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ArcGIS for Server Performance and Scalability—Testing Methodologies

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Introduction

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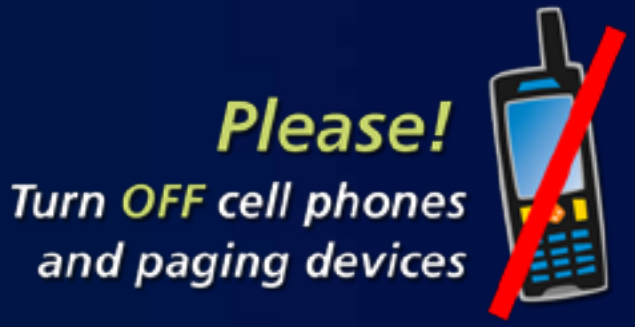
Audience

- Testers
- Developers
- Architects



Outline

- Performance factors
- Tuning and monitoring
- Testing
- Capacity planning

Performance factors

Performance engineering

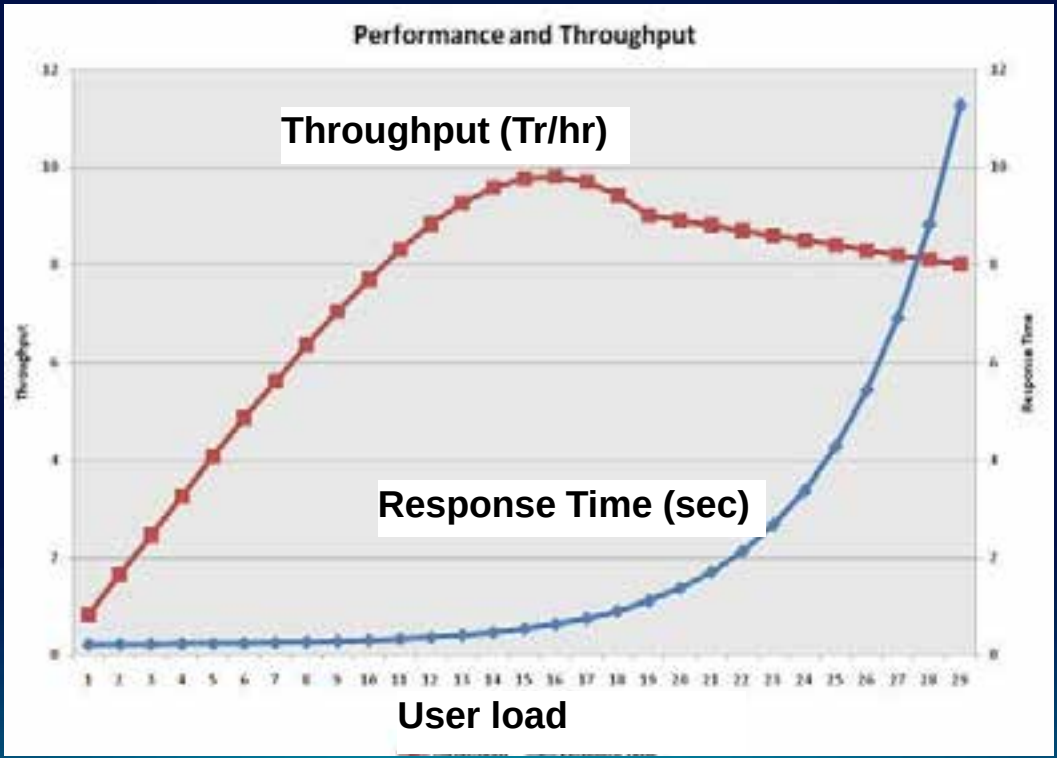
Addressed through each project phases

- Testing and tuning conduced typically during:
- Development
  - Prototype
  - Unit test
- Deployment
- Operations

Performance and Scalability

Definitions

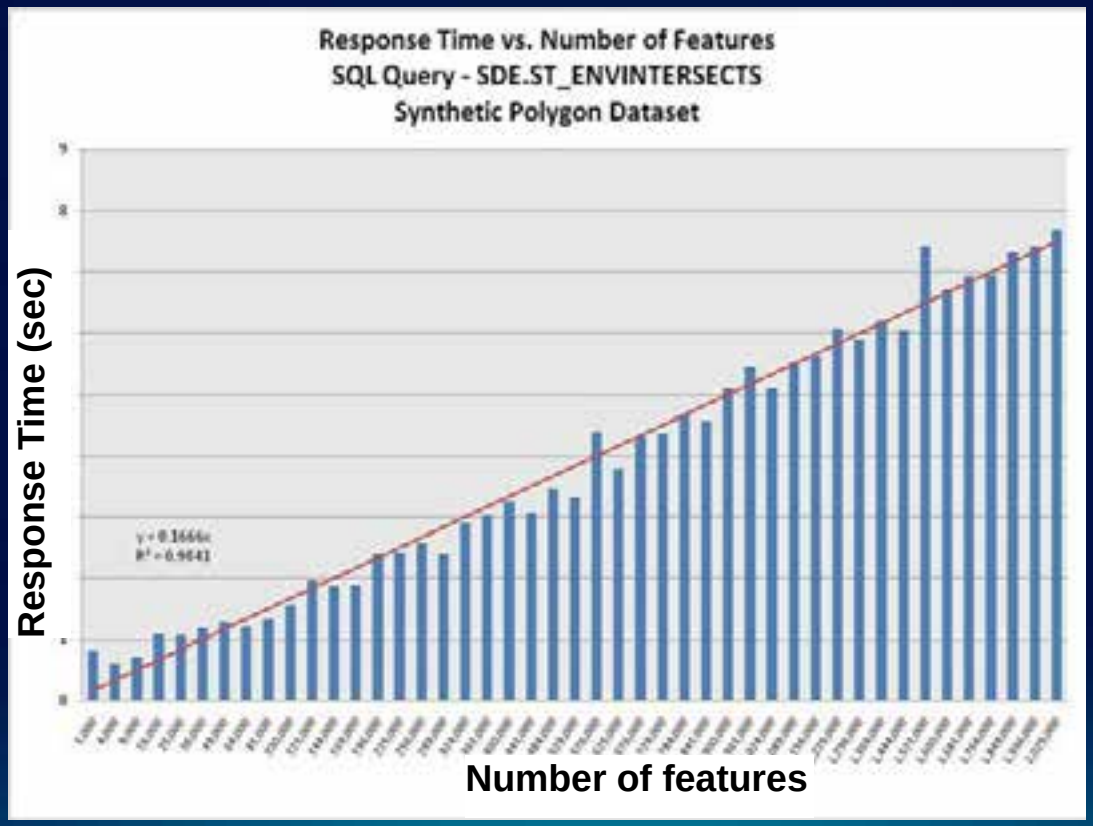
- **Performance: The speed at which a given operation occurs**
- **Scalability: The ability to maintain performance as load increases**



GIS Services

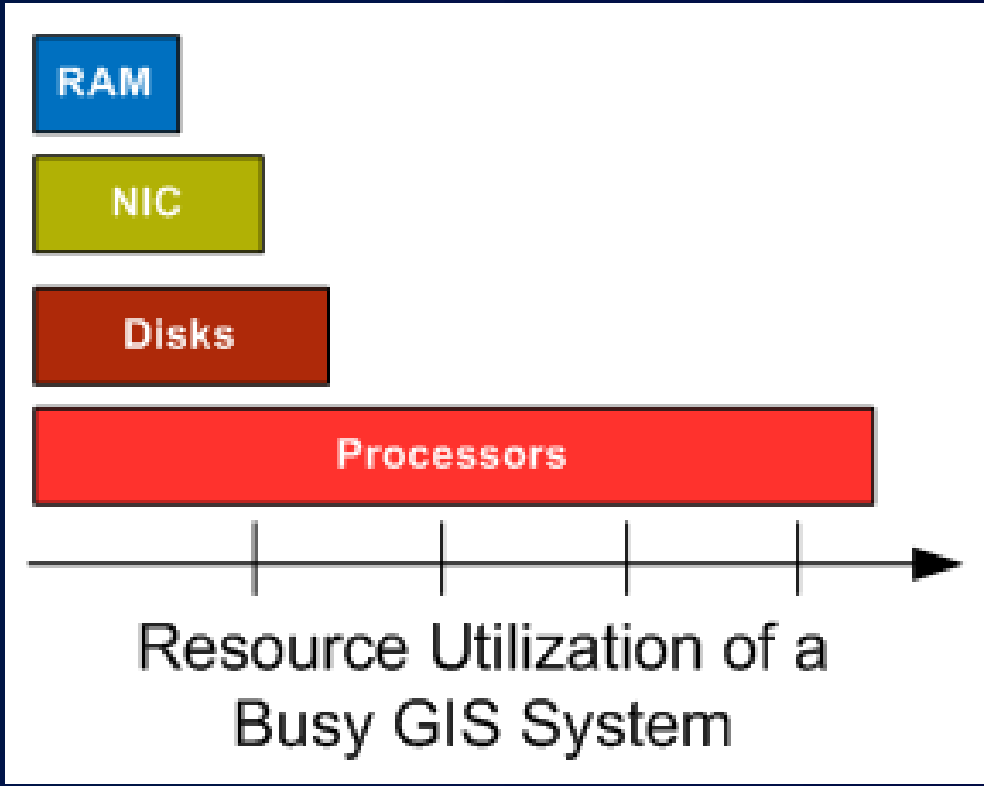
Map service

- **Performance related to number of features and vertices**



Hardware resources

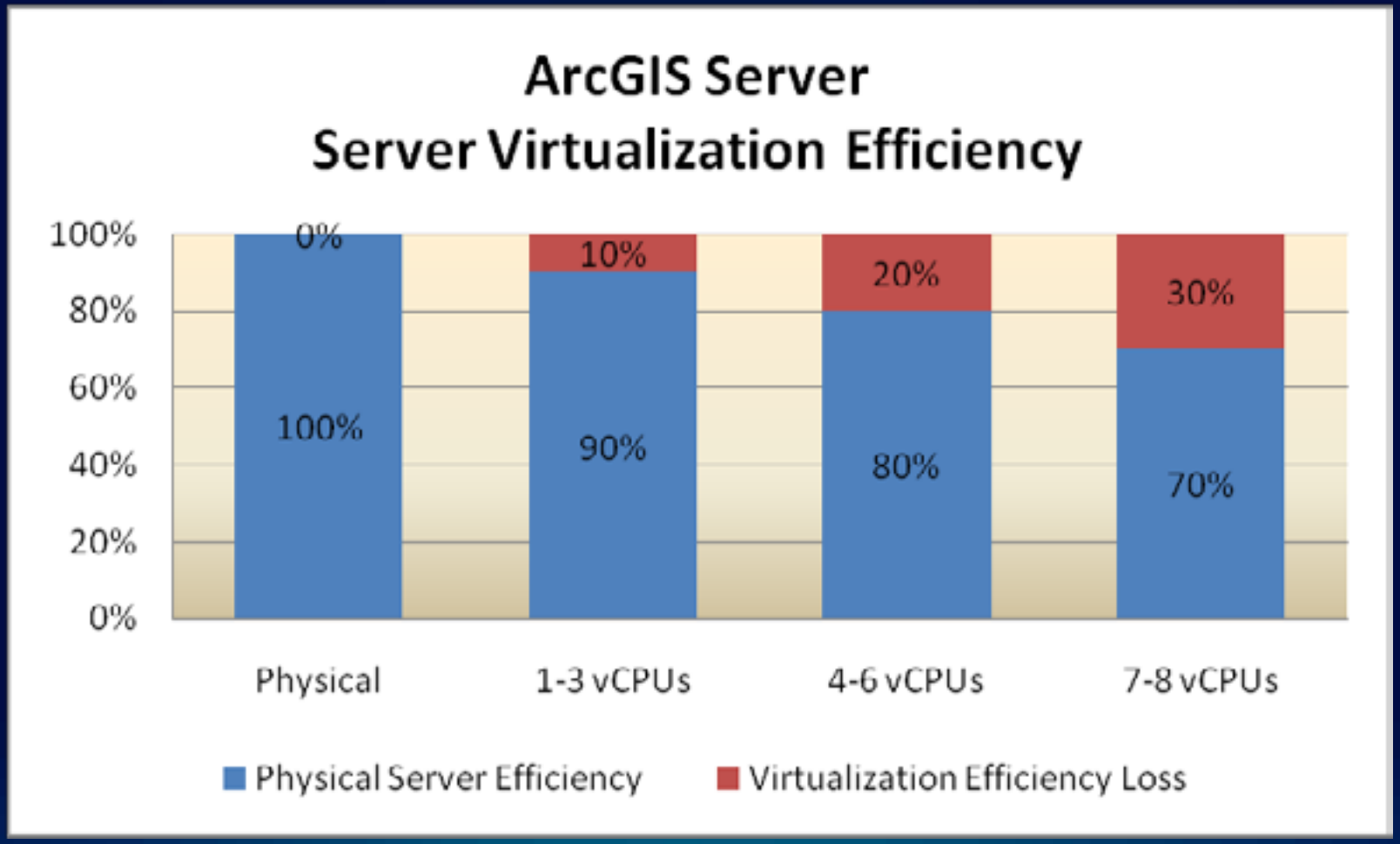
- CPU
- Network
  - bandwidth
  - latency
- Memory
- Disk



Most well-configured and tuned GIS systems are processor-bound.

