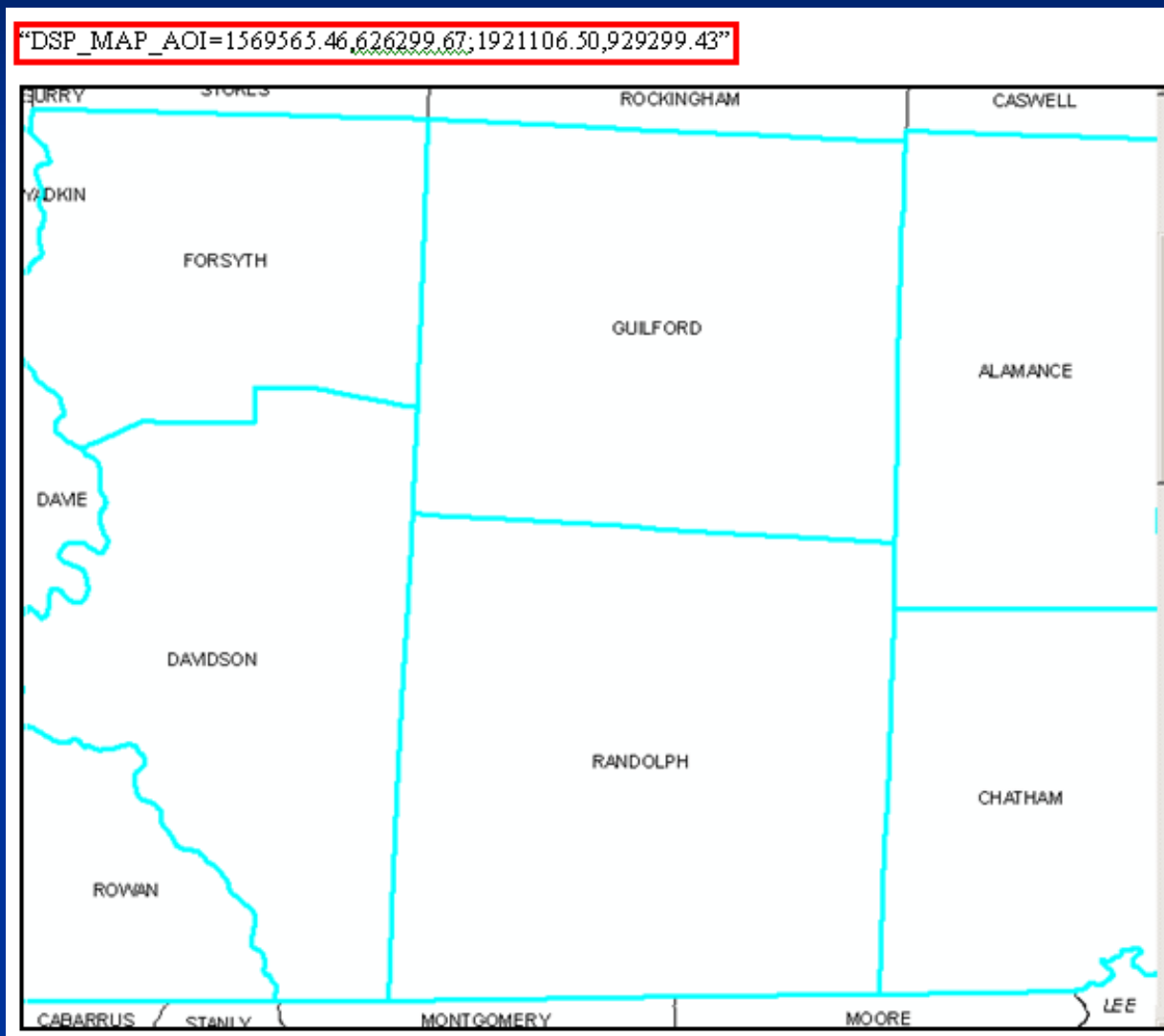
= 50 concurrent users

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

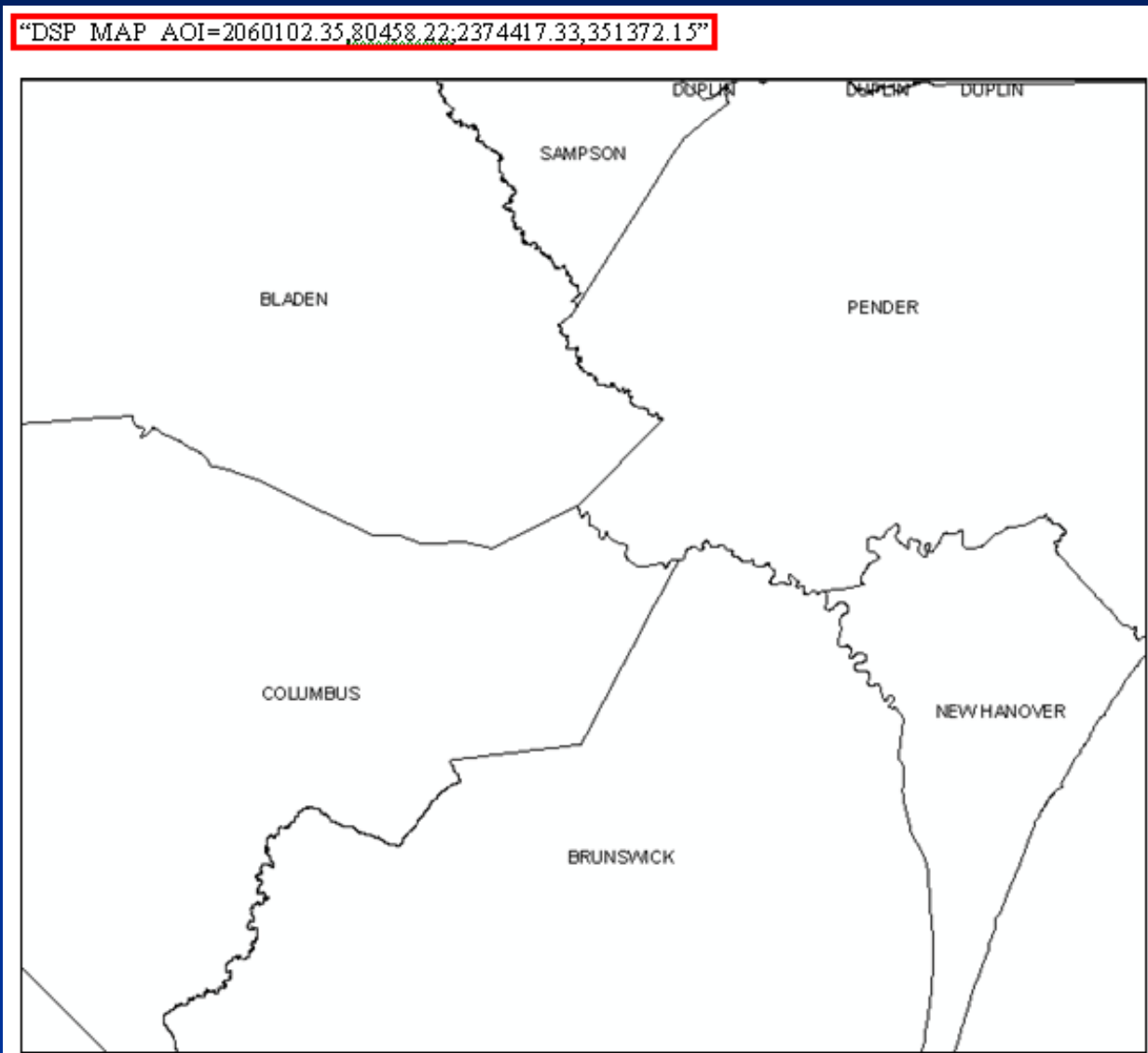
Area of Interest: Vector (~7)

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



Areas of Interest: Raster (~6)

- Plugged text for AOIs into GDBT scripts



GDBT: Client Response Time Monitoring

(A window into the user experience)

Geodatabase Toolset

1:100,000

Draw Performance | Scale & Layer Visibility | Scripting | Layer Description

Summary

Total Fetching Time: 0.195808816140959 sec(s) **Fetch Timer**

Total Draw Time: 0.216952809866671 sec(s) **Draw Timer**

For:

3 feature layers 1101 features fetched

3 visible layers 0 labels fetched

Layer Name	Total Count	Fetch Time	Draw Time (Features/Sec)
0 NC1.DBO.Statewide_Roads_orig	831	0.175221429287479	4742
1 NC1.DBO.Railroads_arcs	270	0.0202194149108686	13353
2 NC1.DBO.CountyBoundary_arcs	0	0.000367971942611...	0

