July 23–27 | San Diego Convention Center

ArcGIS Enterprise Systems: Performance and Scalability - Testing Methodologies

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Introductions

Who are we?

- Esri Professional Services, Enterprise Implementation
  - Frank Pizzi
  - Andrew Sakowicz

Introductions

- Target audience
  - GIS, DB, System administrators
  - Testers
  - Architects
  - Developers
  - Project managers
- Level
  - Intermediate

Agenda

- Performance engineering throughout project phases
- Performance Factors – Software
- Performance Factors - Hardware
- Performance Tuning
- Performance Testing
- Monitoring Enterprise GIS

Performance Engineering

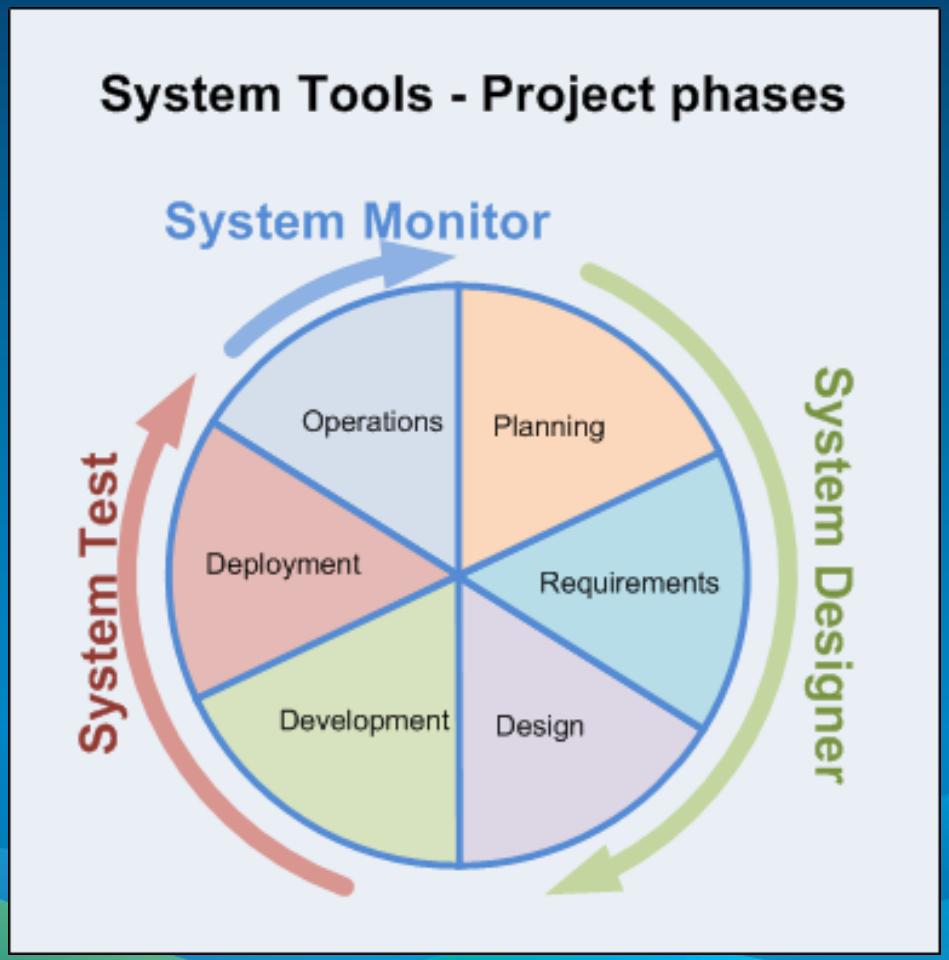
Benefits

- Lower costs
  - Optimal resource utilization
  - Less hardware and licenses
  - Higher scalability
- Higher user productivity
  - Better performance

Performance Engineering throughout Project Phases

Performance Engineering throughout Project

- Tools



Performance Factors - Software

Performance Factors - Software

- Application
- GIS Services

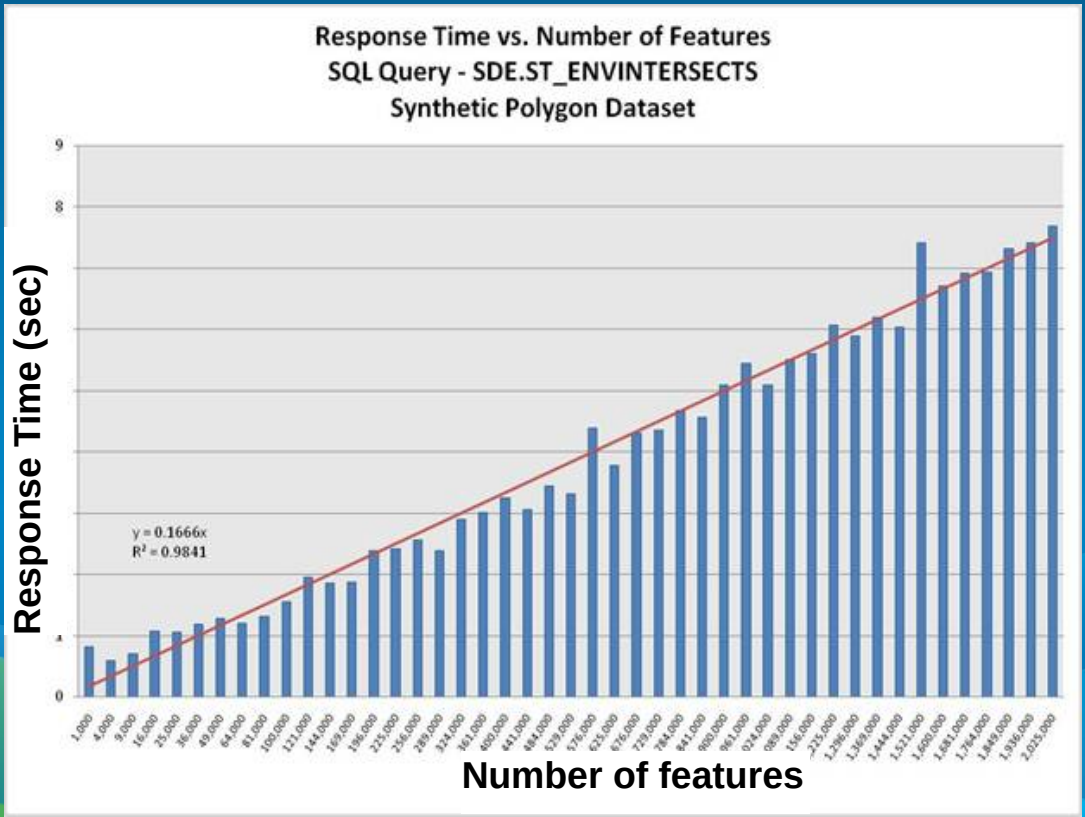
Performance Factors - Software

- Application
  - Type (e.g., mobile, web, desktop)
  - Stateless vs. stateful (ADF)
  - Design
    - Chattiness
    - Data access (feature service vs. map service)
  - Output image format