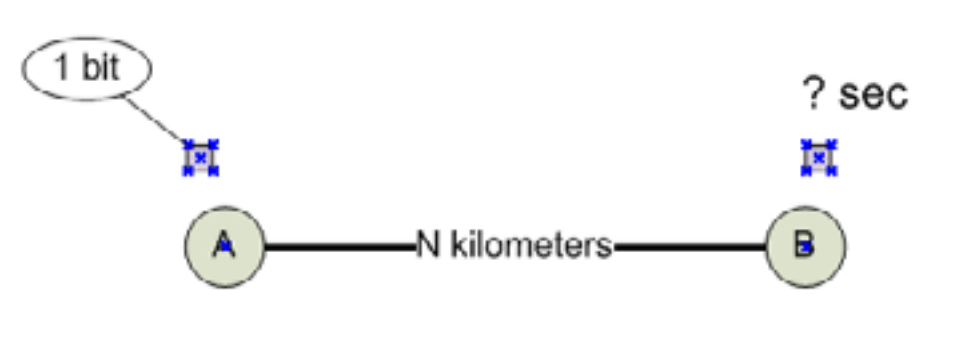
Virtualization overhead

10% to 30%

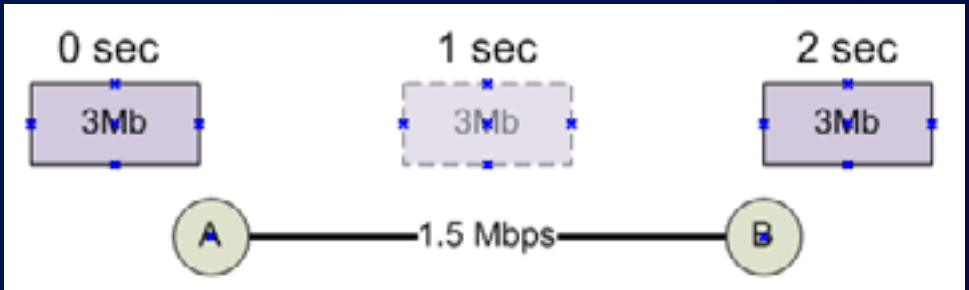


Network transport time

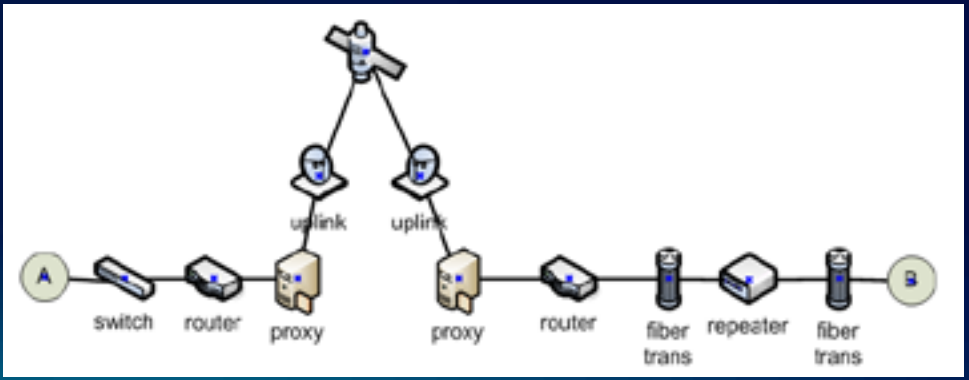
1. Distance



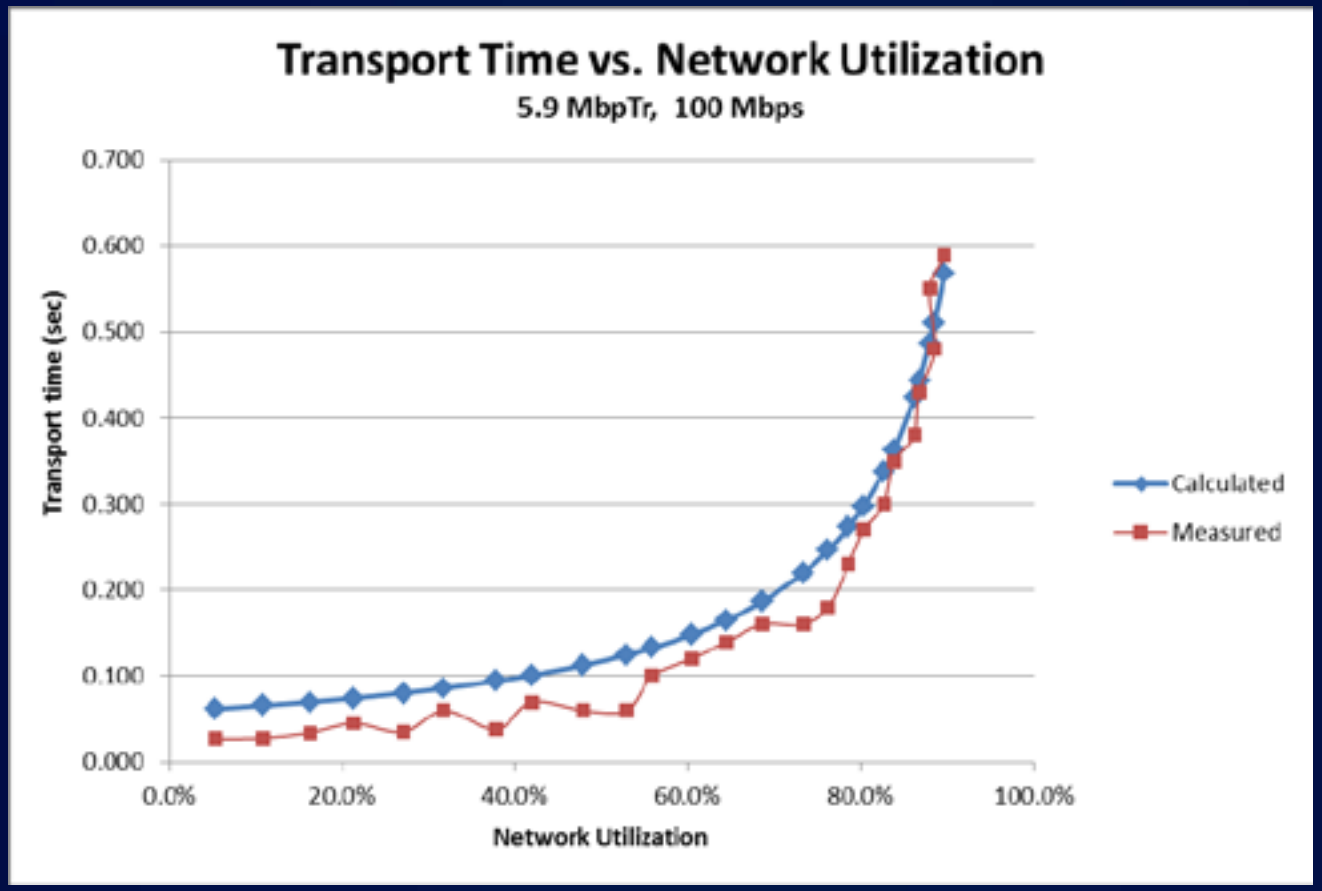
2. Payload



3. Infrastructure



Network transport time



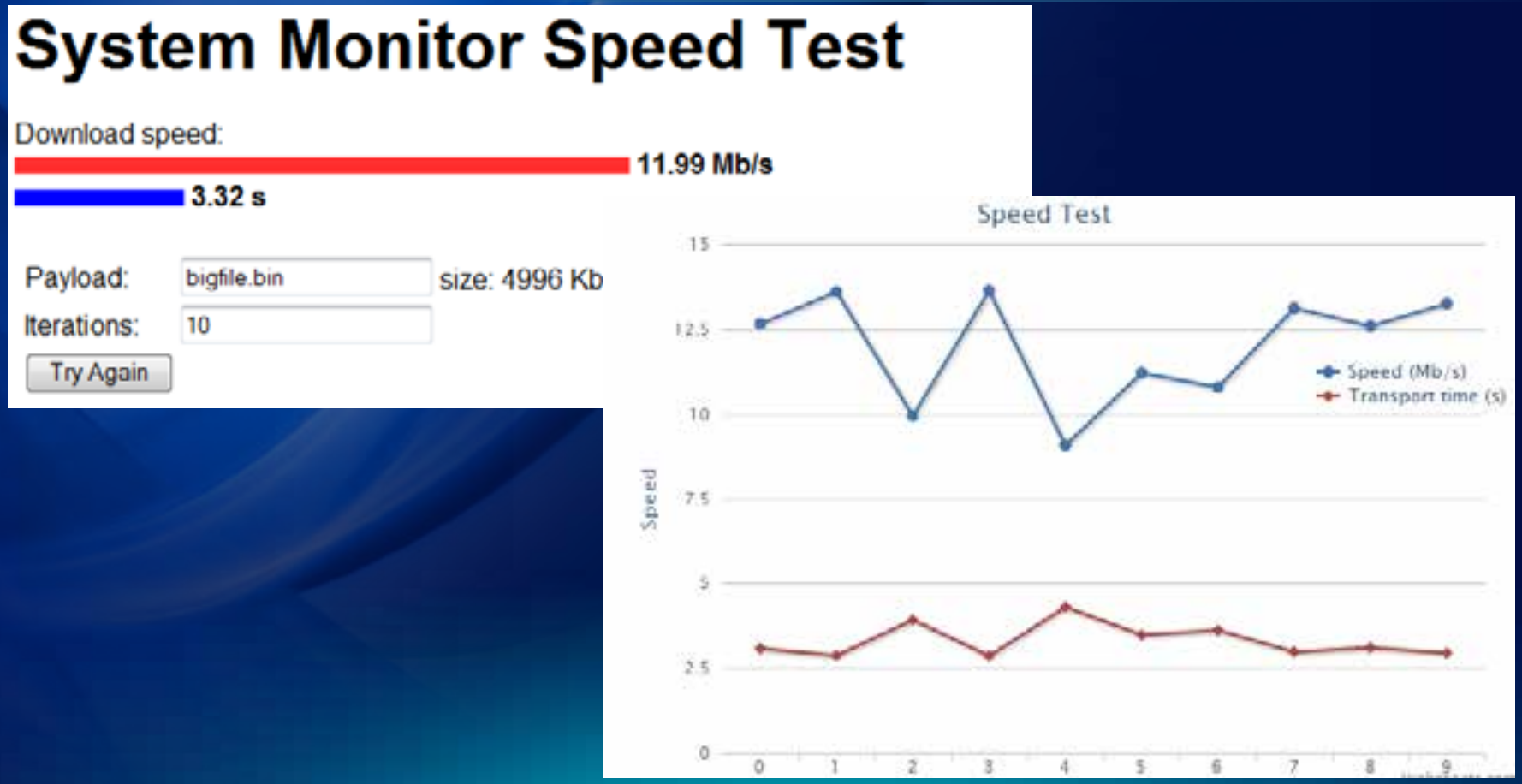
$$Transport(\text{sec}) = \frac{MbpTr}{Mbps - Mbps_{used}}$$

Network transport time

- **Impact of service and return type on network transport time**
  - **Compression**
  - **Content, e.g., Vector vs. Raster**
  - **Return type, e.g., JPEG vs. PNG**

					Network Traffic Transport Time (sec)					
					56 kbps	1.54 Mbps	10 Mbps	45 Mbps	100 Mbps	1 Gbps
Application Type	Service/Op	Content	Return Type	Mb/Tr	0.056	1.540	10.000	45.000	100.000	1000.000
ArcGIS Desktop	Map	Vector		10	178.571	6.494	1.000	0.222	0.100	0.010
Citrix/ArcGIS	Map	Vectror+Image	ICA Comp	1	17.857	0.649	0.100	0.022	0.010	0.001
Citrix/ArcGIS	Map	Vector	ICA Comp	0.3	5.357	0.195	0.030	0.007	0.003	0.000
ArcGIS Server	Map	Vector	PNG	1.5	26.786	0.974	0.150	0.033	0.015	0.002
ArcGIS Server	Image		JPG	0.3	5.357	0.195	0.030	0.007	0.003	0.000
ArcGIS Server	Map Cache	Vector	PNG	0.1	1.786	0.065	0.010	0.002	0.001	0.000
ArcGIS Server	Map Cache	Vector+Image	JPG	0.3	5.357	0.195	0.030	0.007	0.003	0.000

Demo: Network speed test

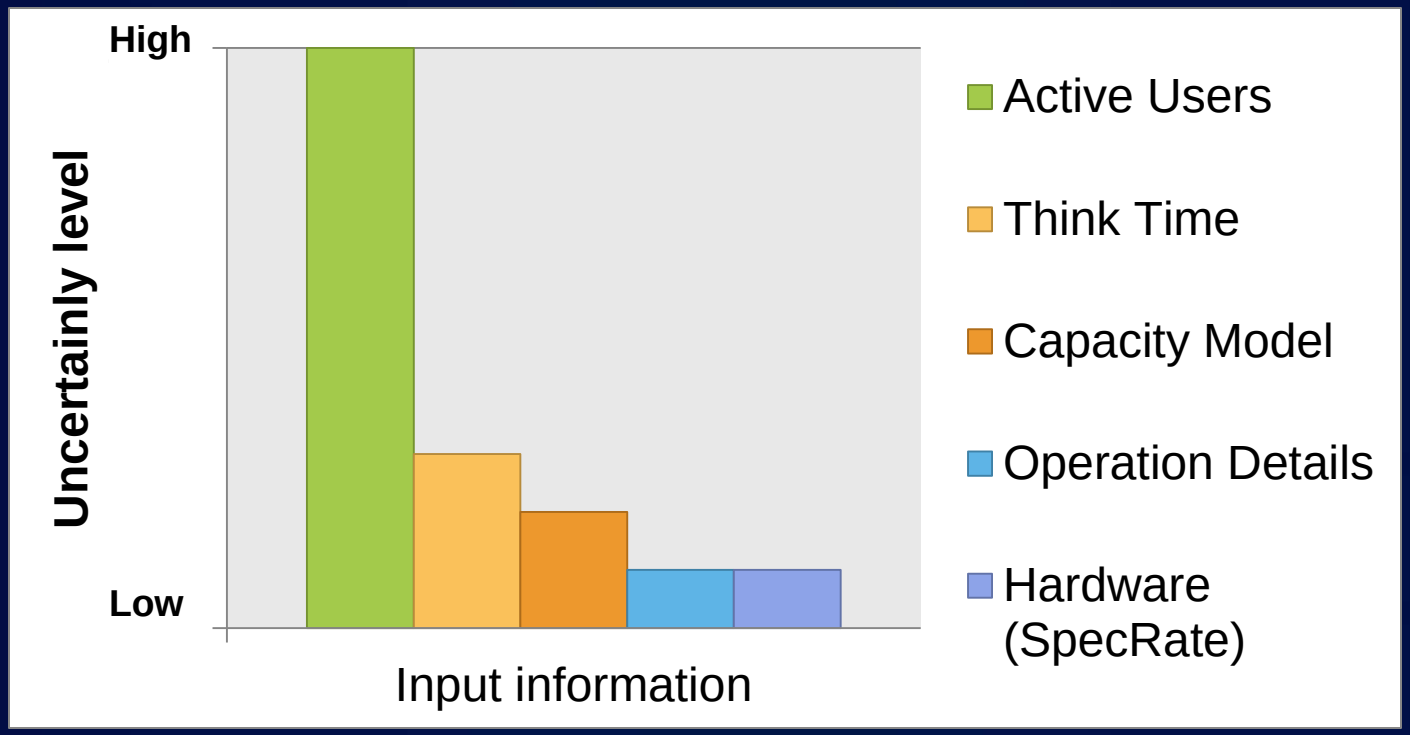


Memory

Item	Low	High	Delta
Dynamic Map	50 MB	500 MB	900%
Image Service	20 MB	1,024 MB	5,020%
Geoprocessing	100 MB	2,000 MB	1,900%
SOM	30 MB	70 MB	133%
XenApp Session	500 MB	1.2 GB	140%
DBMS Session	10 MB	75 MB	650%
DBMS Cache	200 MB	200 GB	99,900%