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

10 interactive
samples per test
round:

5 vector

5 raster +
vector

Test_ID	Samp_Num	FetchTime	DrawTime	TotalDisplayTime	COMMENTS
5002	1	0.33	0.74	0	start 12:52
	2	0.03	1.07	0	
	3	0.04	0.79	0	
	4	0.04	0.74	0	
	5	0.04	0.44	0	
	6	0.08	1.16	0	
	7	0.26	1.17	0	
	8	0.25	1.36	0	
	9	0.12	1.00	0	
	10	0.06	1.47	0	end 12:57

```
5002_GDBTEST.log - WordPad
File Edit View Insert Format Help
12:49:07 - THINKING_TIME=10
12:49:07 - DSP_RANDOMEXTENTS=30
12:49:07 - -----
12:54:21 - Display times (sec): Min = 0.234375 Max = 2.71875 Avg = 0.4765625
12:54:21 - -----
12:54:21 - End script [D:\SDE_TEST\LEVEL2\SCRIPTS\rdrn_dsp_5usr_vec_100k.txt]
12:54:21 -
12:54:21 -
12:54:21 - ***** Summary *****
12:54:21 - Table
12:54:21 - Total Duration
12:54:21 - DISPLAY
12:54:21 - DISPLAY
12:54:21 - DISPLAY
12:54:21 - Operation
12:54:21 - Total Duration
12:54:21 - DSP_MAPSCALE
12:54:21 - THINKING_TIME
12:54:21 - DSP_RANDOMEXTENTS
12:54:21 - # Edits
12:54:21 - Total Time (secs)
12:54:21 - 1
12:54:21 - 0
12:54:21 - 0
12:54:21 - 1
12:54:21 - 314.56
12:54:21 - 0
12:54:21 - 0
12:54:21 - 1
12:54:21 - 314.34
For Help, press F1
NUM
```