Performance Factors - Software

Map service

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



Performance Factors - Software

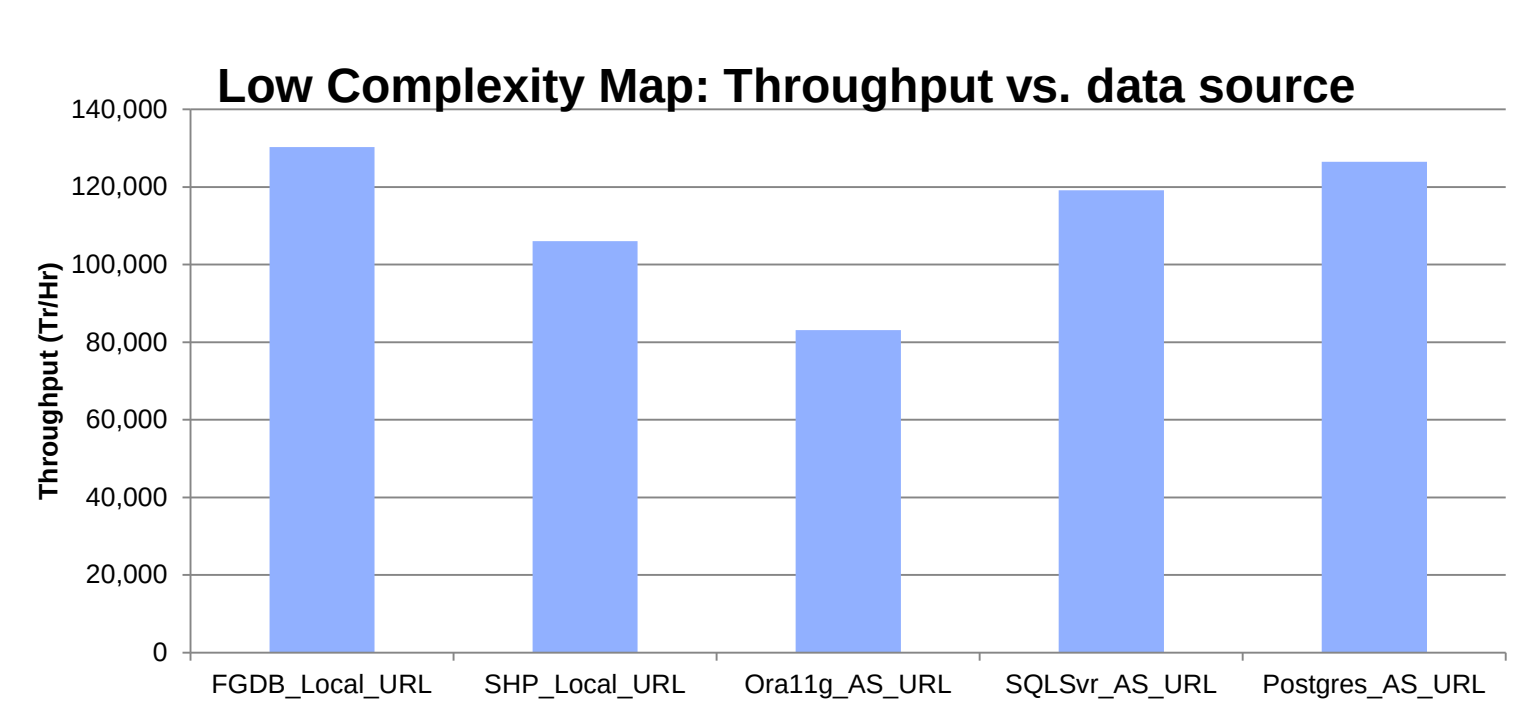
GIS Services—Geodata

- Database Maintenance/Design
  - Keep versioning tree small, compress, schedule synchronizations, rebuild indexes, and have a well-defined data model.
- Geodata Service Configuration
  - Server Object usage timeout (set larger than 10 min. default)
  - Upload/Download default IIS size limits (200K upload/ 4 MB download)

Performance Factors - Software

GIS Services—Data storage

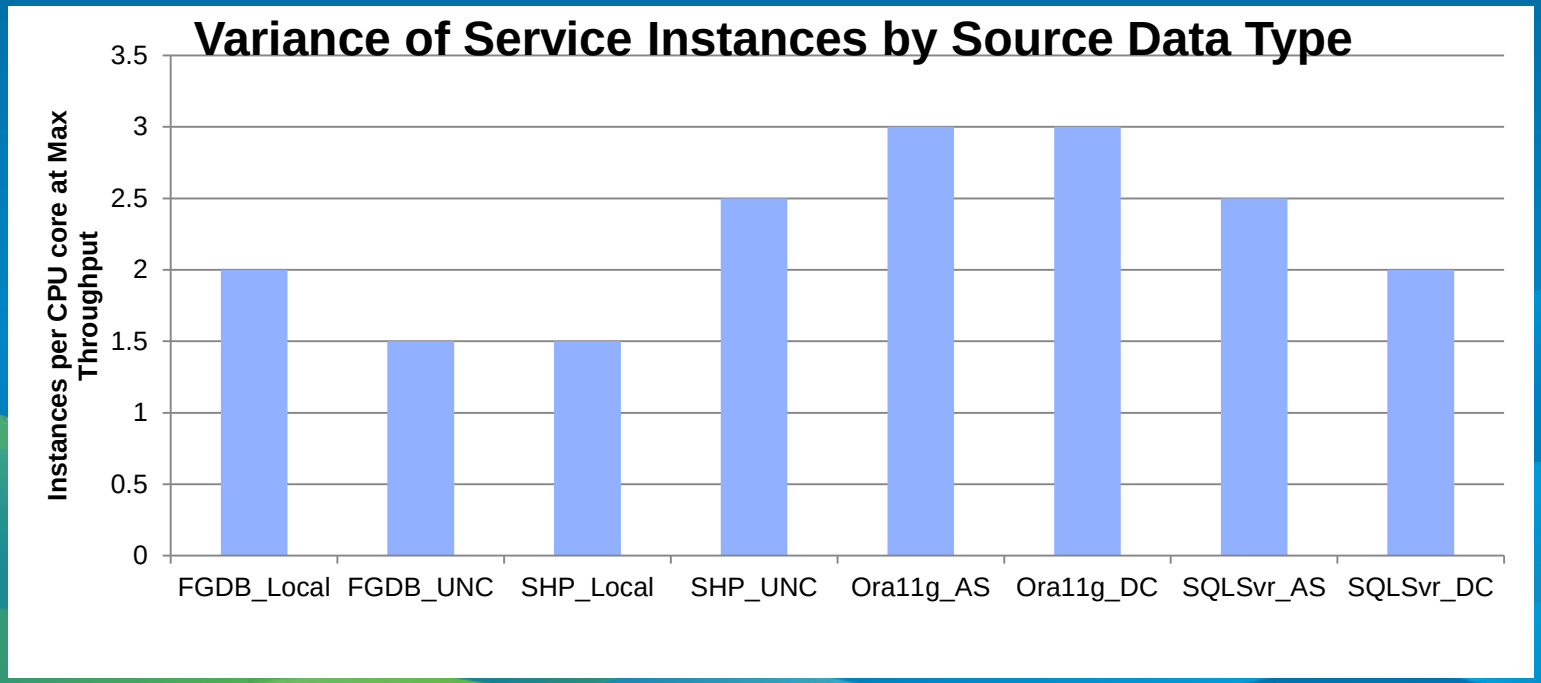
- Typically a low impact
- Small fraction (< 20%) of total response time



Performance Factors - Software

GIS Services—ArcSOC instances

- **ArcSOC Instances max**
  - **#CPU Cores (10.1)**
  - **#CPU Cores * n (prior to 10.1) , n = 1 … 4**

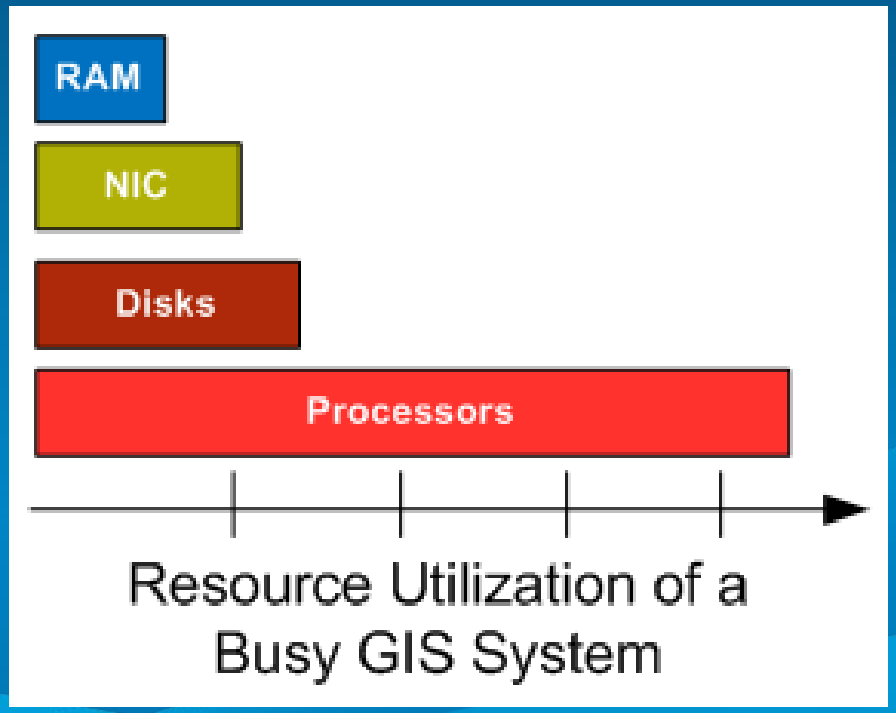


Performance Factors - Hardware

Performance Factors - Hardware

Hardware Resources

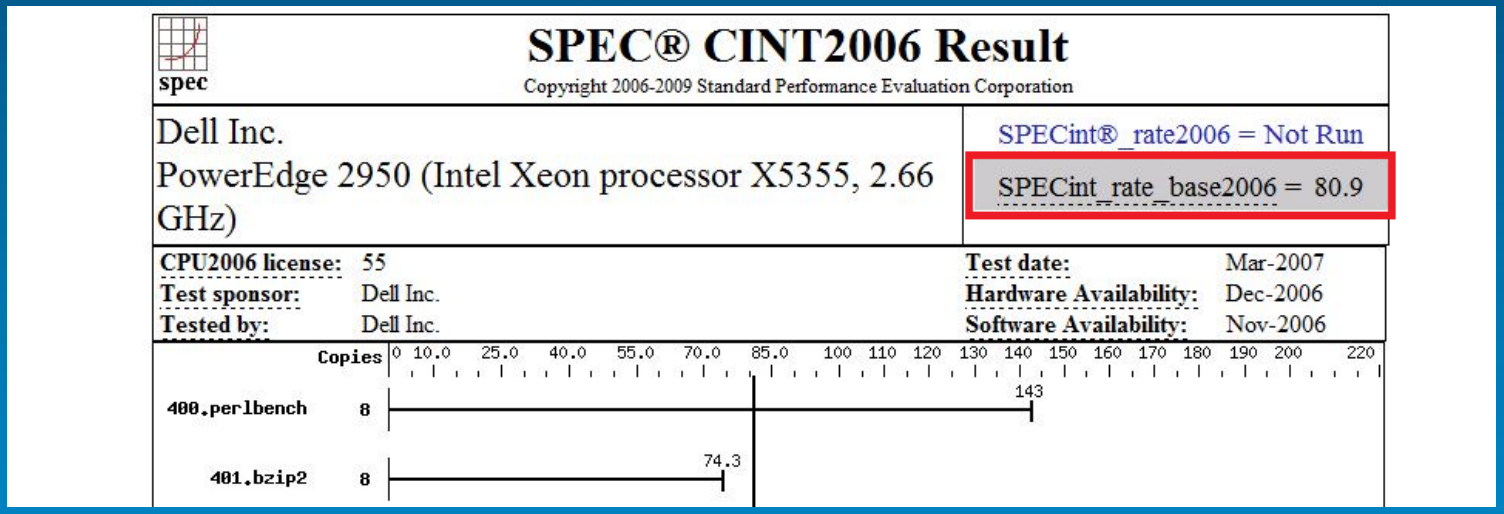
- CPU
- Network bandwidth and latency
- Memory
- Disk