User load

User has the highest uncertainty



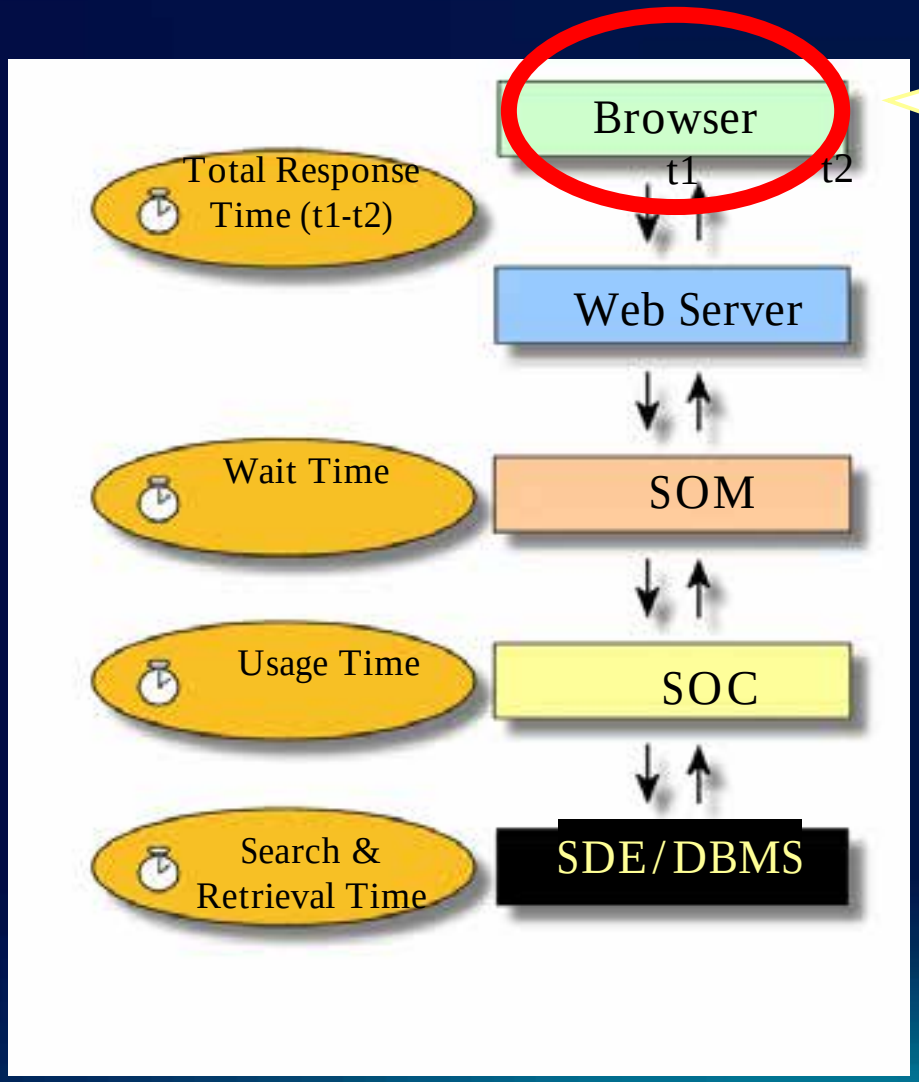
Tuning and Monitoring

Tuning process

1. **Profile and measure response time at the client application**
2. **Conduct measurements at software stack below**
3. **Correlate and account measurements between tiers**
4. **Identify root cause**

Do not misdiagnose “victims for culprits”

Measure response time at the client application

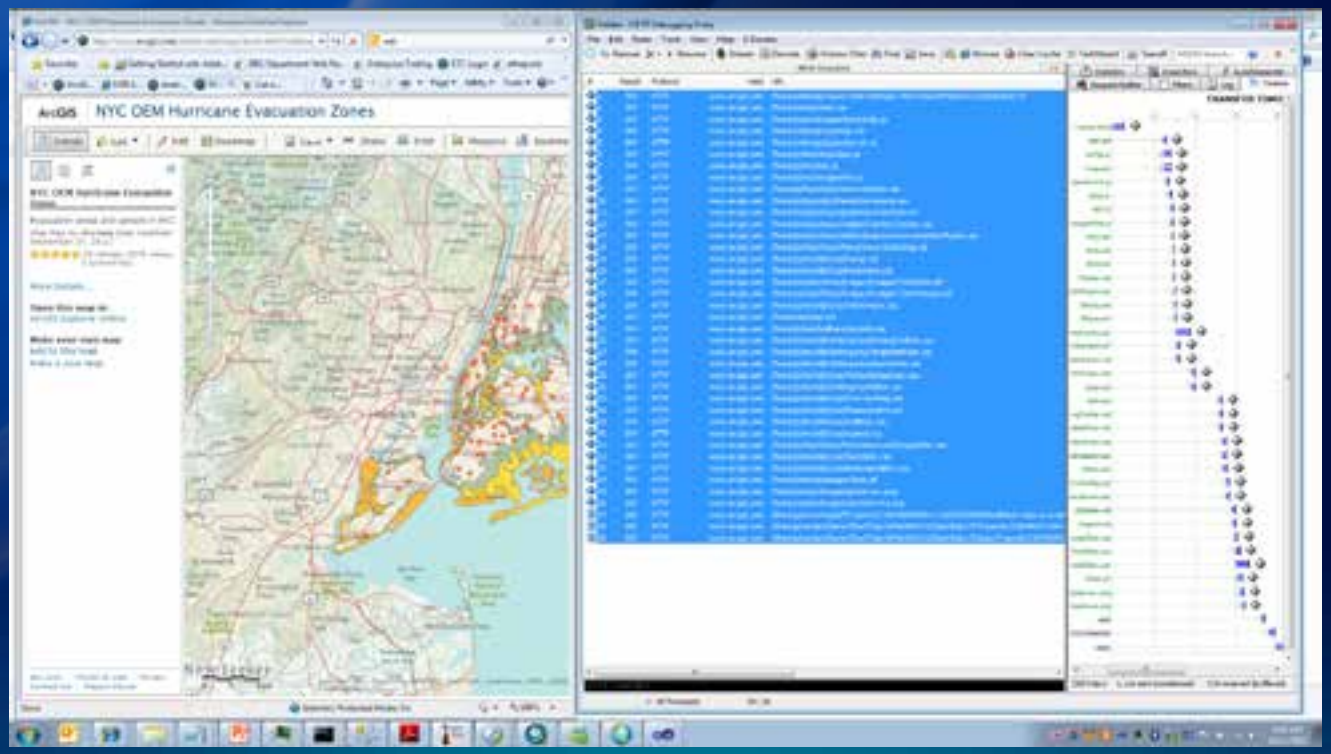


A test is executed at the web browser.

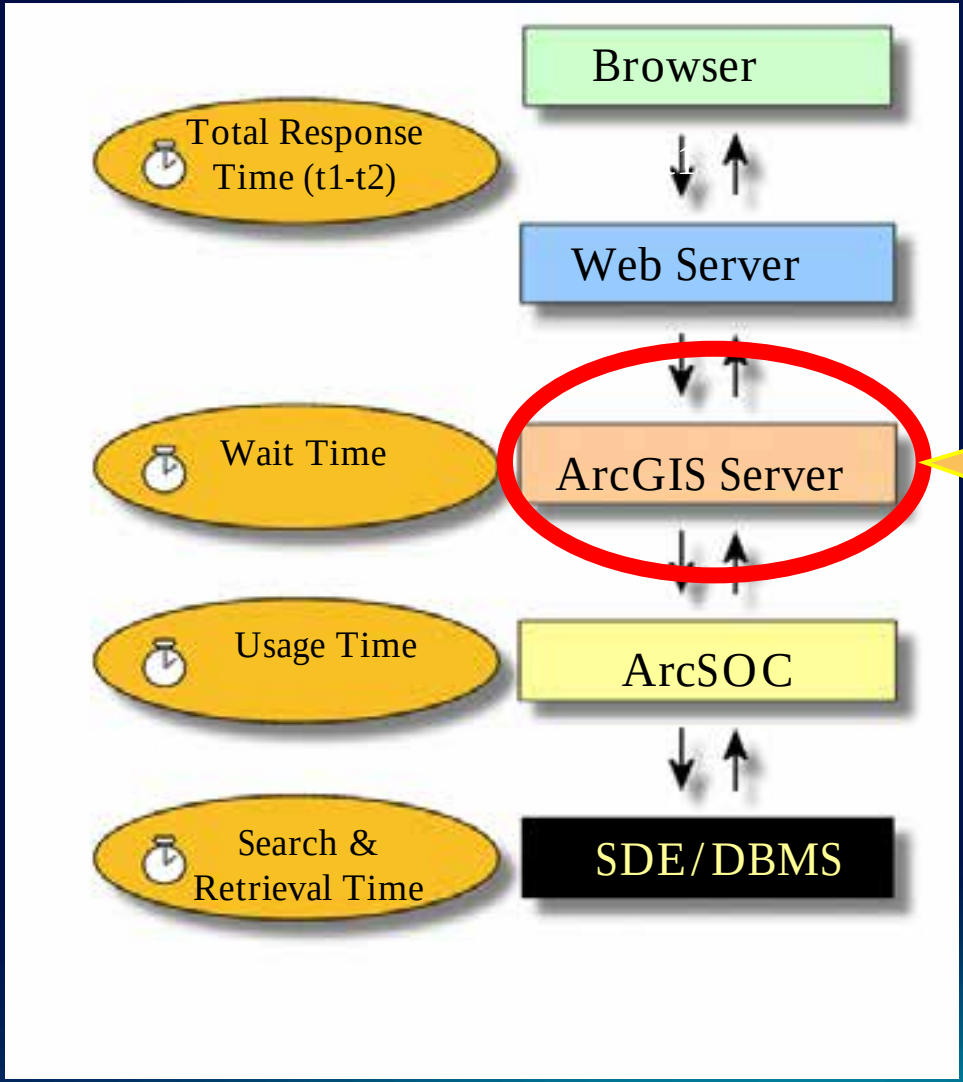
It measures web browser call's elapsed time (roundtrip between browser and data source).

Demo: Profile web application

Fiddler http://www.fiddler2.com/



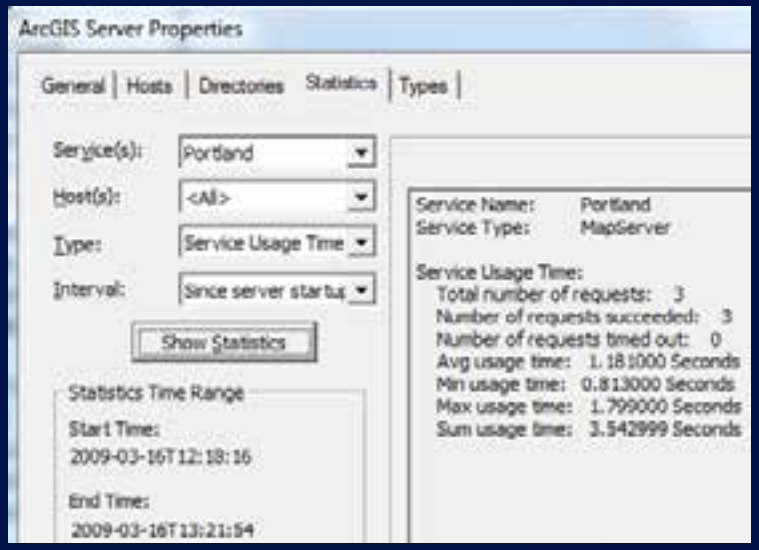
Analyze ArcGIS Server statistics



Analyze ArcGISServer statistics using Arc Catalog, Manager or logs.

Analyze ArcGIS Server statistics

Correlate and account measurements between tiers



<Msg time="2009-03-16T12:23:22" type="INFO3" code="103021" target="Portland.MapServer" methodName="FeatureLayer.Draw" machine="myWebServer" process="2836" thread="3916" elapsed="0.05221">Executing query.</Msg>

<Msg time="2009-03-16T12:23:23" type="INFO3" code="103019" target="Portland.MapServer" methodName="SimpleRenderer.Draw" machine="myWebServer" process="2836" thread="3916">Feature count: 27590</Msg>

<Msg time="2009-03-16T12:23:23" type="INFO3" code="103001" target="Portland.MapServer" methodName="Map.Draw" machine="myWebServer" process="2836" thread="3916" elapsed="0.67125">End of layer draw: STREETS</Msg>

Web server log

Log Parser

- http://www.microsoft.com/downloads/details.aspx?FamilyID=890cd06b-abf8-4c25-91b2-f8d975cf8c07&displaylang=en

Logparser "SELECT date, QUANTIZE(time, 3600) as Hour, cs-uri-stem, count(*) as Req/hr

FROM C:\inetpub\logs\LogFiles\W3SVC1\u_ex120308.log

WHERE cs-uri-stem like '%/arcgis/rest/services/World_Street_Map_MapServer1/MapServer/export%' group by date, Hour, cs-uri-stem order by Hour“

ArcGIS Server log

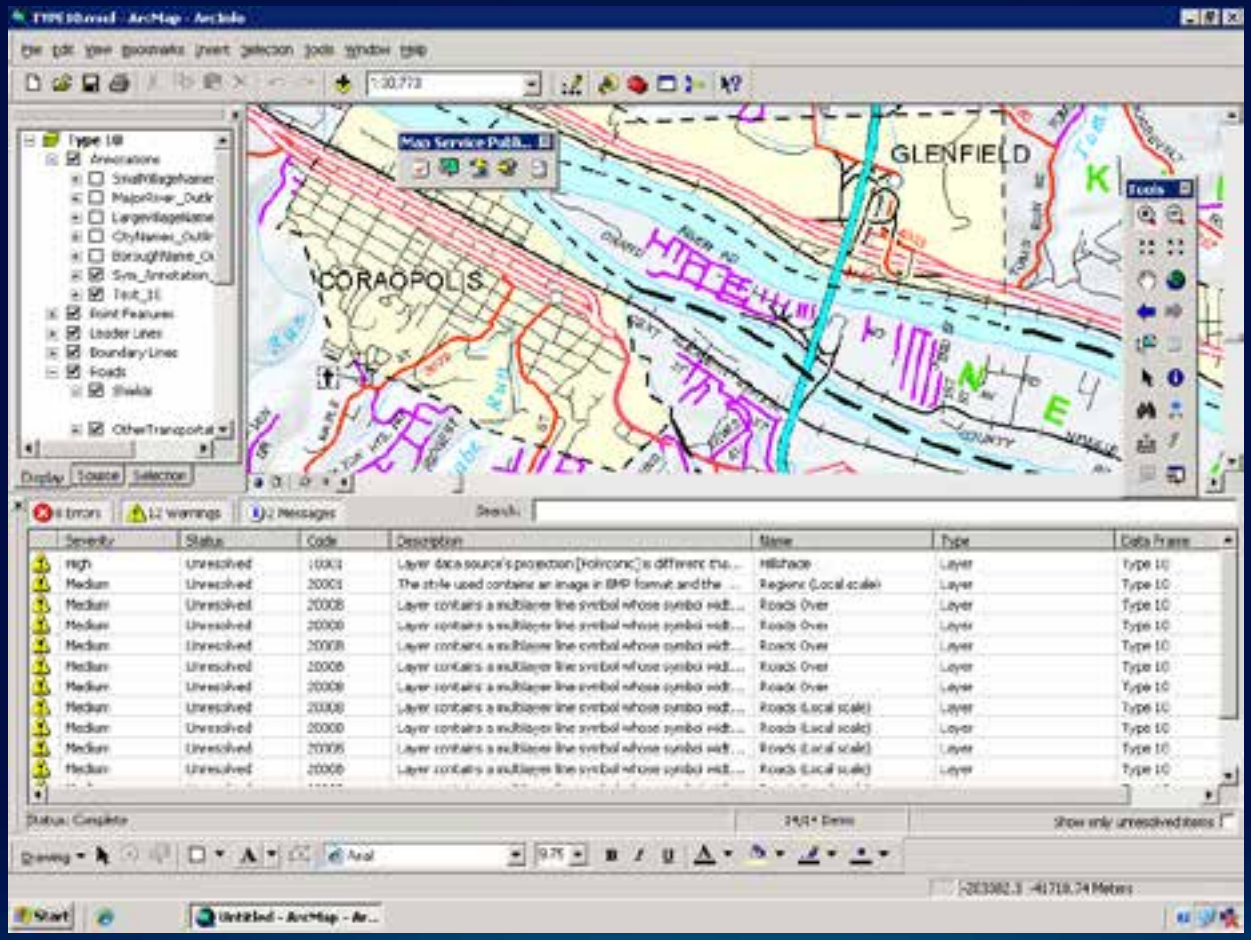
ASLog

- http://resources.arcgis.com/gallery/file/enterprise-gis/details?entryID=6B439B7C-1422-2418-3418-E6E3B1480A40