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

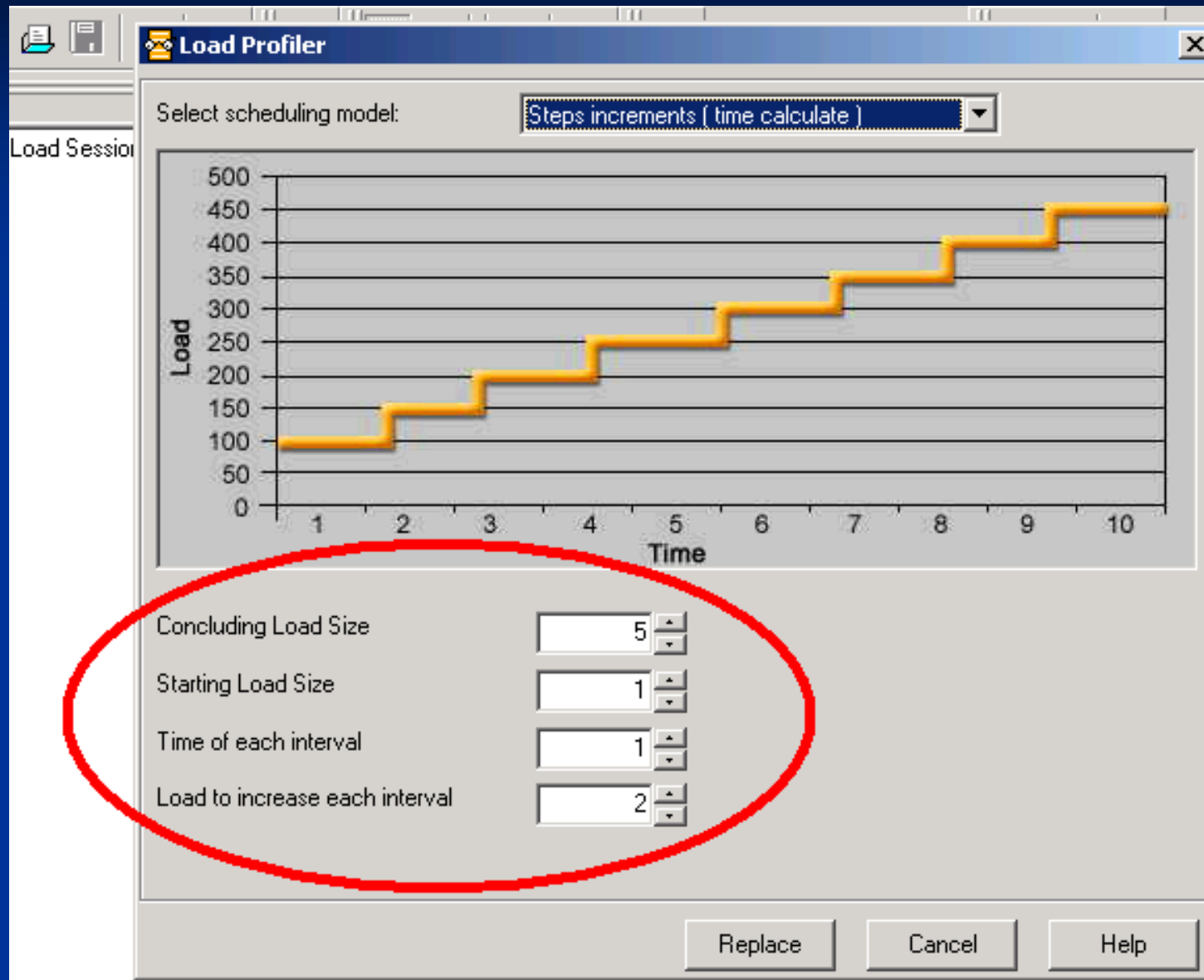
WebLoad IDE: Agenda

The screenshot displays the WebLOAD IDE interface for a project named "VDOT1". The menu bar includes File, Edit, View, Record, Run, Tools, Window, and Help. The toolbar contains various icons, with the Run icon (a red circle with a white play symbol) highlighted by a red circle. Below the toolbar is the "Agenda Tree" panel, which lists a sequence of URLs and actions to be performed during a load test. The left sidebar shows a "General" tab with several icons: Sleep, Message, JavaScriptObject, Comment, GlobalInputFile, Try, and a return icon.