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

Performance Factors - Hardware

CPU Processor Speed – Spec rate



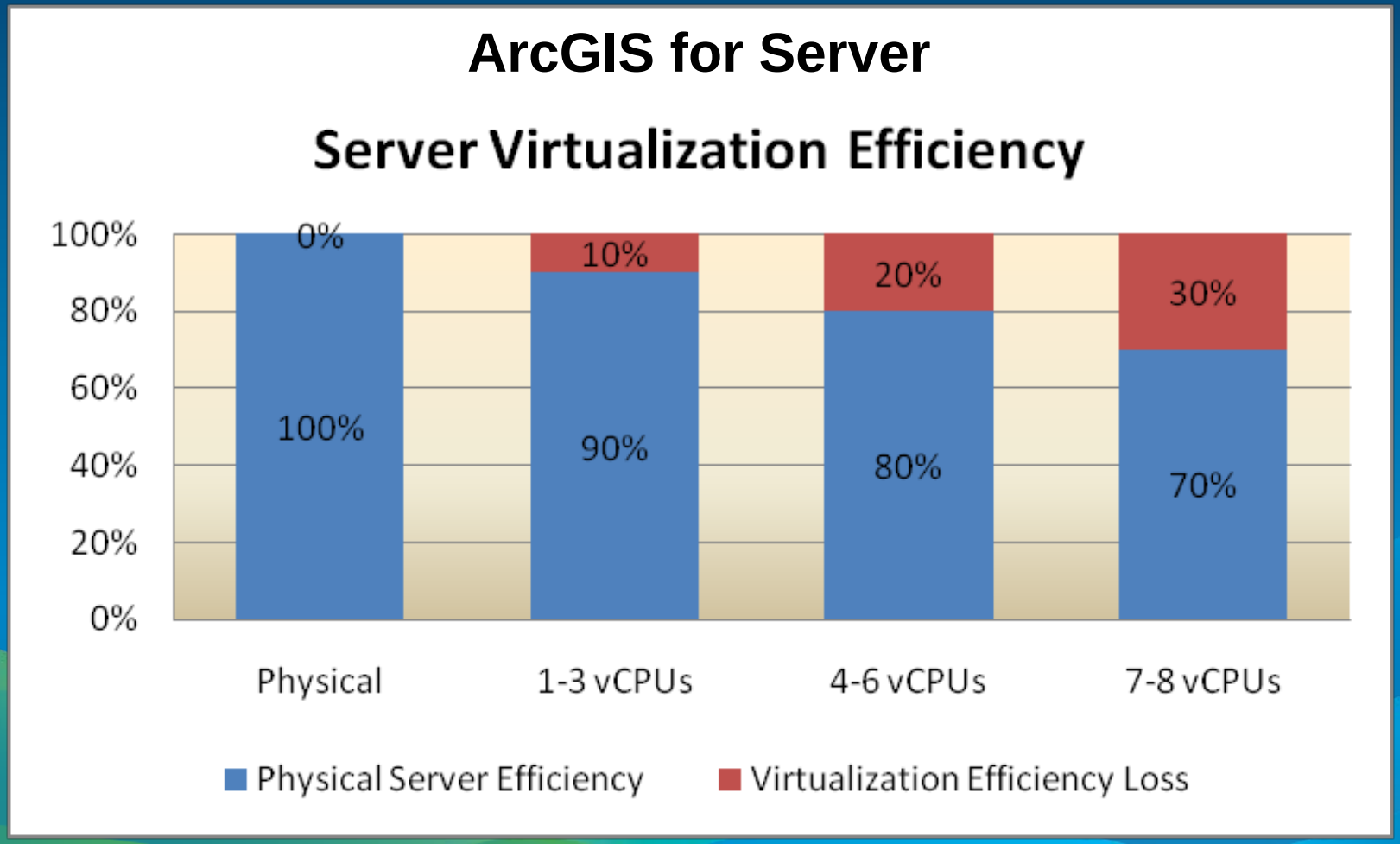
Design Phase—Performance Factors

Hardware Resources—Memory

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

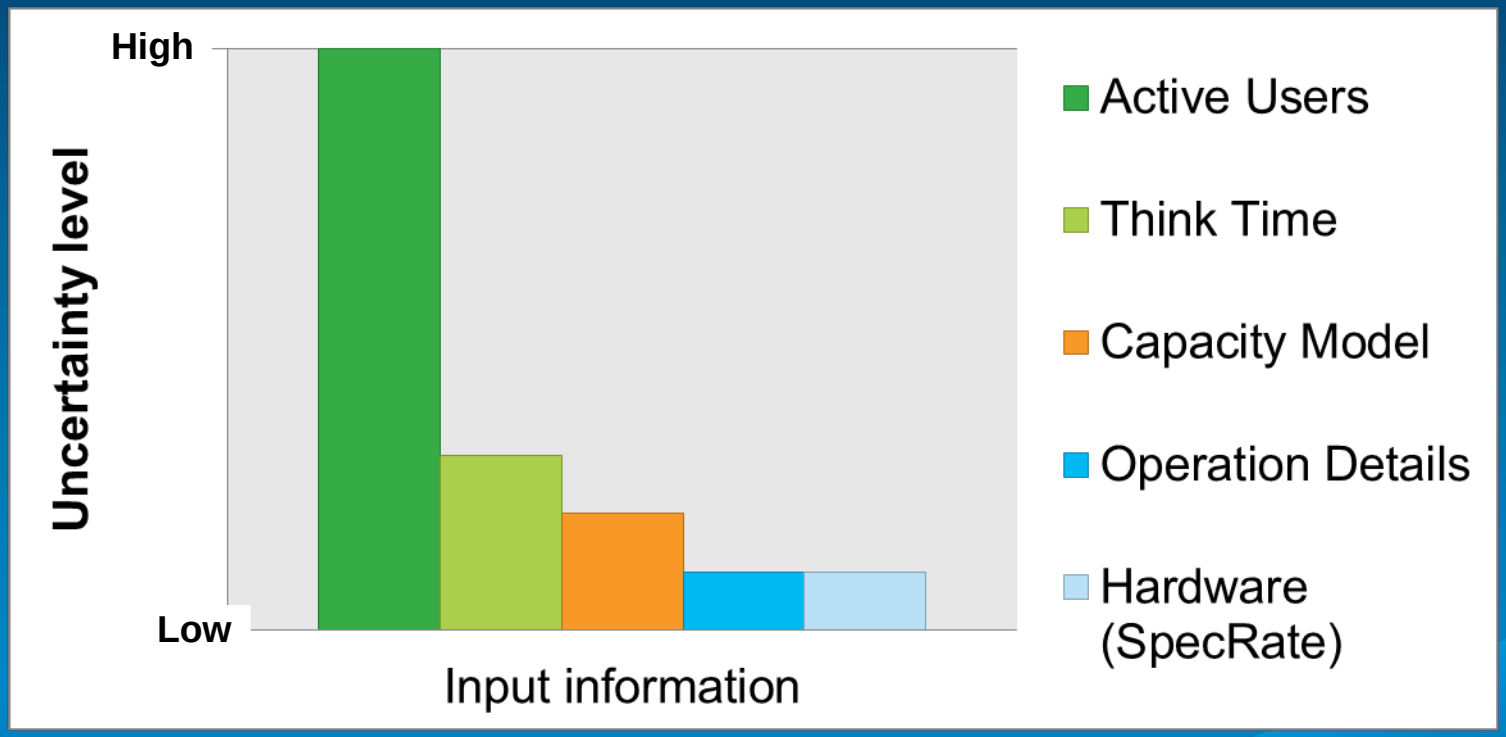
Performance Factors - Hardware

Performance degrades with the higher number of virtual processors.