Time	Target	methodName	Elapsed	message
8/19/2011 10:07	EOC.MapServer	UniqueValueRenderer.Draw	0	Feature count: 36792
8/19/2011 10:07	EOC.MapServer	Map.Draw	11.30888	End of layer draw: Roadway Cleared
8/19/2011 10:07	EOC.MapServer	Map.Draw	0	Beginning of layer draw: Passable Lanes
8/19/2011 10:07	EOC.MapServer	FeatureLayer.Draw	0.00521	Executing query.
8/19/2011 10:07	EOC.MapServer	UniqueValueRenderer.Draw	0	Feature count: 37143
8/19/2011 10:07	EOC.MapServer	Map.Draw	8.24199	End of layer draw: Passable Lanes

Identify root cause

Analyze Map Tool



Identify root cause

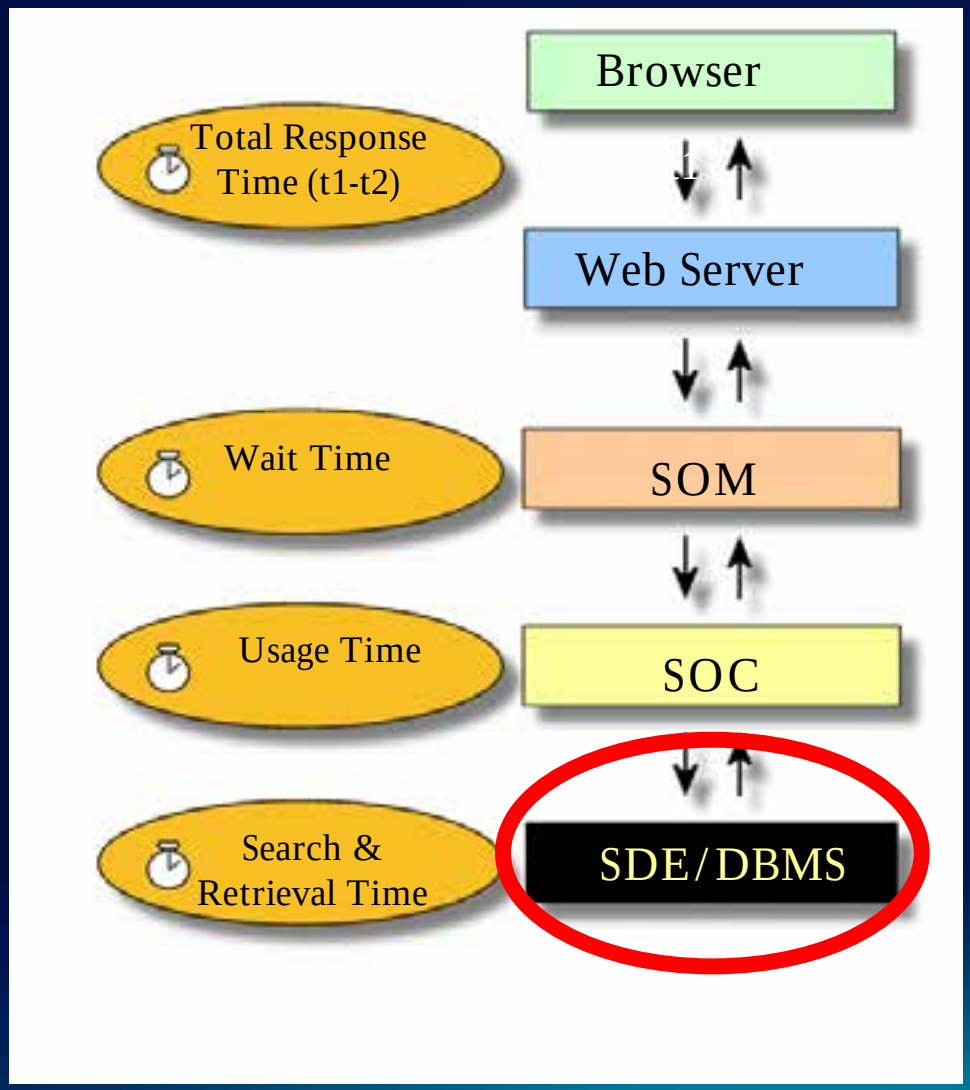
Mxdperfstat on http://resources.arcgis.com

C:>mxdperfstat -mxd Portland_Dev09_Bad.mxd -xy 7655029;652614 -scale 8000

Item	At Scale	Layer Name	Refresh Time (sec)	Recommendations	Features	Vertices	Labeling	Geography Phase (sec)	Graphics Phase (sec)	Cursor Phase (sec)	DBMS CPU	DBMS LIO
18	8,000	Tax Lots	1.05	Simplify labeling, symbology: GraphicsPhase=.83;	2,226	33,872	True	.14	.83	.20	.08	6,396
19	8,000	Tax Lots Query Def	.13		1	26	False	.03	.02	.06	.03	3,204
20	8,000	TaxlotDenseLabel	1.84	Simplify labeling, symbology: GraphicsPhase=1.03; simplify geometry and/or set label scale; convert polygon to polyline: vertices fetched=200001; simplify geometry and/or set label scale: vertices fetched=200001;	1	200,001	True	.73	1.03	.95	.01	266
21	8,000	TaxlotDenseNoLabel	.53	simplify geometry: vertices fetched=200001;	1	200,001	False	.47	.02	.97	.00	140

Analyze database statistics

Correlate and account measurements between tiers



Analyze database statistics

Oracle Trace

```
select username, sid, serial#, program, logon_time from v$session where
  username='STUDENT';

USERNAME     SID    SERIAL# PROGRAM     LOGON_TIM

------------------------------ ---------- ---------- ----------------------------

  --------STUDENT   132      31835 gsrvr.exe    23-OCT-06

SQL> connect sys@gis1_andrews as sysdba

Enter password:

Connected.

SQL> execute
  sys.dbms_system.set_ev(132,31835,10046,12,'');
```

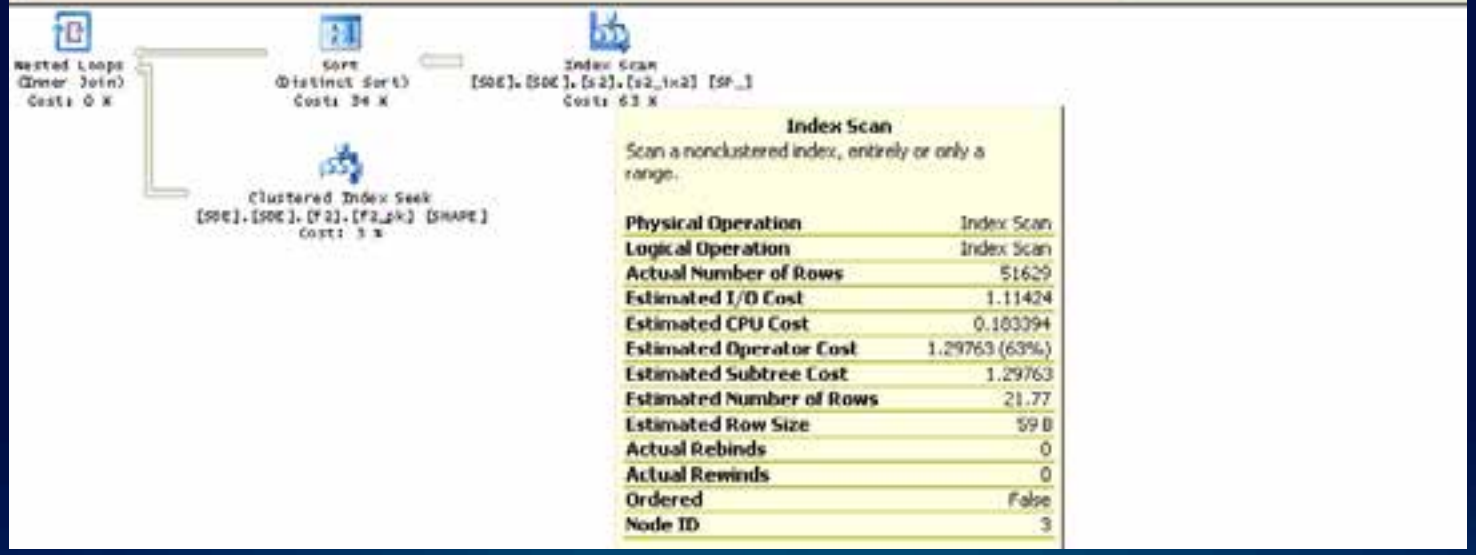
DBMS trace is a very powerful diagnostic tool.

Analyze database statistics

SQL Profiler

ArcSDE_trace (ANDREWS2)

EventClass	Login...	Application...	TextData	CPU	Duration	RowCounts	Reads
Trace Start							
Showplan XML Statistics P...	sde	SDE:5932	<ShowPlanXML xmlns="http://schemas....				
SP:StmtCompleted	sde	SDE:5932	SELECT state_id,owner,creation_time...	10	0	1	2
Showplan XML Statistics P...	sde	SDE:5932	<ShowPlanXML xmlns="http://schemas....				
SP:StmtCompleted	sde	SDE:5932	SELECT lineage_name, time_last_modi...	0	0	1	2
Showplan XML Statistics P...	sde	SDE:5932	<ShowPlanXML xmlns="http://schemas....				
SP:StmtCompleted	sde	SDE:5932	SELECT S_.eminx,S_.eminy,S_.emaxx,S...	0	0	0	0
Showplan XML Statistics P...	sde	SDE:5932	<ShowPlanXML xmlns="http://schemas....				
SP:StmtCompleted	sde	SDE:5932	SELECT S_.eminx,S_.eminy,S_.emaxx,S...	521	2624	36251	11...



Testing

Testing

Objectives

- Capacity planning
- Resource bottlenecks
- Benchmark

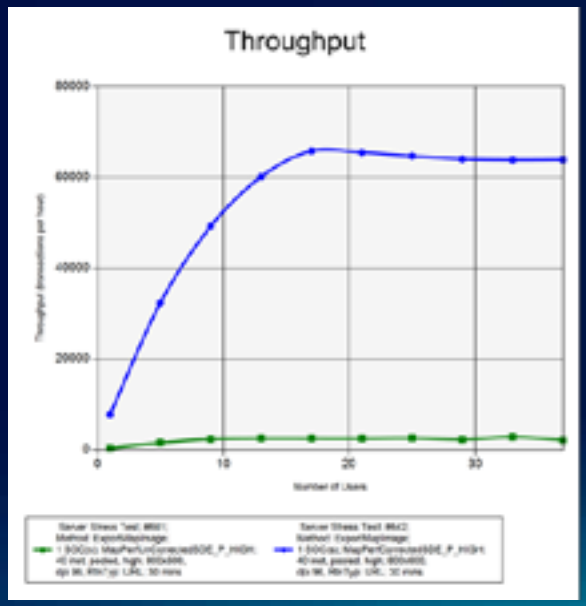
Iterative process

Testing steps

- Validated
  - functional
  - configuration
  - performance of single user operation
- Create a test data
- Develop test scripts, including user load
- Run test, including monitoring
- Analyze results

Validate configuration

- Critical step in successful GIS deployments
- Incorrect settings can limit access to hardware resources
- Configure ArcGIS Server Instances



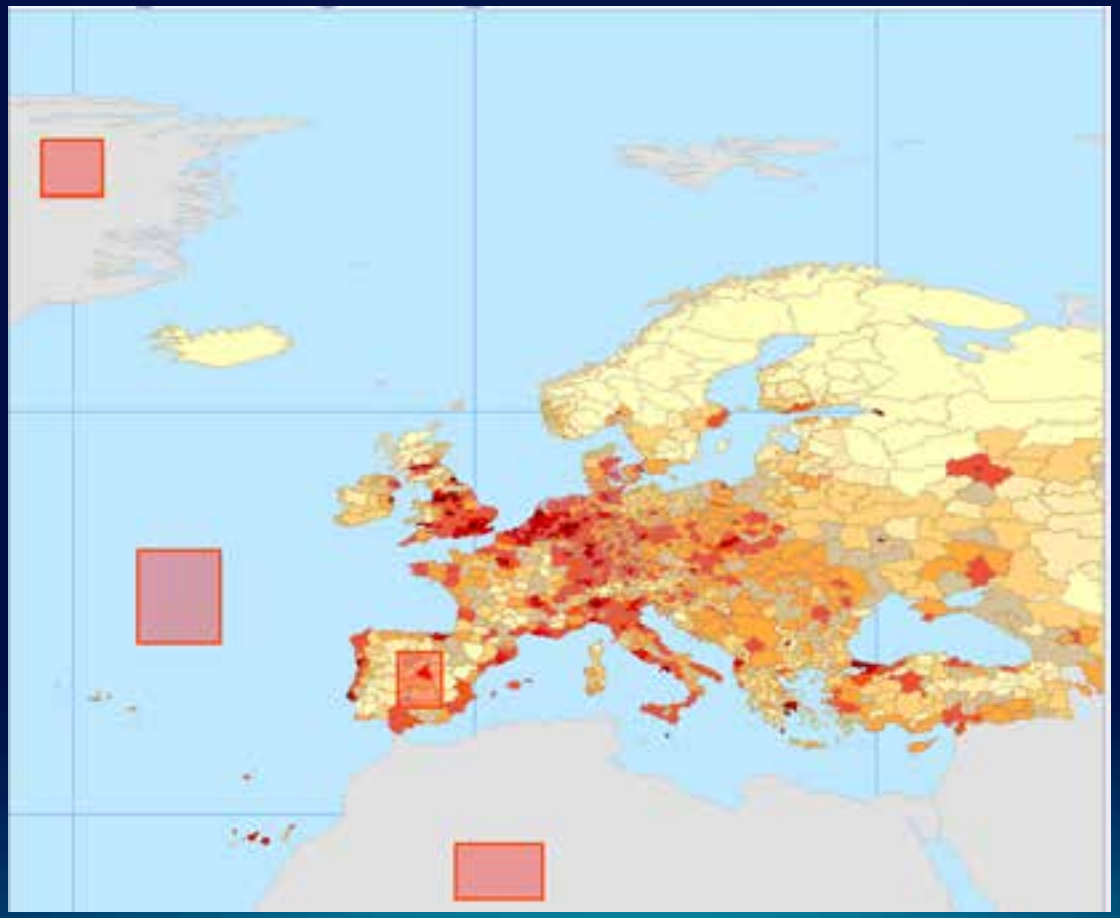
Corrected
(Unloaded TT: 0.34 sec)
(2.1 Instances/core)