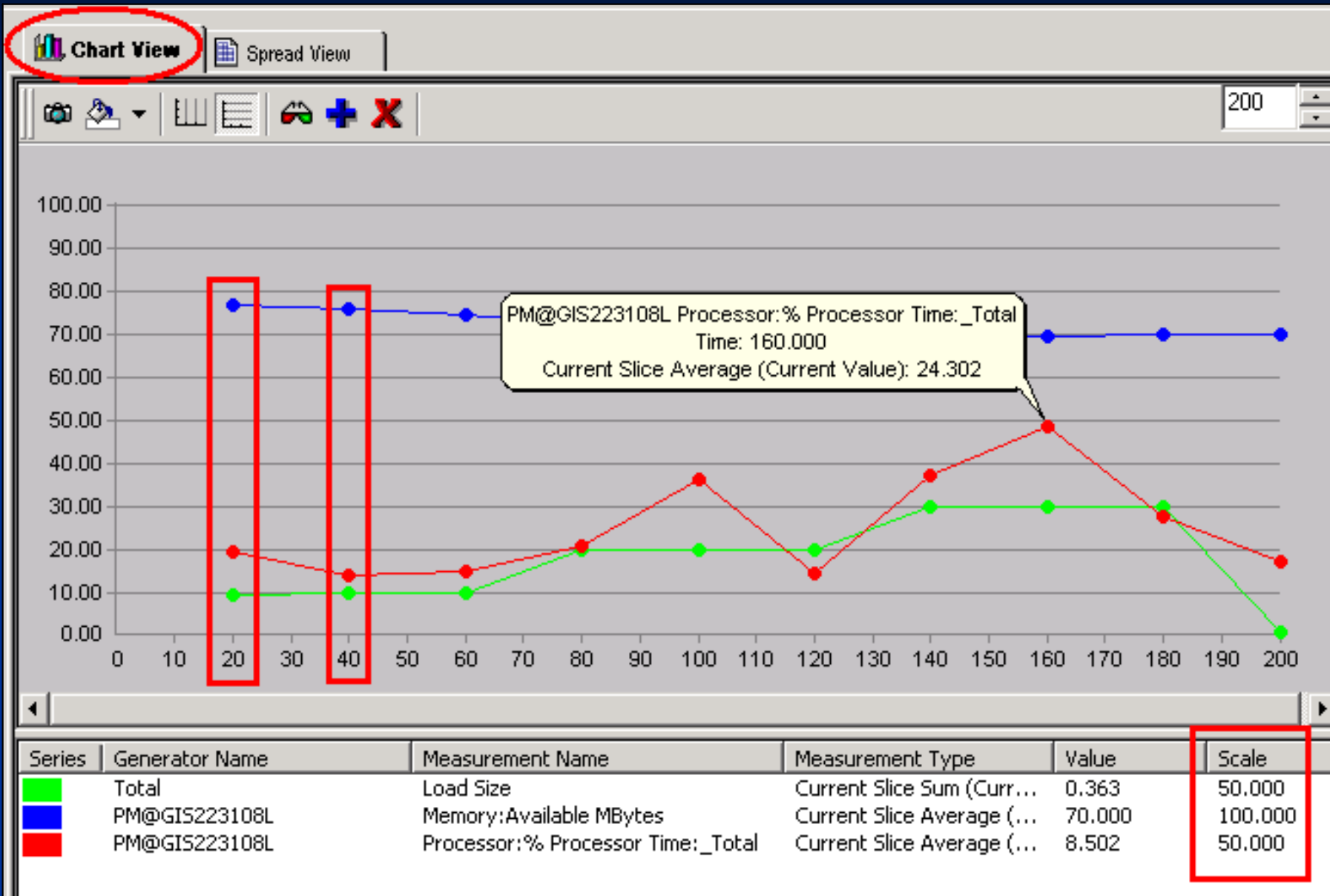
Agenda Tree

- 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=True&Encode=False
- http://gis.virginiadot.org/arcims_path/ims?ServiceName=vdotgis_ov&ClientVersion=4.0&Form=True&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=True&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=True&Encode=False
- http://gis.virginiadot.org/website/vdotgis_ext/toc.htm
- Sleep