Capacity Planning

Uncertainty of input information

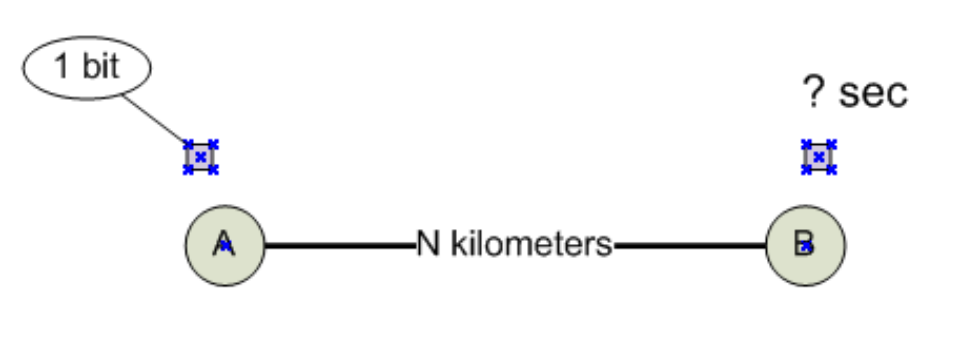


Define user load first.

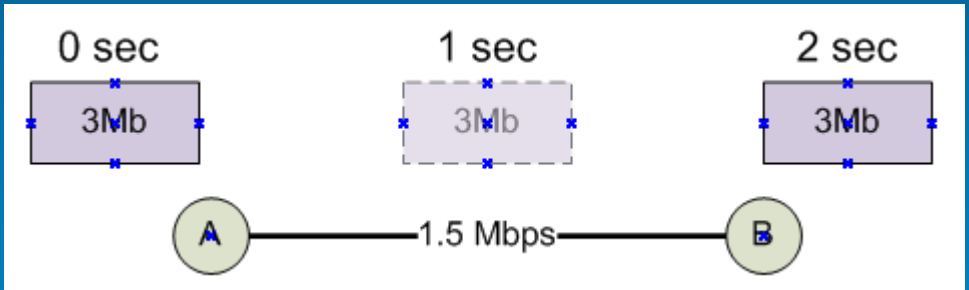
Performance Factors - Hardware

Network

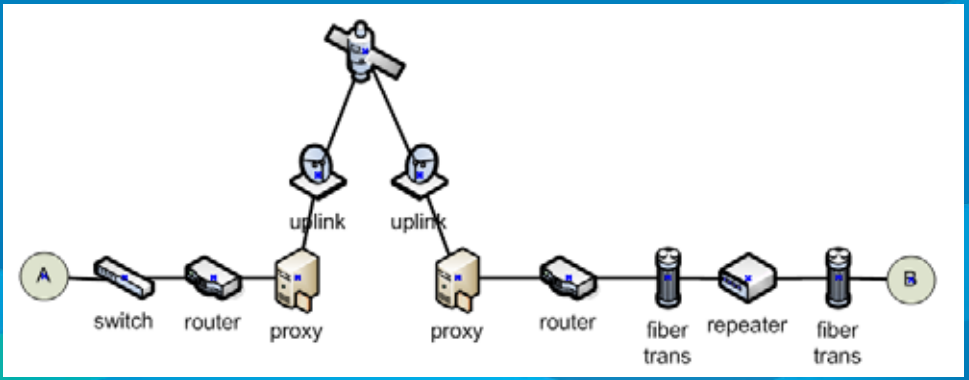
1. Distance



2. Payload



3. Infrastructure



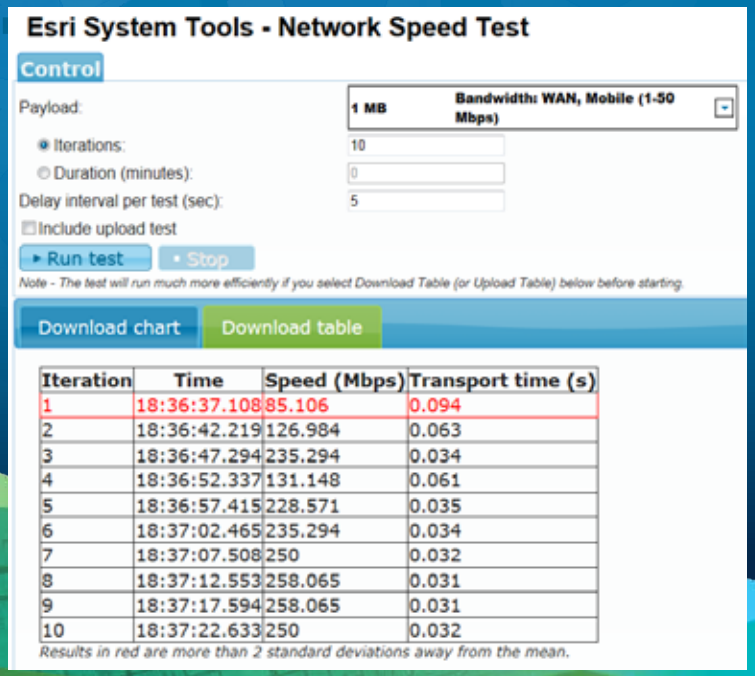
Performance Factors - Hardware

Hardware Resources—Network

- **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 Tool:
http://localhost/speedtest/

Performance Tuning

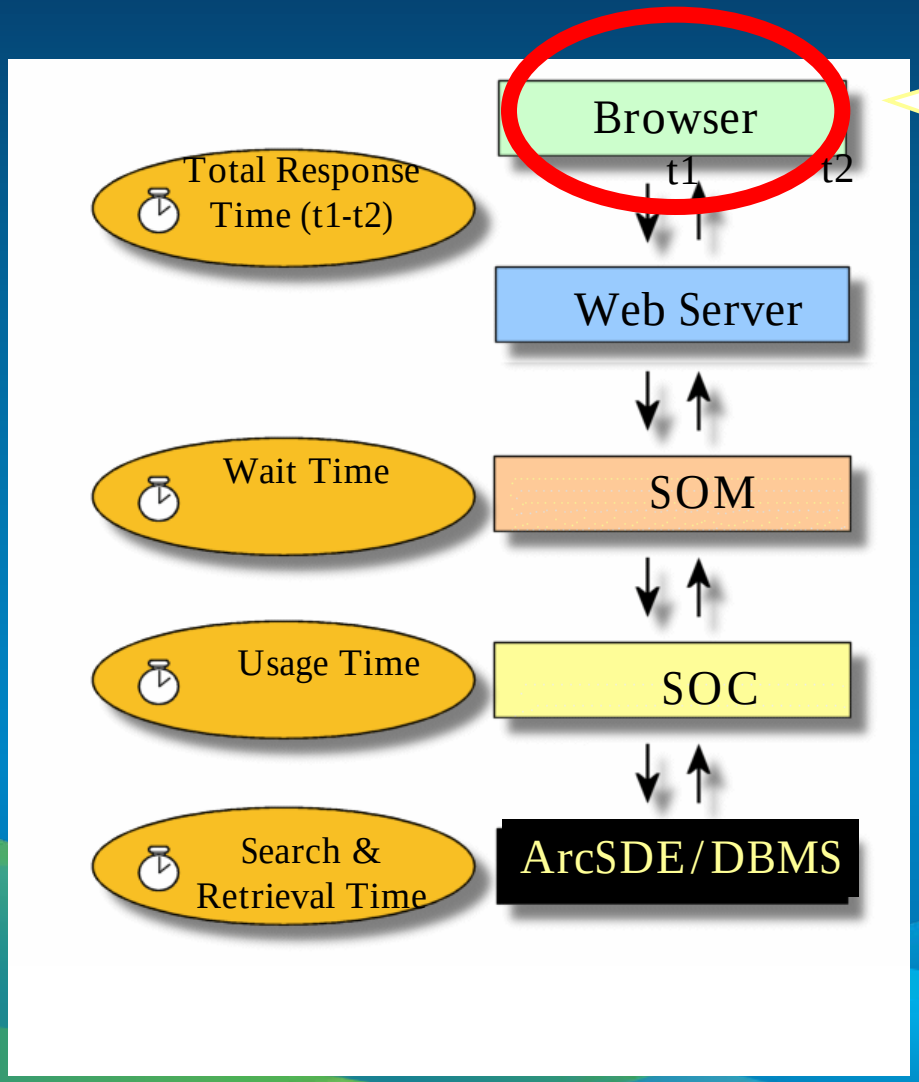
Tuning

Process

- Profile individual user operations and tune if needed
- Drill down through software stack:
  - Application
  - Service
  - MXD
  - Layer
  - DBMS query
- Correlate your findings between tiers