Uncorrected
(Unloaded TT: 11.97 sec)
(1.6 Instances/core)

Testing

Test representative area of interests

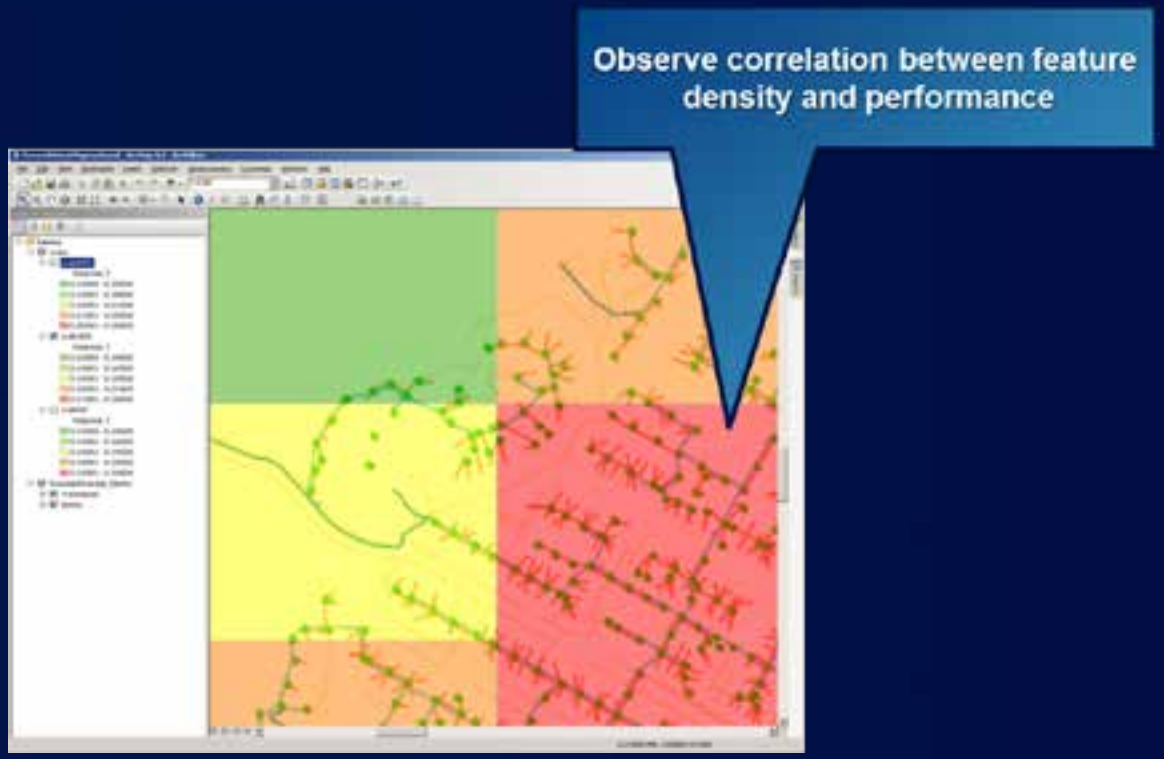
- Is Random data appropriate?



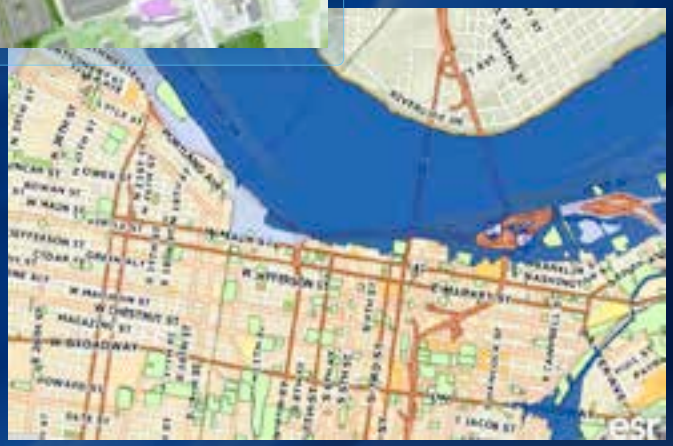
Test data

Test representative area of interests

- PerfHeatMap
  - Red – slowest
  - Green - fastest



http://arcscripts.esri.com/details.asp?dbid=16880



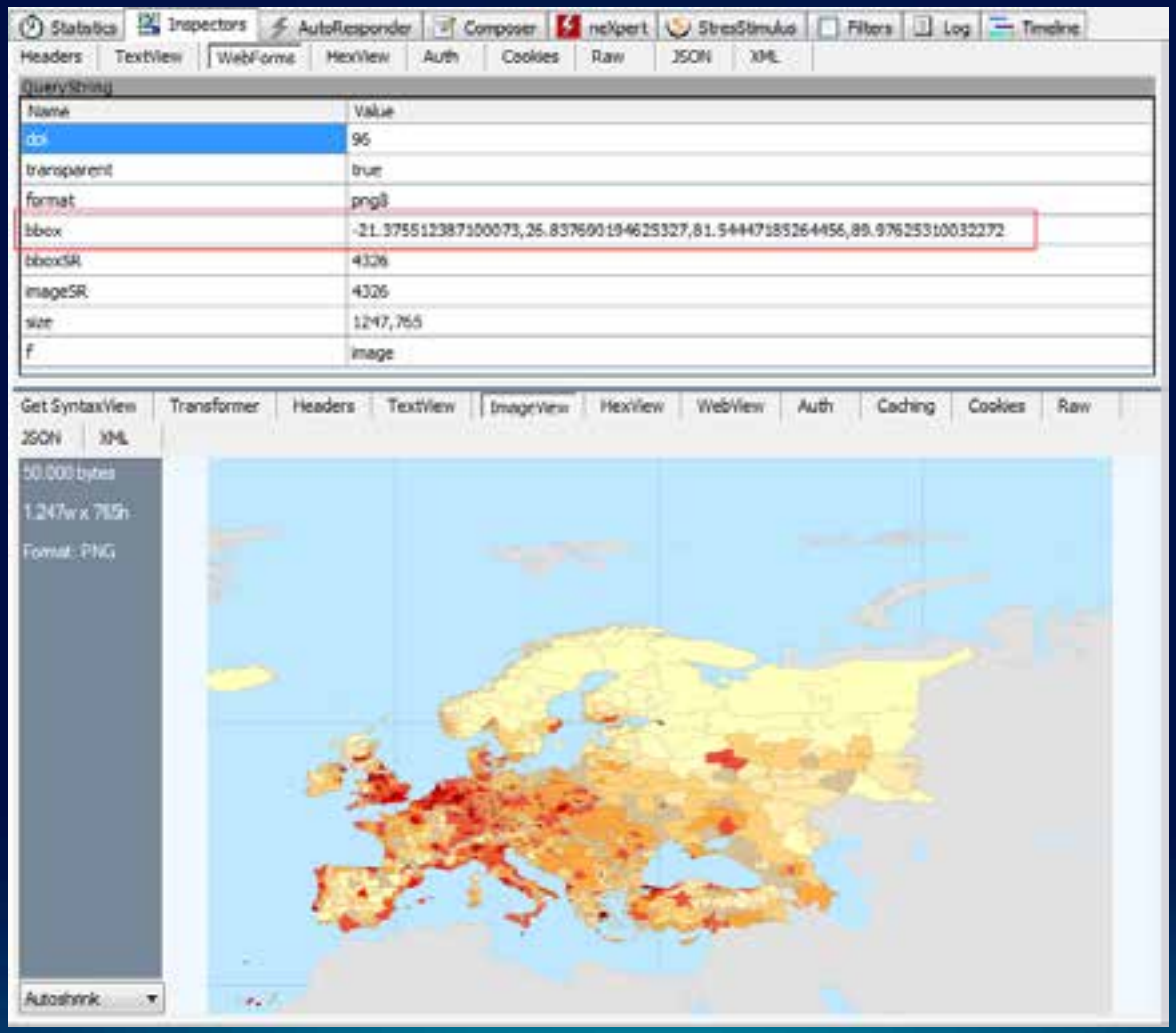
Testing the ArcGIS Server REST API

Test data

- Bounding box
  - Use representative areas of interest
- Attribute Data
  - Can be used to parameterize a web request
- Geometry Data
  - Points
  - Lines
  - Polygons

Test data

Bbox data



Test scripts

- Record user workflow
- Create single user web test
  - Define transactions
  - Set think time and pacing
  - Parameterize transaction inputs using test data
  - Verify test script with single user

Load test

- Create load test
  - User load
  - Performance counters

Load test

Avoid these mistakes

- Applying unreasonable load
- Running too many tests
- Deployment is not configured correctly
- Deployment is not exclusive to testing
- Test results are not repeatable
- Test client is bottleneck
- Test definition does not have proper validation rules

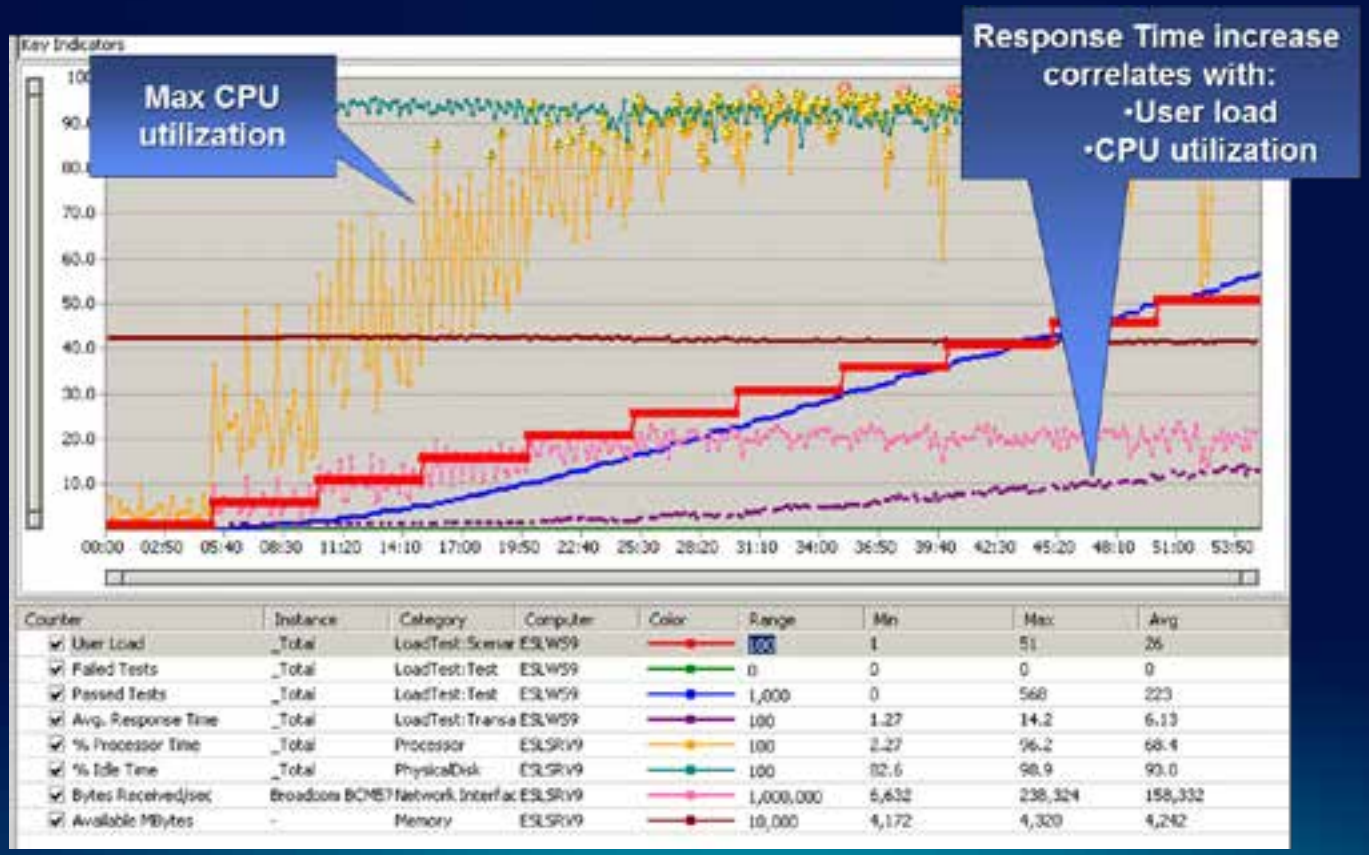
Analyze results

- Compare and correlate key measurements
  - Response Time Vs. Throughput
  - CPU, Network, Disk, and Memory on all tiers
  - Passed and Failed tests
- Validation
  - Lack of errors does not validate a test
  - Spot check request response content size