WebLoad > WebLoad Console > Load Profile



WebLoad > Monitoring > View - Chart



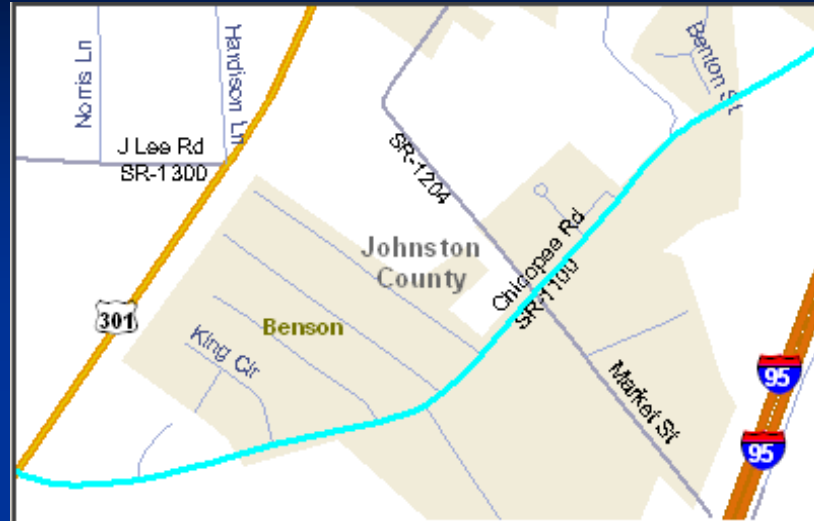
WebLoad: Assumptions Influence Results

- 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

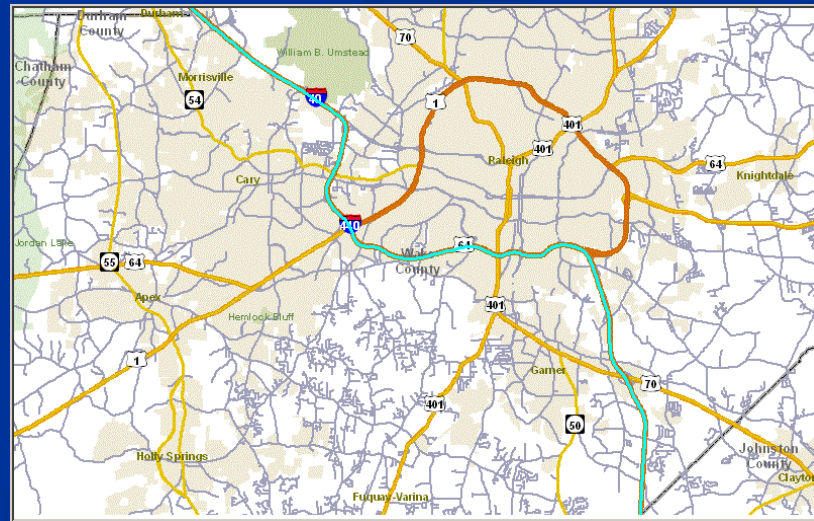
First Agenda:

- 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

$(\text{Total \# of images} / \text{duration of test in mins}) / 6 \text{ DPM}$
= effective concurrent users

■ Example:

- 1,000 GIFs produced
- 5 minute test run
- 6 Displays Per Minute user productivity
- $1000 \text{ GIFS} / 5 \text{ mins} = 200 \text{ total Displays Per Minute}$
- $200 \text{ total DPM} / 6 \text{ DPM user productivity} = \sim 33 \text{ effective concurrent users}$

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
 - Run ArcMap over 56K dial-up connection in emergency situations
- Stability over a WAN
 - Many dropped packets vs. LAN
 - Lose connection and reattach to ArcMap session still running on Citrix

The Citrix logo is displayed in a white, pixelated font against a dark blue rectangular background. The word "CITRIX" is in all caps, with a registered trademark symbol (®) to the right. The letters have a blocky, digital appearance with small white dots at the top and bottom of the 'i' and 'x'.

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

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

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**
 - <http://www.esri.com/library/whitepapers/pdfs/sysdesig.pdf>
- **ESRI Support Forums**
 - <http://support.esri.com>

Thank You. Questions?

Contacts:

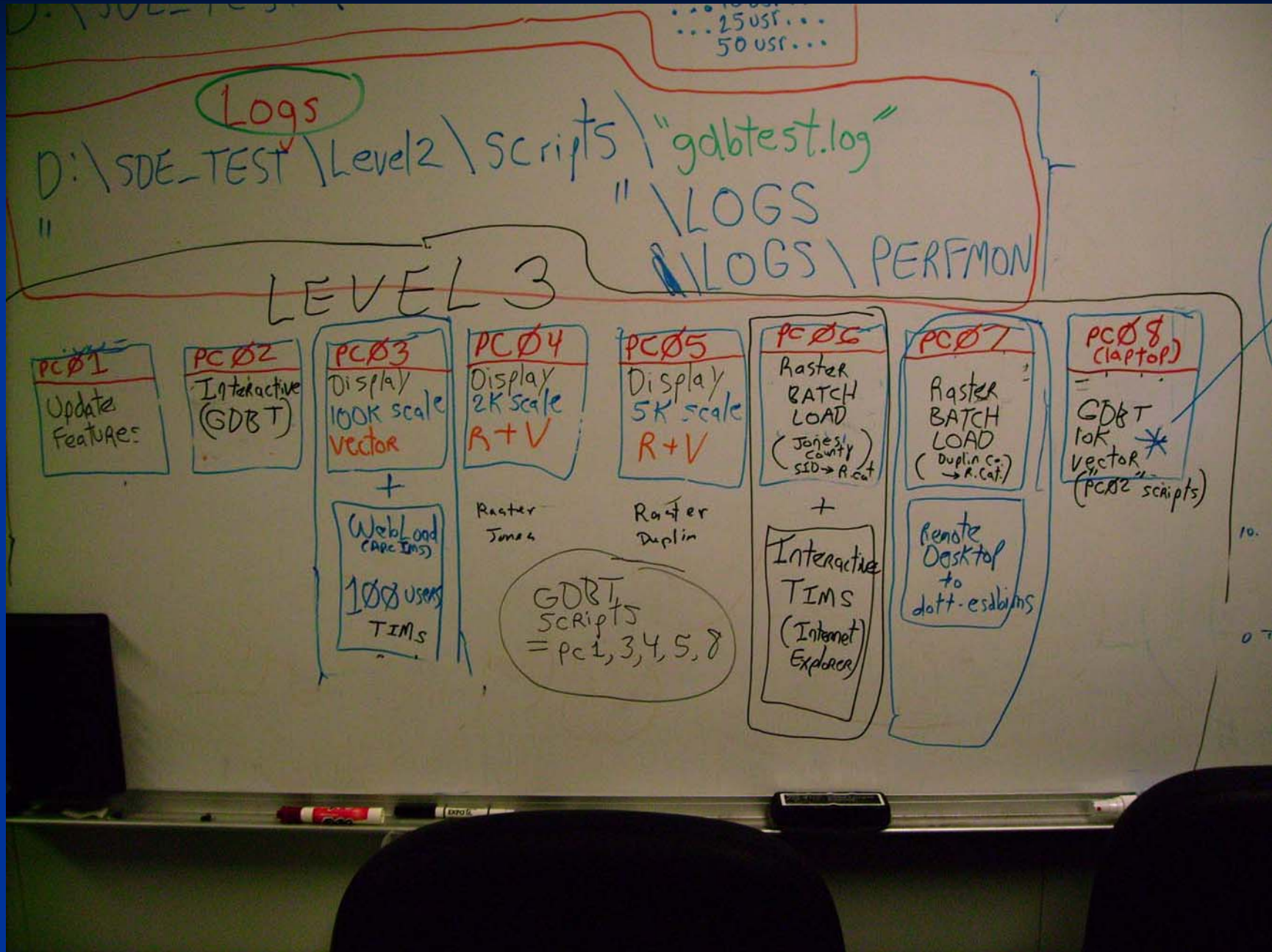
Dana Nibby

dmnibby@dot.state.nc.us

Dave Johnson

ddjohnson@dot.state.nc.us

Additional Material



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

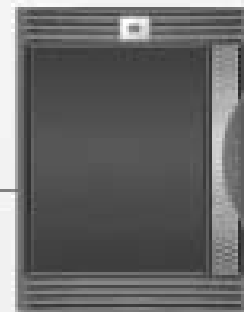
Itanium 64



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



Itanium 64



EVA6000 SAN



300 GB

NCDOT GIS Project Lab Progress and Architecture

Updated 06/08/07 - DWA



DOT-ArcGISSup01

- Server 2003 SP 1
- Future Test Builds: Citrix, etc. (supporting role)



DOT-ArcIMS01

- Server 2003 SP 1
- Already built to standard for ESDB testing
- Would have to leverage additional resources for dual IMS load balancing trials
- SDE Client for Direct-Connect? (test load on server)
- Servlet Exec AS



DOT-ArcGISSVR01

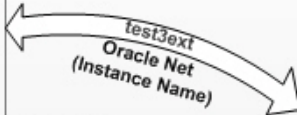
- Server 2003 SP 1
- Coming Soon



DOT-ArcSDE01

- Server 2003 SP 1
- ArcSDE 9.2 with SP2
- Custom DBtune files (draft)
- Oracle Net Client (Runtime)

Gigabit ethernet, via Nortel switch



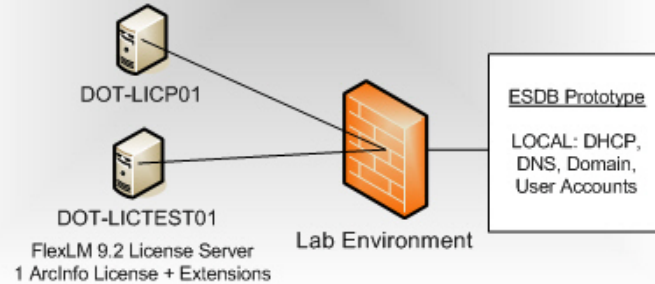
Oracle User
 SDE
 sde_vector
 sde_raster
 sde_editor1
 gis_viewer

Oracle Role
 direct grants
 direct grants
 sde_owner
 sde_editor
 sde_viewer
 sde_install

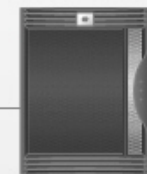
ESRI Defined Role
 not applicable
 not applicable
 Data creators
 Data editors
 Data viewers
 ArcSDE administrator

Oracle Accounts

LAN/WAN Architecture



Itanium 64



EVA6000 SAN



300 GB

Oracle 10g R2 Database

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
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Hardware Specs