Tuning

Profile user transaction response time



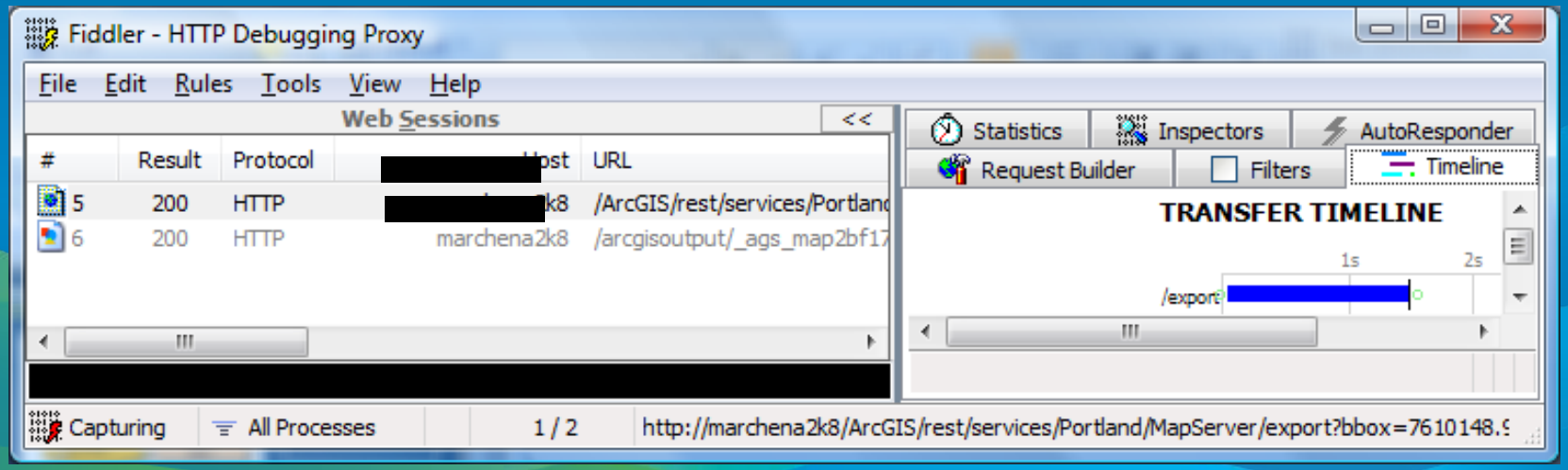
A test is executed at the web browser.

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

Tuning

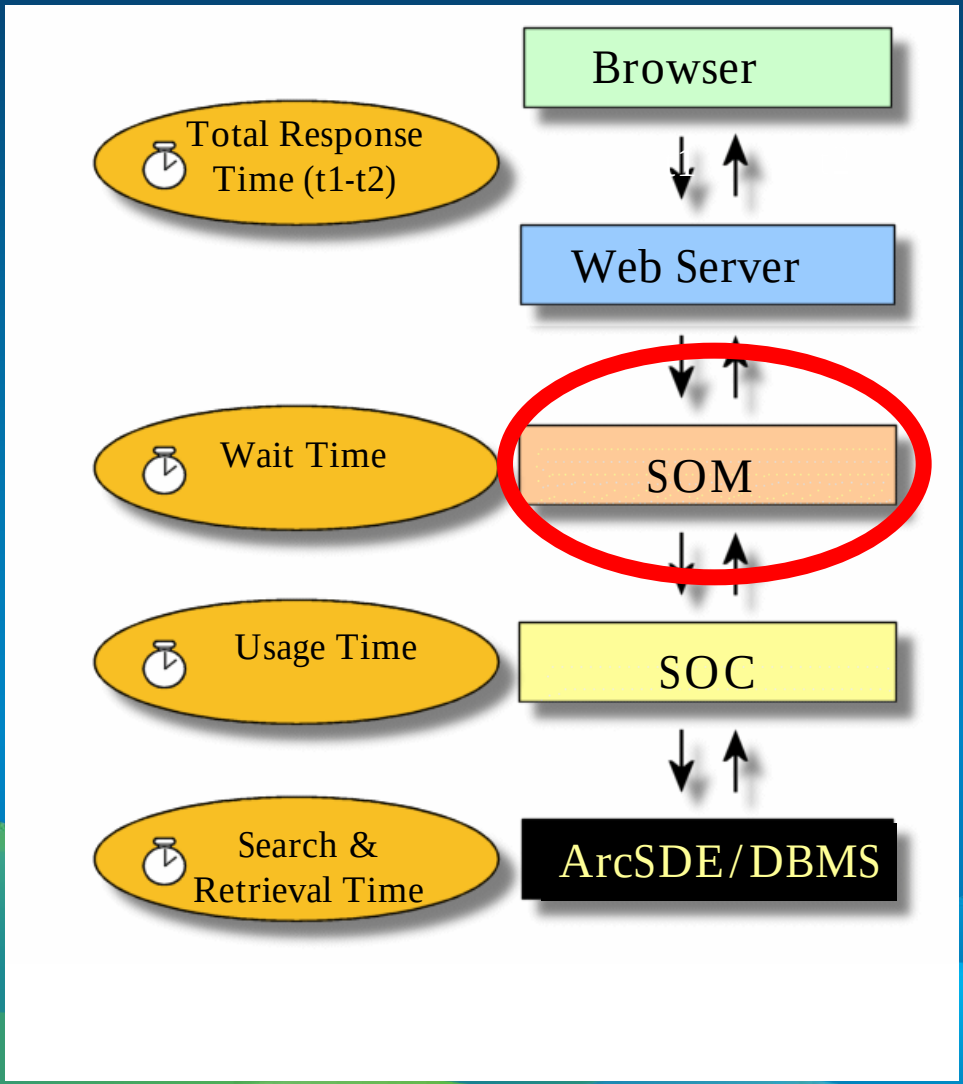
Web diagnostic tools: Fiddler

- Understand each request URL.
- Verify cache requests are from virtual directory, not dynamic map service.
- Validate host origin (reverse proxy).
- Profile each transaction response time.



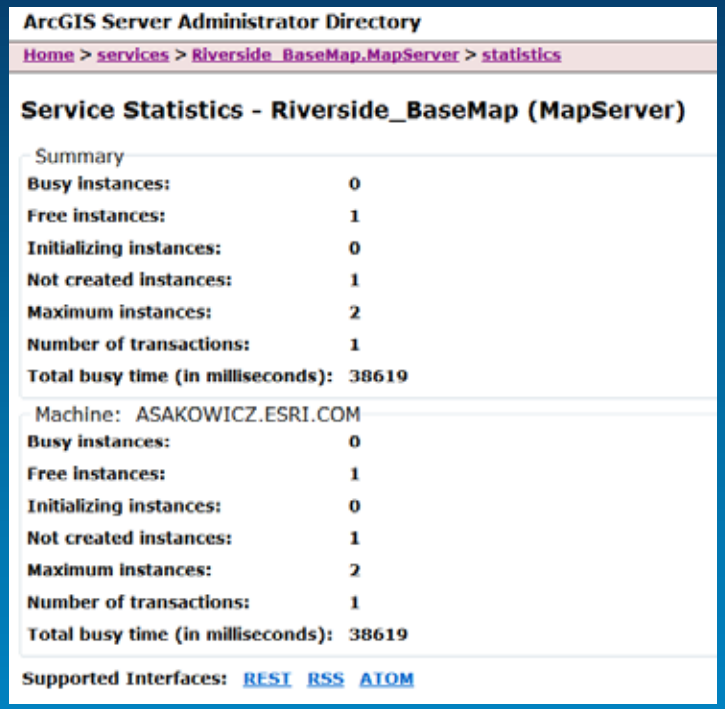
Tuning

Analyze SOM/SOC statistics.



Tuning

Analyze ArcGIS for Server statistics



ArcGIS Server Administrator Directory

Home > services > Riverside_BaseMap.MapServer > statistics

Service Statistics - Riverside_BaseMap (MapServer)

Summary

Busy instances:	0
Free instances:	1
Initializing instances:	0
Not created instances:	1
Maximum instances:	2
Number of transactions:	1
Total busy time (in milliseconds):	38619

Machine: ASAKOWICZ.ESRI.COM

Busy instances:	0
Free instances:	1
Initializing instances:	0
Not created instances:	1
Maximum instances:	2
Number of transactions:	1
Total busy time (in milliseconds):	38619