Analyze results

Valid

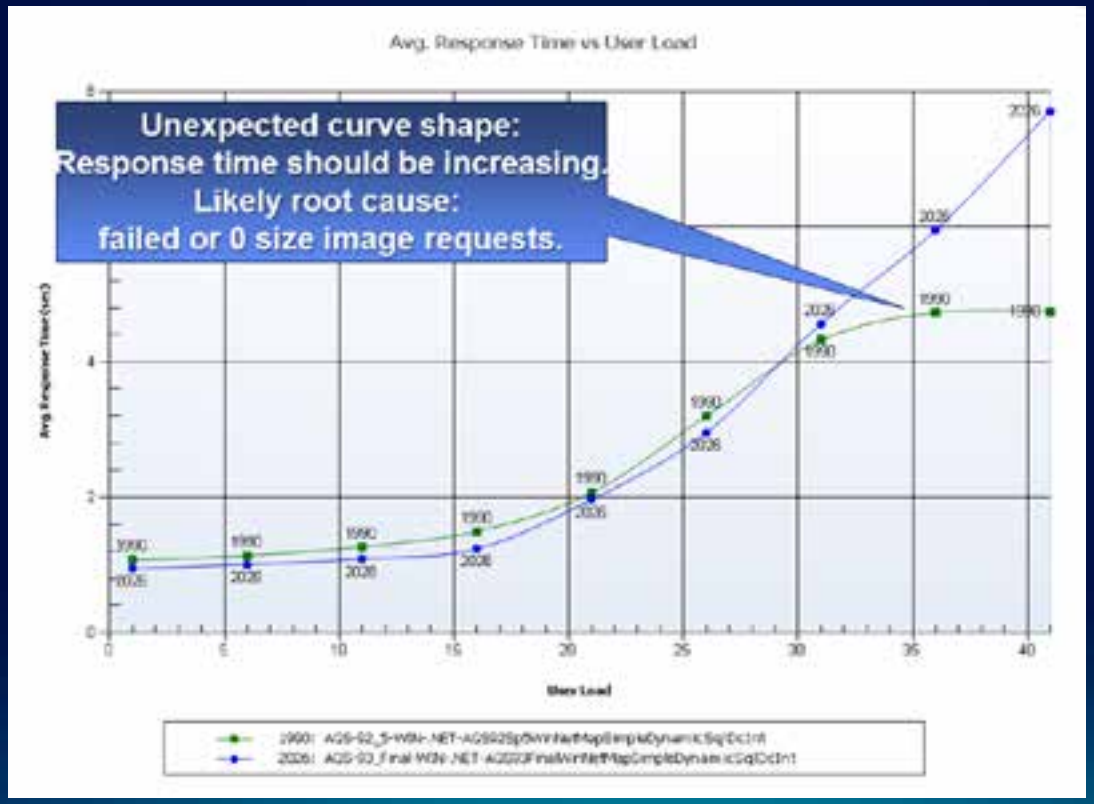
- ***Expected*** **CPU and Response time correlation**



Analyze results

Invalid

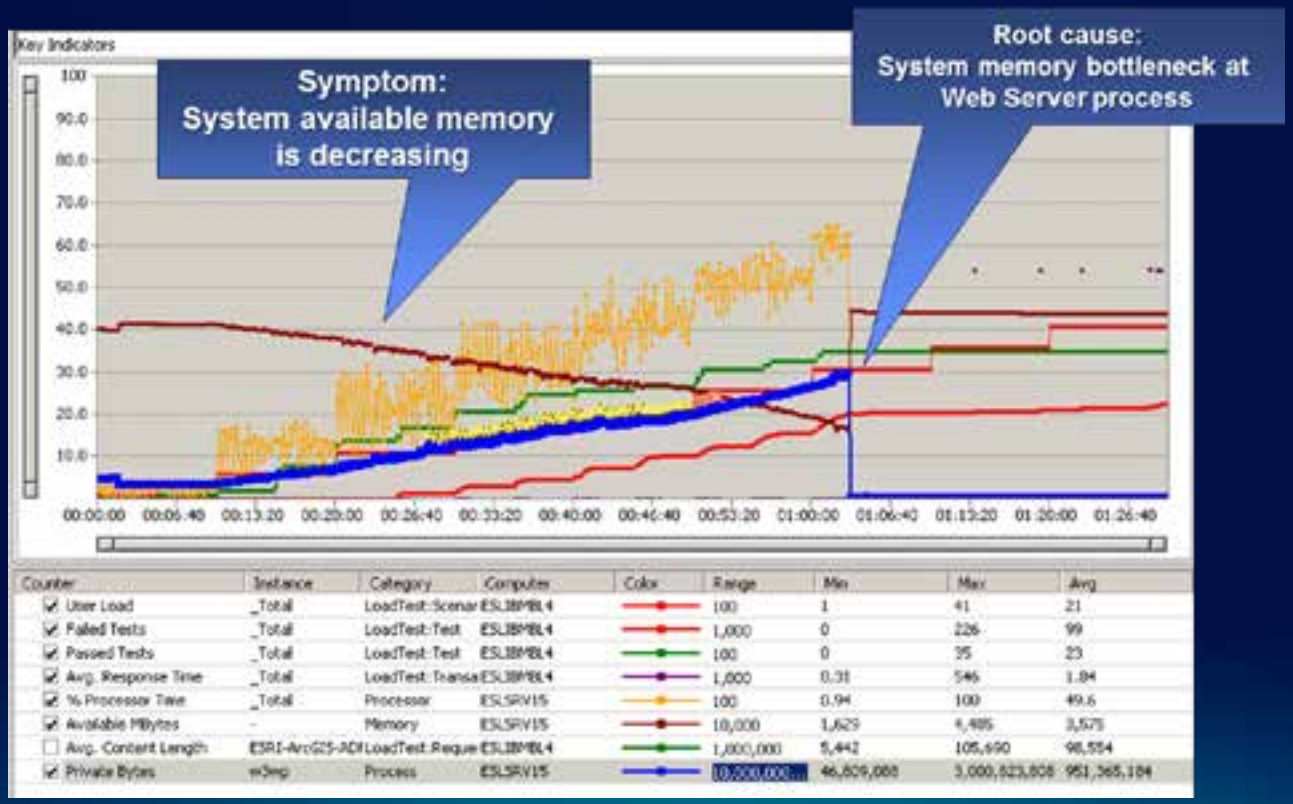
- **Validation Example**
  - ***Unexpected*** **response time under heavy load?**



Analyze results

Invalid

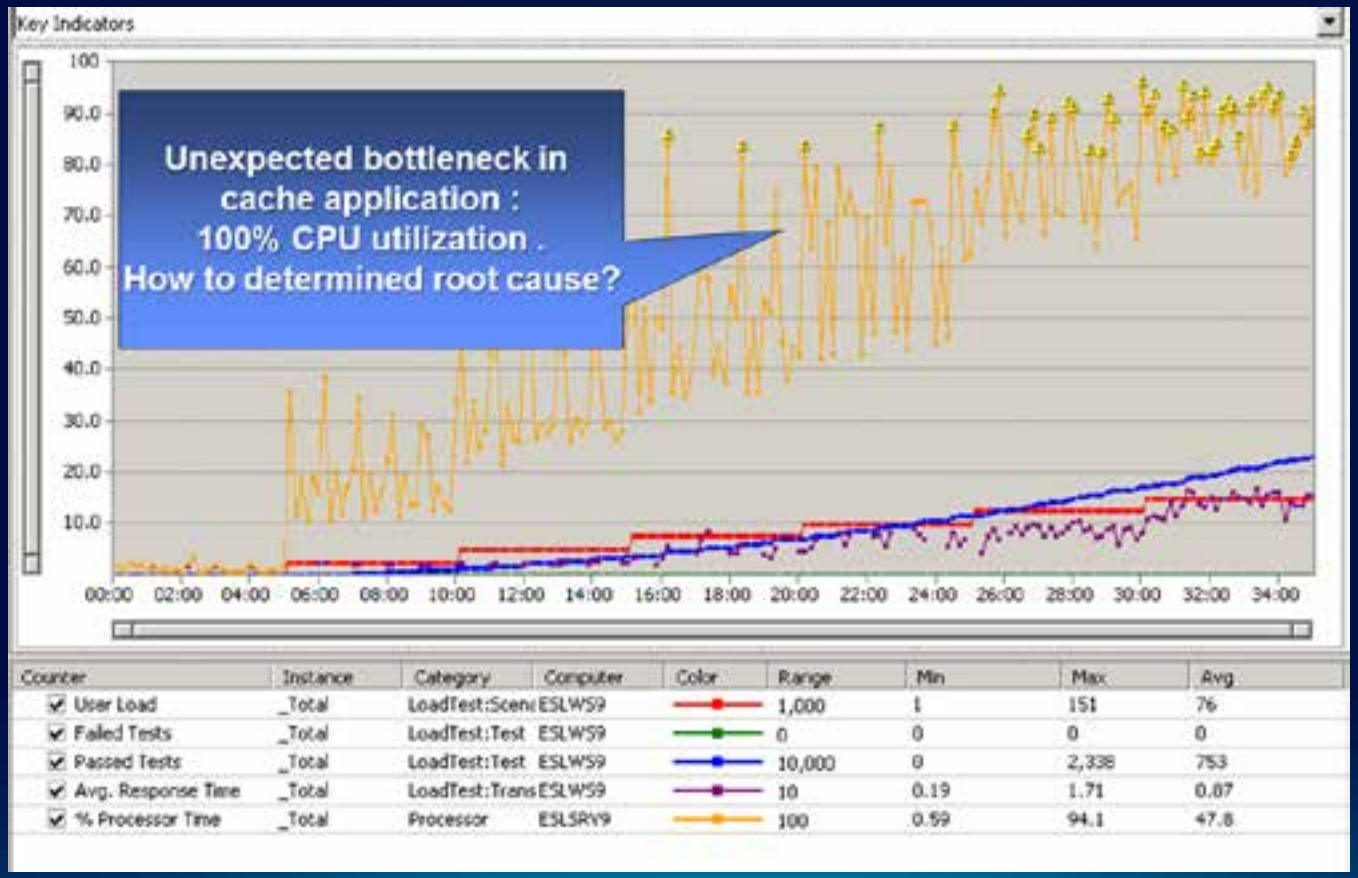
- **Validation Example**
  - **Test failure – memory bottleneck in w3wp process**

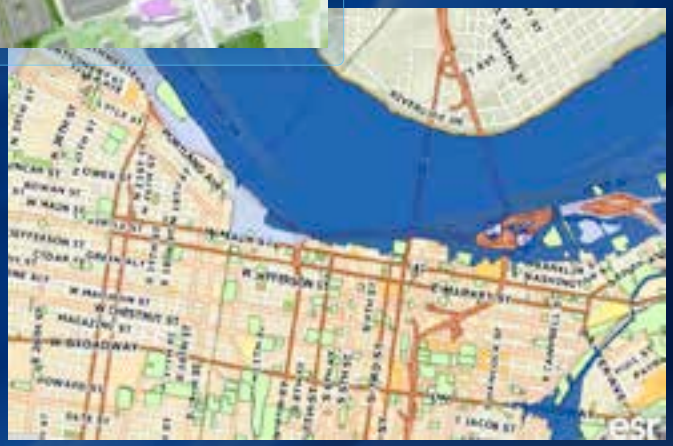


Analyze results

Invalid

- **Validation Example – *Unexpected* CPU utilization**





Test Case: Accounting for database CPU

Test Case: Accounting for database CPU

Profile a single user – record cpu

- WORKLOAD REPOSITORY report for

Host Name	Platform	CPUs	Cores	Sockets	Memory (GB)
pvtlinux.esri.com	Linux x86 64-bit	4	4	2	7.80

	Snap Id	Snap Time	Sessions	Cursors/Session
Begin Snap:	3008	13-Mar-12 11:52:29	32	8.2
End Snap:	3010	13-Mar-12 12:08:39	35	12.3
Elapsed:		16.18 (mins)		
DB Time:		1.29 (mins)		

Host CPU (CPUs: 4 Cores: 4 Sockets: 2)

Load Average Begin	Load Average End	%User	%System	%WIO	%Idle
0.05	0.05	1.7	0.1	1.7	98.1

Instance CPU

%Total CPU	%Busy CPU	%DB time waiting for CPU (Resource Manager)
1.7	91.5	0.0

Test Case: Accounting for database CPU

Profile a single user – find top queries

-

WORKLOAD REPOSITORY report for

Host Name	Platform	CPUs	Cores	Soc
pvtlinux.esri.com	Linux x86 64-bit	4	4	

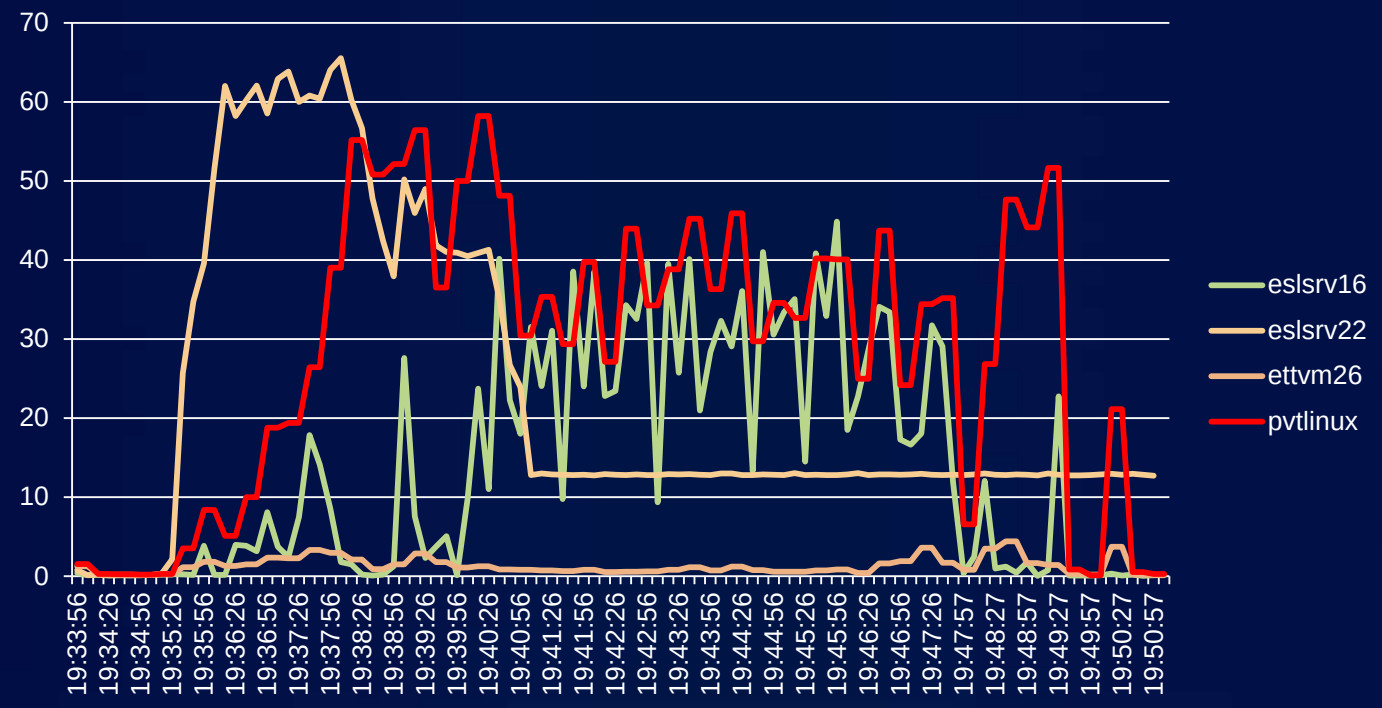
	Snap Id	Snap Time	Sessions
Begin Snap:	3008	13-Mar-12 11:52:29	3
End Snap:	3010	13-Mar-12 12:08:39	3
Elapsed:		16.18 (mins)	
DB Time:		1.29 (mins)	

SQL ordered by CPU Time

CPU Time (s)	Executions	CPU per Exec (s)	%Total	Elapsed Time (s)	%CPU	%IO	SQL Id
37.68	20	1.88	58.30	37.75	99.81	0.11	2fxu4s81kqqa
10.80	10	1.08	16.71	11.12	97.12	0.06	akyzdhksdtyu
10.42	10	1.04	16.11	10.74	96.96	0.07	3hhpdpyjauvh
3.71	1	3.71	5.74	4.45	83.35	14.80	572fbaj0fdw2
3.39	2	1.70	5.25	8.45	40.16	58.73	1184uah384av
2.85	2	1.42	4.41	6.76	42.14	56.24	0vq530bp9n7
2.25	1	2.25	3.48	2.26	99.35	0.59	03w6dqd487j
2.06	20	0.10	3.18	2.31	89.27	11.13	6wkpd0frj4q5
1.10	30	0.04	1.71	1.11	99.39	0.52	djpskqc3quh
0.89	2	0.45	1.38	1.23	72.41	27.58	7dwup5bn902
0.81	20	0.04	1.25	0.98	82.10	18.09	9zj3fvcx9z75z

Test Case: Accounting for database CPU

Validate load test



*expected CPU Utilization=1.7% * 20 users = 34%*

Report

- Executive Summary
- Test Plan
  - Workflows and Work load
- Deployment documentation
- Results and Charts
  - Key Indicators, e.g. Response Time, Throughput
  - System Metrics, e.g. CPU %
  - Errors
- Summary and Conclusions
- Appendix

Report

- Determine System Capacity
  - Resource Utilization > X%
  - Maximum acceptable response times
    - 95% of transactions under X seconds
    - Max response time < X seconds
  - Identify bounding factor for each tier
    - Document capacity for each tier component
    - Document bounding factor for each tier

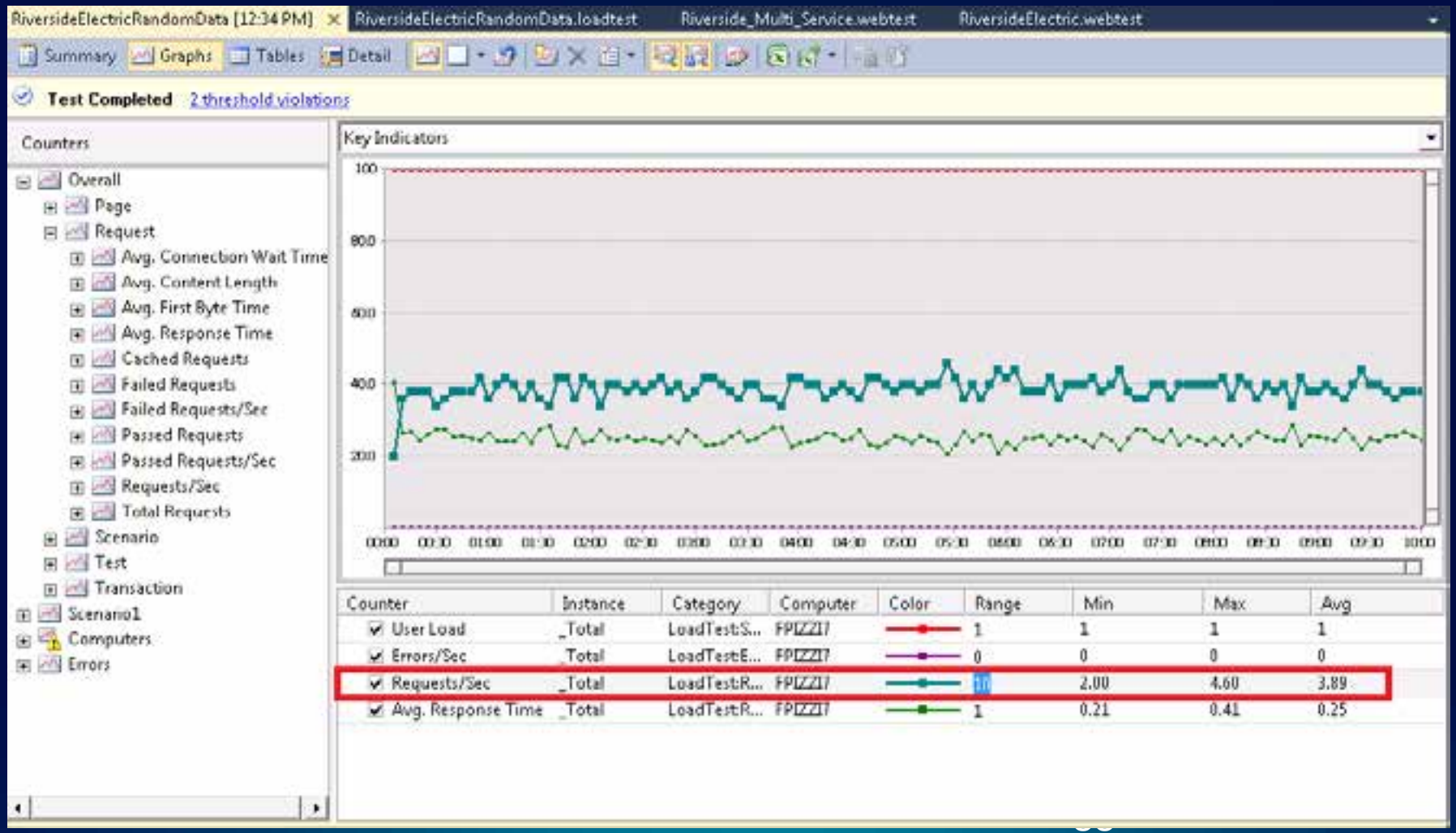
Testing

Test Tools

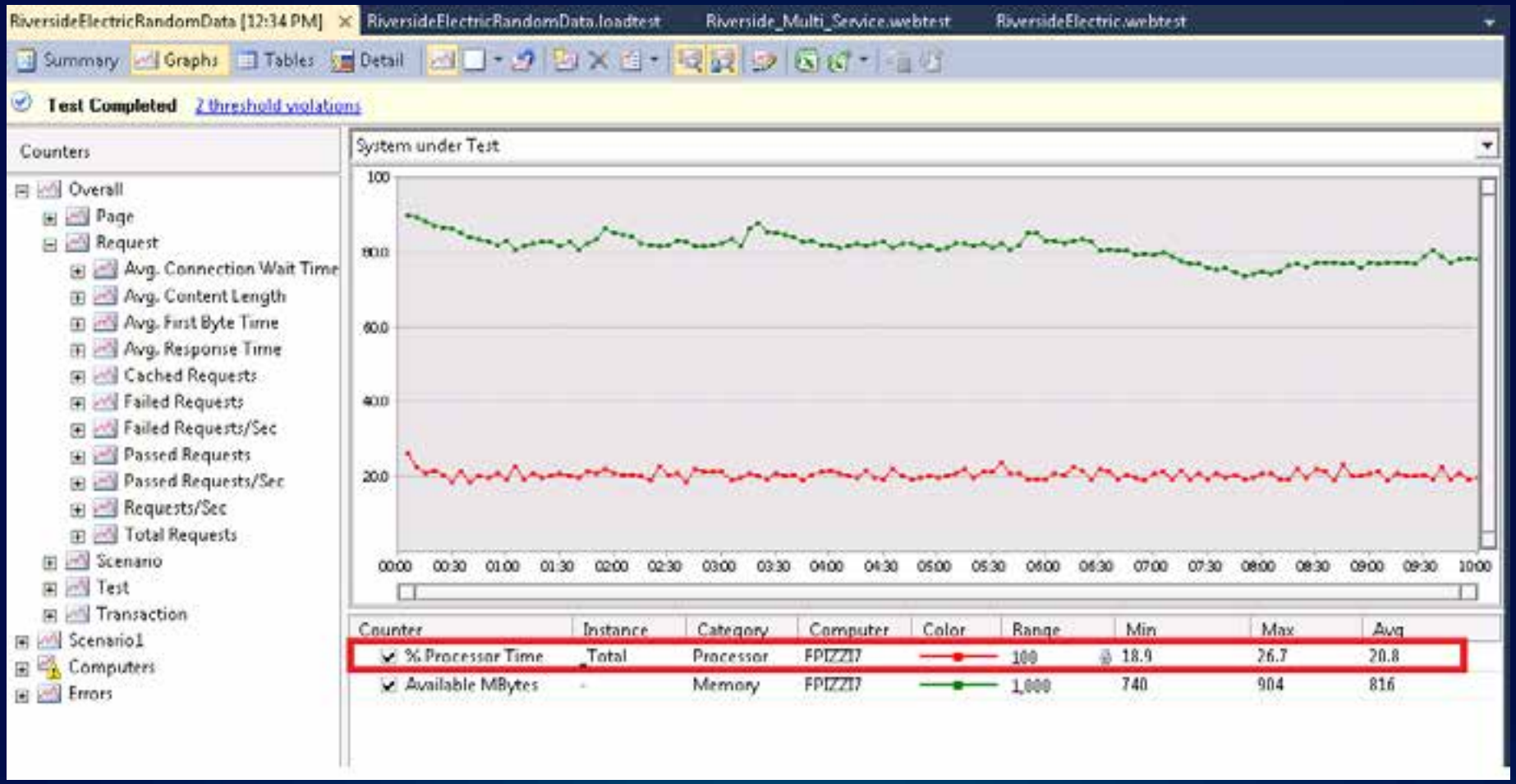
- Commercial Tools
  - Load Runner
  - Visual Studio
  - Silk Performer
- Free Tools
  - Apache JMeter
  - Open STA
  - WCAT (Fiddler extension simplifies use)
  - SoapUI
  - Curl

Using test results as input for capacity planning

Throughput (Req/sec)



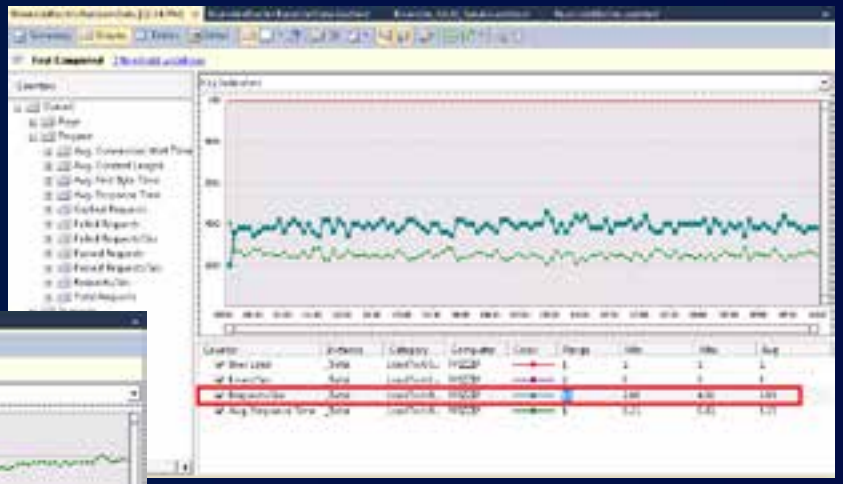
CPU utilization

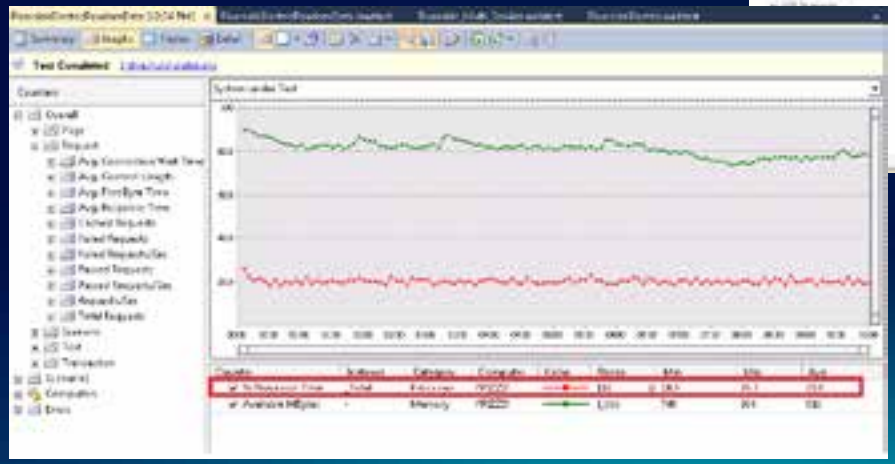


Test Results as Input into Capacity Planning

Load Test Results – input into capacity models

- Average throughput over the test duration
  - 3.89 request/sec ~ 14,004 request/hour
- Average response time over the test duration
  - .25 seconds
- Average CPU Utilization
  - 20.8%
  - Mb/request = 1.25 Mb





Test Results as Input into Capacity Planning

Load Test Results – input into CPU capacity model

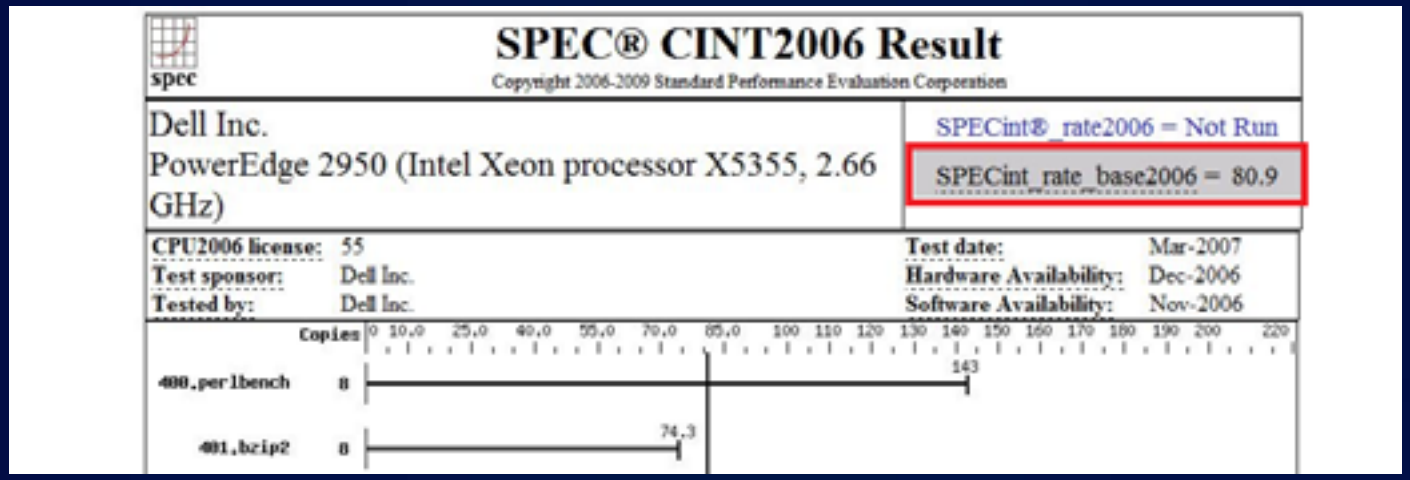
- **Input from testing**
  - **#CPUs = 4 cores**
  - **%CPU = 20.8**
  - **TH = 14,004 requests/hour**
  - **SPEC per Core of machine tested = 35**
- **ST = (4*3600*20.8)/(14,004 *100) = 0.2138 sec**
  - **Note* very close to Average response time of .25**

$$ST = \frac{\#CPU \times 3600 \times \%CPU}{TH \times 100}$$

Test Results as Input into Capacity Planning

Target values

1. **Server SpecRate/core=10.1**



SPEC® CINT2006 Result

Copyright 2006-2009 Standard Performance Evaluation Corporation

Dell Inc.
PowerEdge 2950 (Intel Xeon processor X5355, 2.66 GHz)