Supported Interfaces: REST RSS ATOM

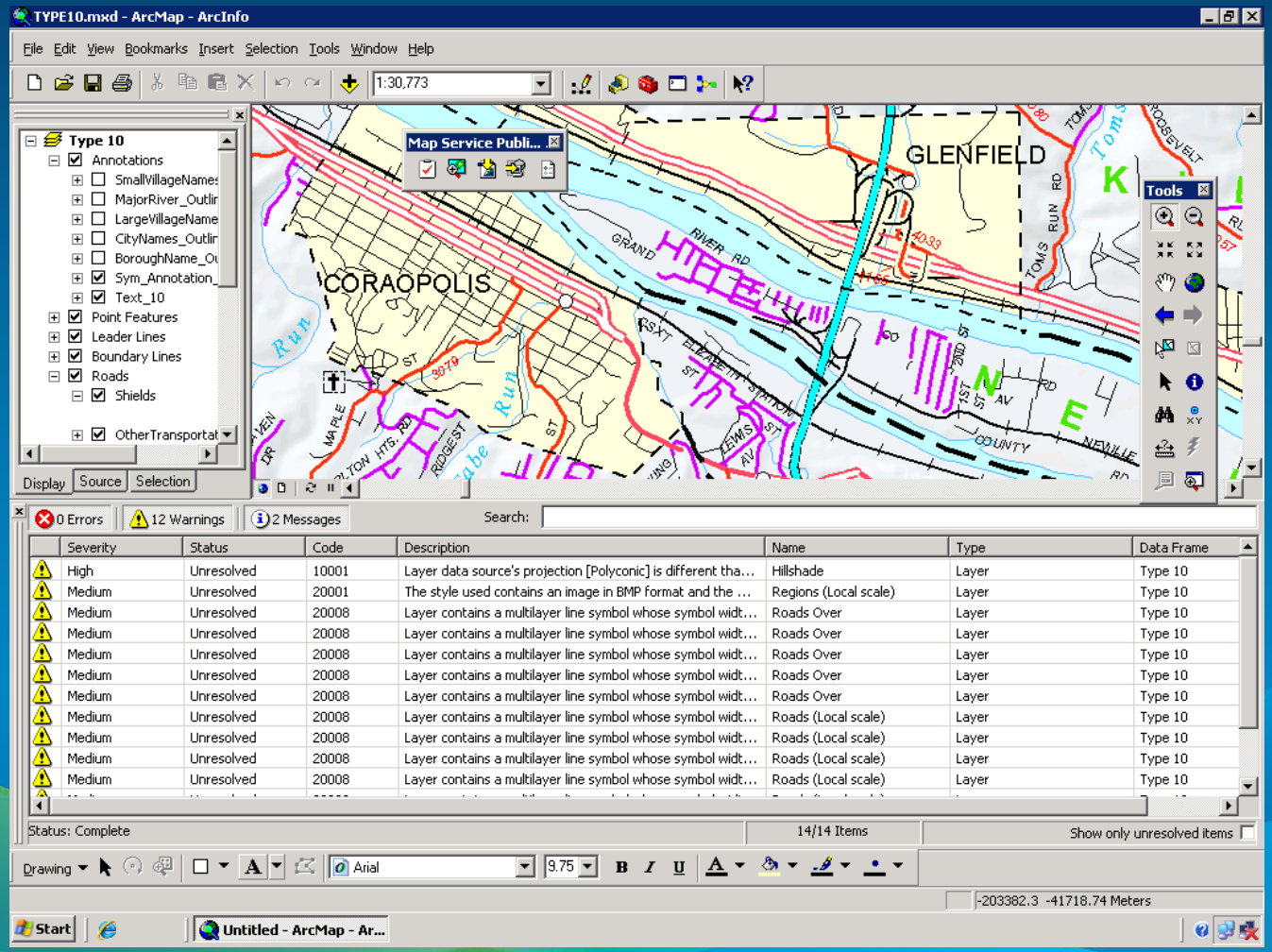
<Msg time="2009-03-16T12:23:22" type="INFO3" code="103021" target="Portland.MapServer" methodName="FeatureLayer.Draw" machine="myWebServer" process="2836" thread="3916" elapsed="0.05221">Executing query.</Msg>

<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>

Tuning

ArcMap Publish Tool



Tuning

mxdperfstat

resources.arcgis.com/gallery/file/enterprise-gis/details?entryID=6391E988-1422-2418-88DE-3E052E78213C

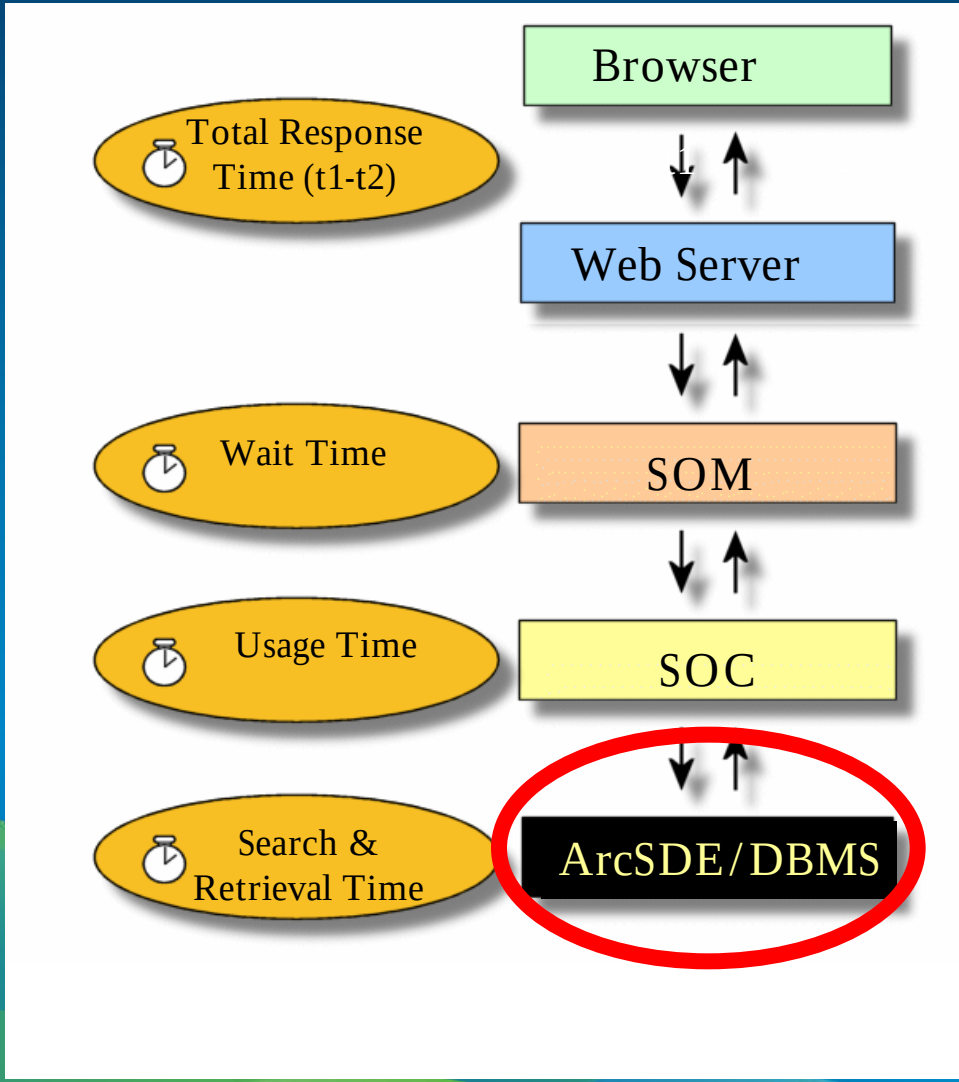
C:>mxdperfstat -mxd Portland_Dev09_Bad.mxd -xy 7655029;652614 -scale 8000

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

- **Issues discovered**
  - **Large numbers of vertices on features**
  - **Labeling of dense features expensive**

Tuning

Data Sources



Tuning

Data Sources—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,'');
```

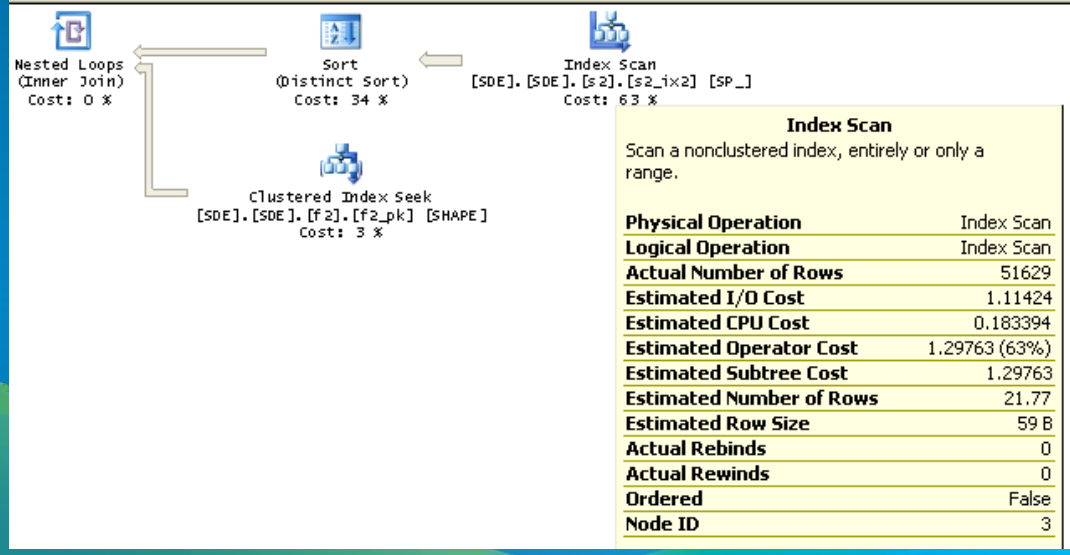
DBMS trace is a very powerful diagnostic tool.

Tuning

Data Sources—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...



Performance Testing

Testing

Performance Testing—Objectives

- Define Objectives
  - Contractual Service-Level Agreement?
- Bottlenecks
- Capacity
- Benchmark

Testing

Performance Testing—Prerequisites

- Functional testing completed
- Performance tuning

Testing

Performance Testing—Test Plan

- Test Plan
  - Workflows
    - Expected User Experience (Pass/Fail Criteria)
    - Single User Performance Evaluation (Baseline)
    - Think Times
    - Active User Load
    - Pacing
    - Valid Test Data and Test Areas
  - Testing Environment
    - Scalability/Stability
    - IT Standards and Constraints
    - Configuration (GIS and Non-GIS)

Testing

Performance Testing—Test tools

- Tool selection depends on objective.
  - Commercial tools all have system metrics and correlation tools.
  - Free tools typically provide response times and throughput but leave system metrics to the tester to gather and report on.

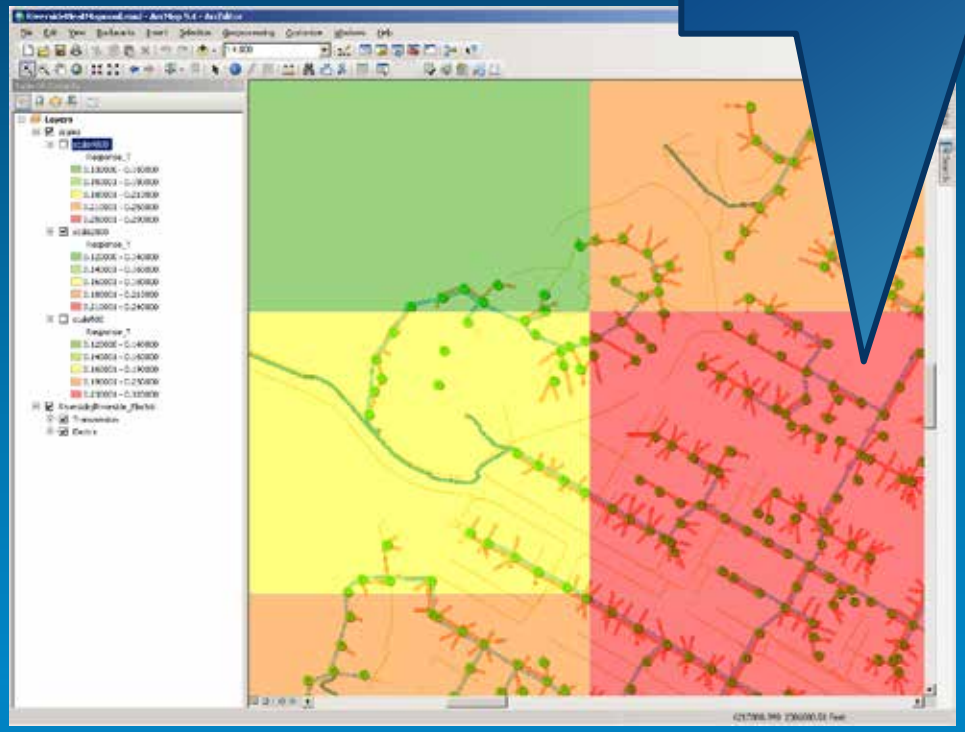
Testing Tools

Test Tools	Open Source	Pros	Cons
LoadRunner	No	•Industry Leader •Automatic negative correlations identified with service-level agreements •HTTP web testing •Click and script •Very good tools for testing SOA •Test results stored in database •Thick client testing •Can be used for bottleneck analysis	•High cost •Test development in C programming language •Test metrics difficult to manage and correlate •Poor user community with few available examples