SPECint®_rate2006 = Not Run
SPECint_rate_base2006 = 80.9

CPU2006 license:	55	Test date:	Mar-2007
Test sponsor:	Dell Inc.	Hardware Availability:	Dec-2006
Tested by:	Dell Inc.	Software Availability:	Nov-2006

	Copies	0 10.0 25.0 40.0 55.0 70.0 85.0 100 110 120 130 140 150 160 170 180 190 200 220
400.perlbench	8	143
401.bzip2	8	74.3

2. **User load=30,000 req/hr**
3. **Network=45 Mbps**

Test Results as Input into Capacity Planning

Target CPU cores calculation

- **Input to Capacity Planning:**
  - ST = Service Time = .2138 sec
  - TH = Throughput desired = 30,000 request/hour
  - %CPU = Max CPU Utilization = 80%
  - SpecRatePerCpuBase = 35
  - SpecRatePerCpuTarget = 10.1
- **Output**
  - #CPU required =([.2138*30,000*100]/3600*80]) *[35/10.1]
  - #CPU required = 7.7 cores ~ 8 cores

$$\#CPU_t = \frac{ST_b \times TH_t \times 100}{3600 \times \%CPU_t} \times \frac{SpecRatePerCPU_b}{SpecRatePerCPU_t}$$

Test Results as Input into Capacity Planning

Target network calculation

- **Input to Capacity Planning:**
  - **Mb/req=1.25**
  - **TH = 30,000 request/hour**

$$Mbps = \frac{TH' \; Mbits/req}{3600}$$

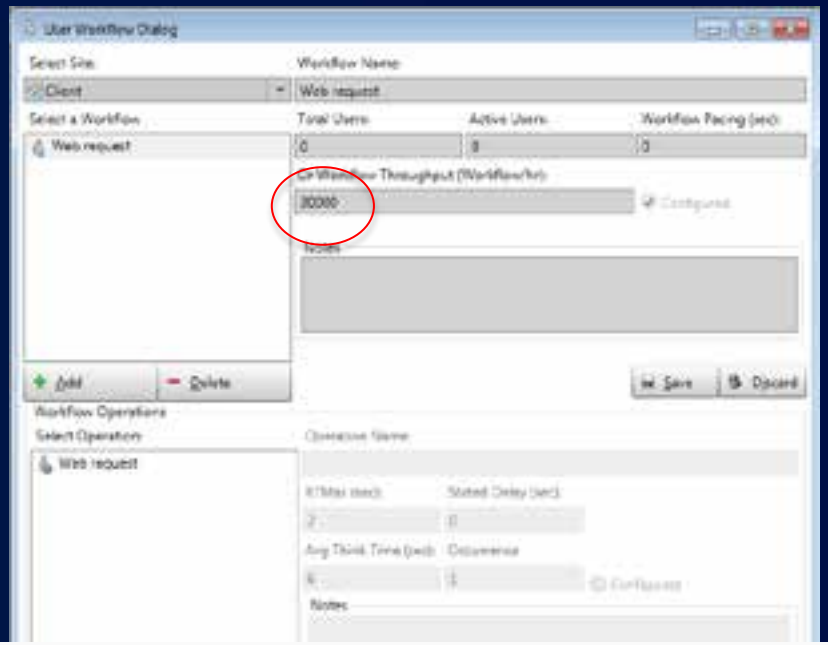
- **Output**
  - **Network bandwidth required = 30000x1.25/3600**
  - **=10.4 Mbps < 45 Mbps available**
  - **Transport=1.25/(45-10.4)=0.036sec**

$$Transport(\sec) = \frac{Mbits/req}{Mbps - Mbps_{used}}$$

Test Results as Input into Capacity Planning

System Designer

- **Input:**
  - **Throughput=30000**
  - **ST=0.21**
  - **Mb/tr=1.25**
  - **Hardware=80.9 Spec**



Model Review | Model Assigned

Selected Model

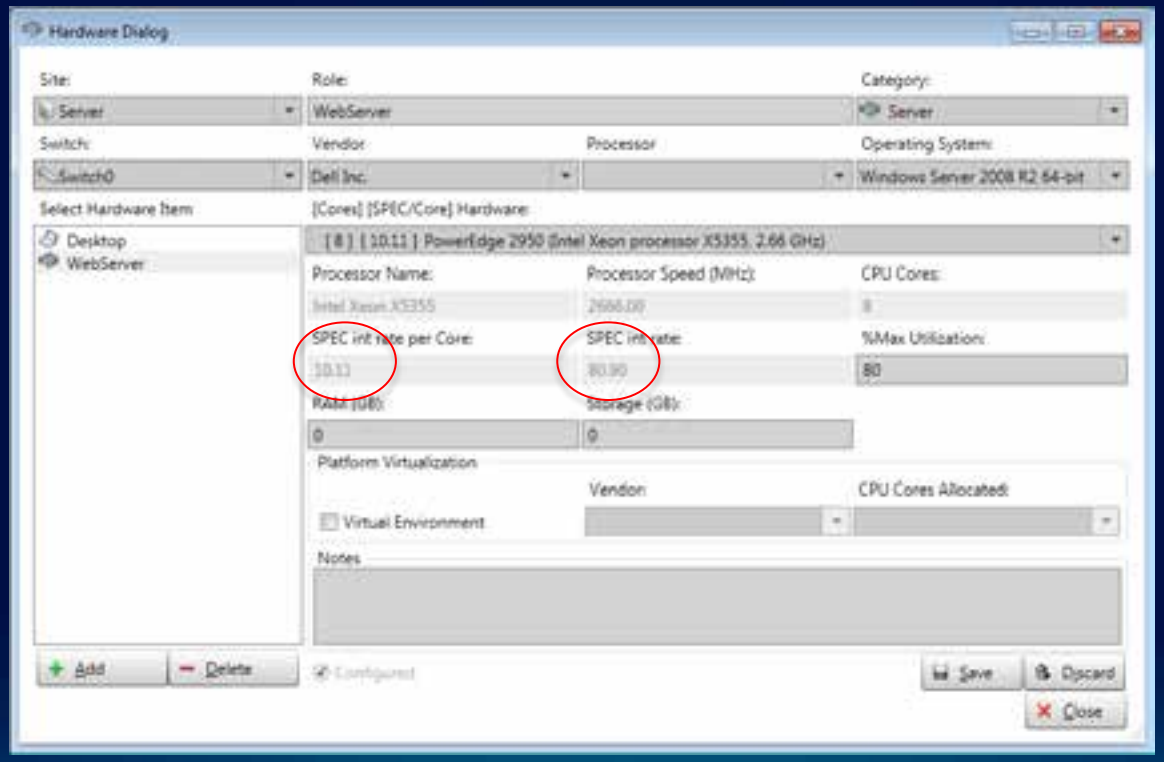
Service Type: Map **Model Name:** ExportMap REST MapService 9.3.1

Model	Function	Tier	Modified	Service Time(sec)	Queue Time(sec)	CPU Cores Calc	Modified	Mb/Tr
✓	Client	Client			0.000	0.00		1.250
✓	WebService	Web Services	✓	0.210	0.004	1.01	✓	1.250

Test Results as Input into Capacity Planning

System Designer

- **Input**
  - **Hardware=80.9 Spec**



Test Results as Input into Capacity Planning

System Designer

- **Review results**

Model Review | Model Assigned

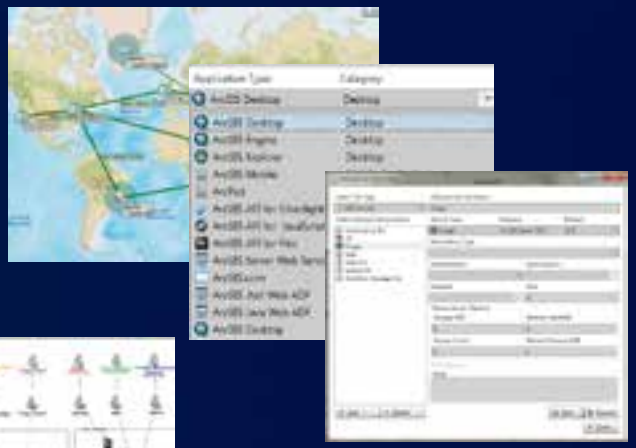
Selected Model

Service Type: Map **Model Name:** ExportMap REST MapService 9.3.1

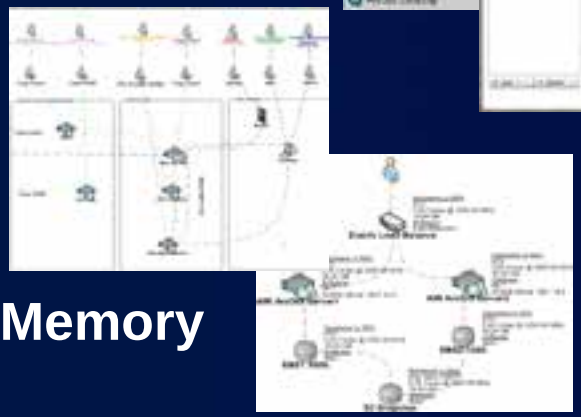
Model	Function	Tier	Modified	Service Time(sec)	Queue Time(sec)	CPU Cores Calc	Modified	Mb/Tr	Mbps Calc	Transport(sec)
✓	Client	Client	○		0.000	0.00	○	1.250	10.42	0.00
✓	WebService	Web Services	✓	0.210	0.046	7.57	✓	1.250	10.42	0.04

Design Tools

System Designer



- Gathering requirements

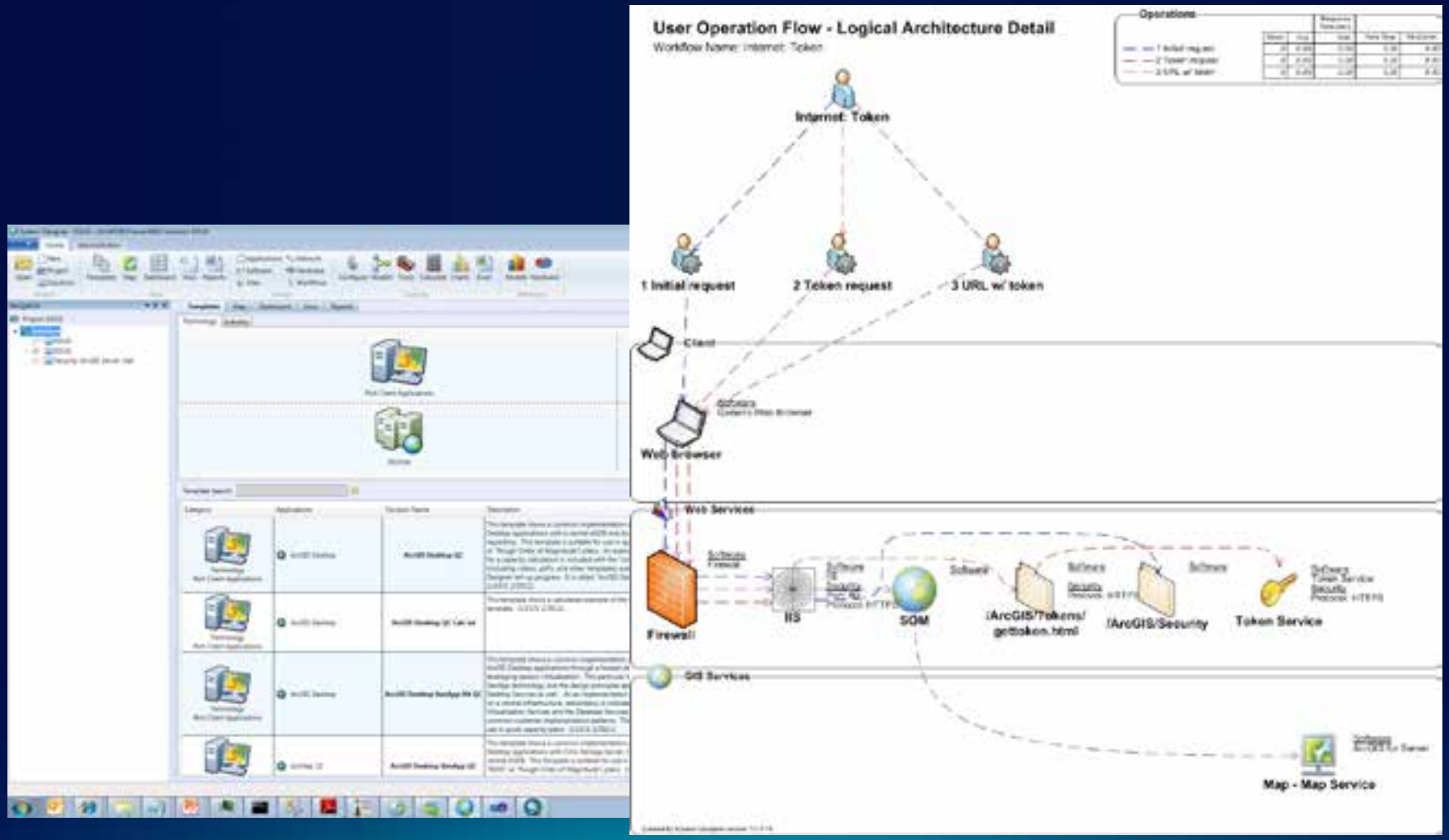


- Designing
- Capacity: CPU, Network, Memory

- Reporting

Design Tools

System Designer Templates



System Designer

- **Download from:**
  - Open Explorer
  - In the Address Bar enter: **ftp://ftp.esri.com/**
  - Right click or select the File menu and choose **Login As**
  - Enter your username and password:
  - username: **eist**
  - password: **eXwJkh9N**
  - Click "Log On“
- **Contact**
  - asakowicz@esri.com

Questions?

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