Silk Performer	No	•Good solution for testing Citrix •Wizard-driven interface guides the user •Can be used for bottleneck analysis	•Moderate to high cost •Test metrics are poor. •Test development uses proprietary language. •Test metrics difficult to manage and correlate •Poor user community with few available examples
Visual Studio Test Team	No	•Low to moderate cost •Excellent test metric reporting •Test scripting in C# or VB .NET •Unit and web testing available •Blog support with good examples •Very good for bottleneck analysis	•No built-in support for AMF •No thick-client options •Moderate user community
JMeter	Yes	•Free •Tool	•Provides only response times •Poor user community with few available examples

Testing

Test Data – heat map

Observe correlation between feature density and performance.



Testing

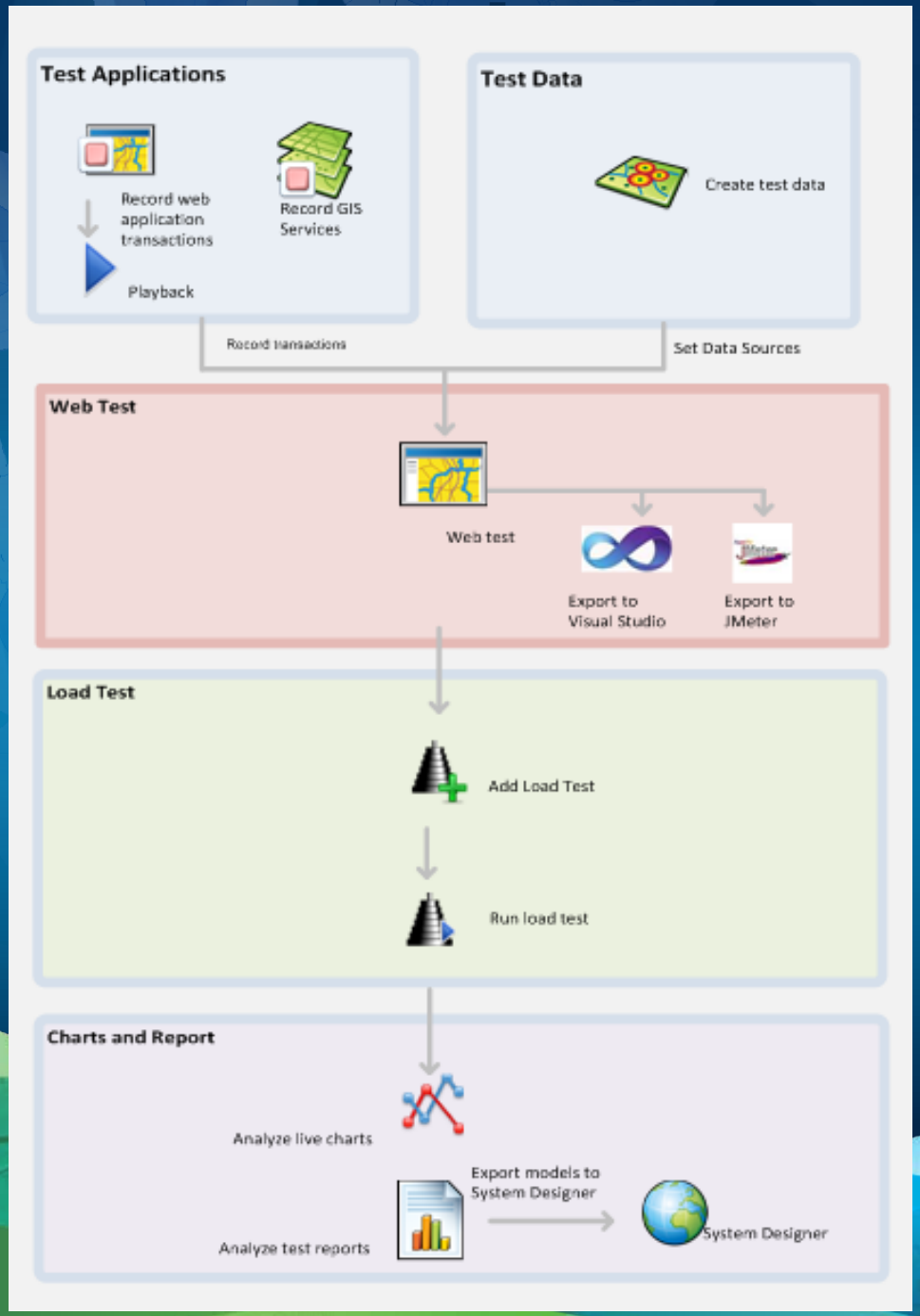
Load Test

- Create load test.
  - Define user load.
    - Max users
    - Step interval and duration
  - Create machine counters to gather raw data for analysis.
- Execute.

Testing

Execute

- Ensure
  - Virus scan is off
  - Only target applications are running
  - Application data is in the same state for every test
  - Good configuration management is critical to getting consistent load test results

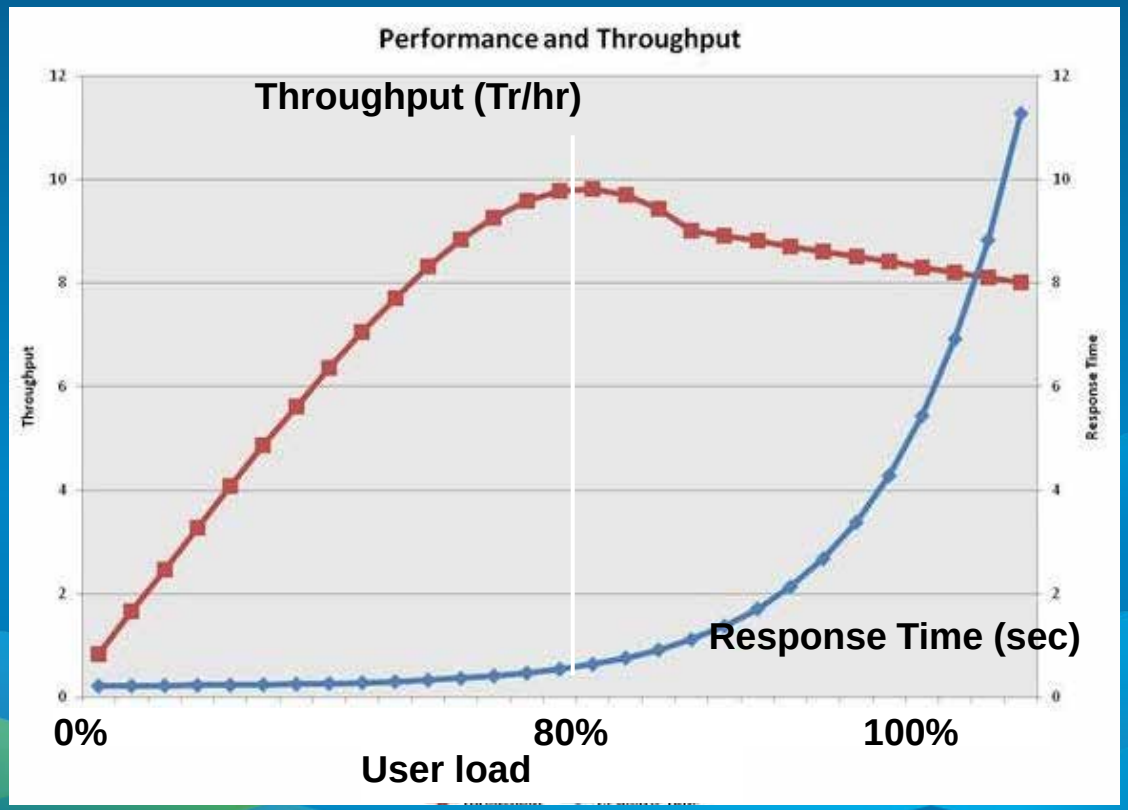


Demo: System Test

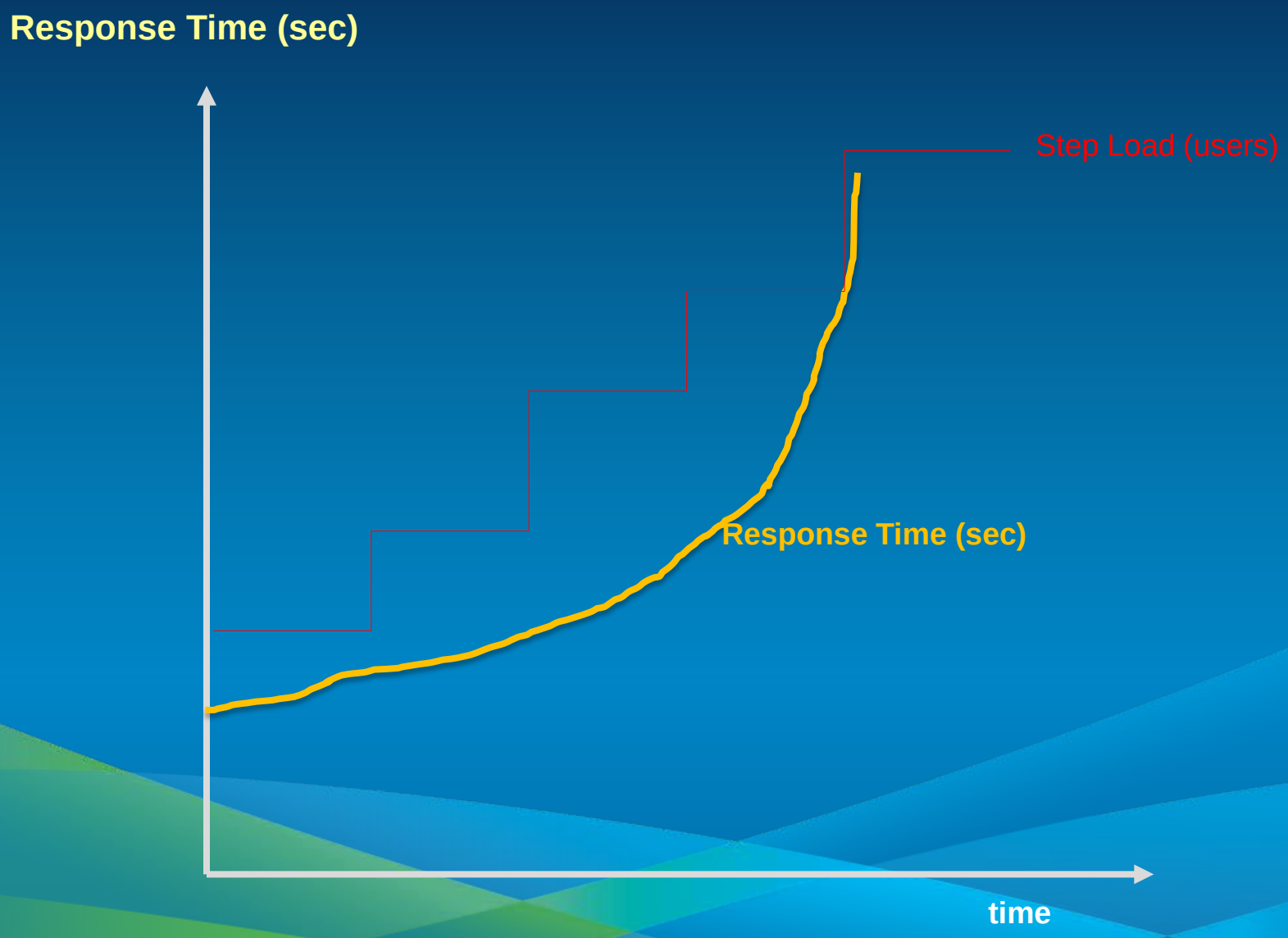
Performance and Scalability

Definitions

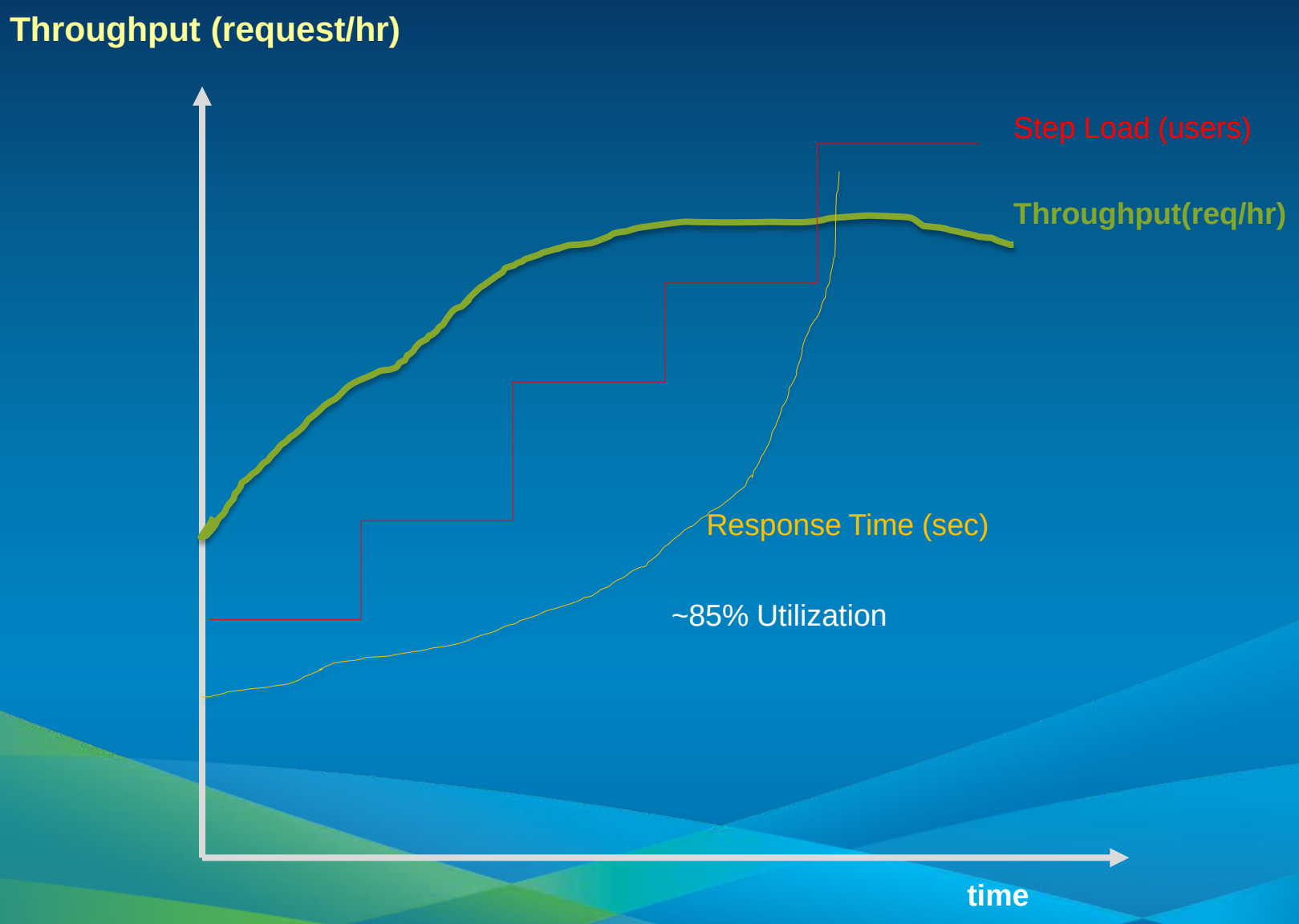
- Performance: The speed at which a given operation occurs
- Scalability: The ability to maintain performance as load increases



Load Test

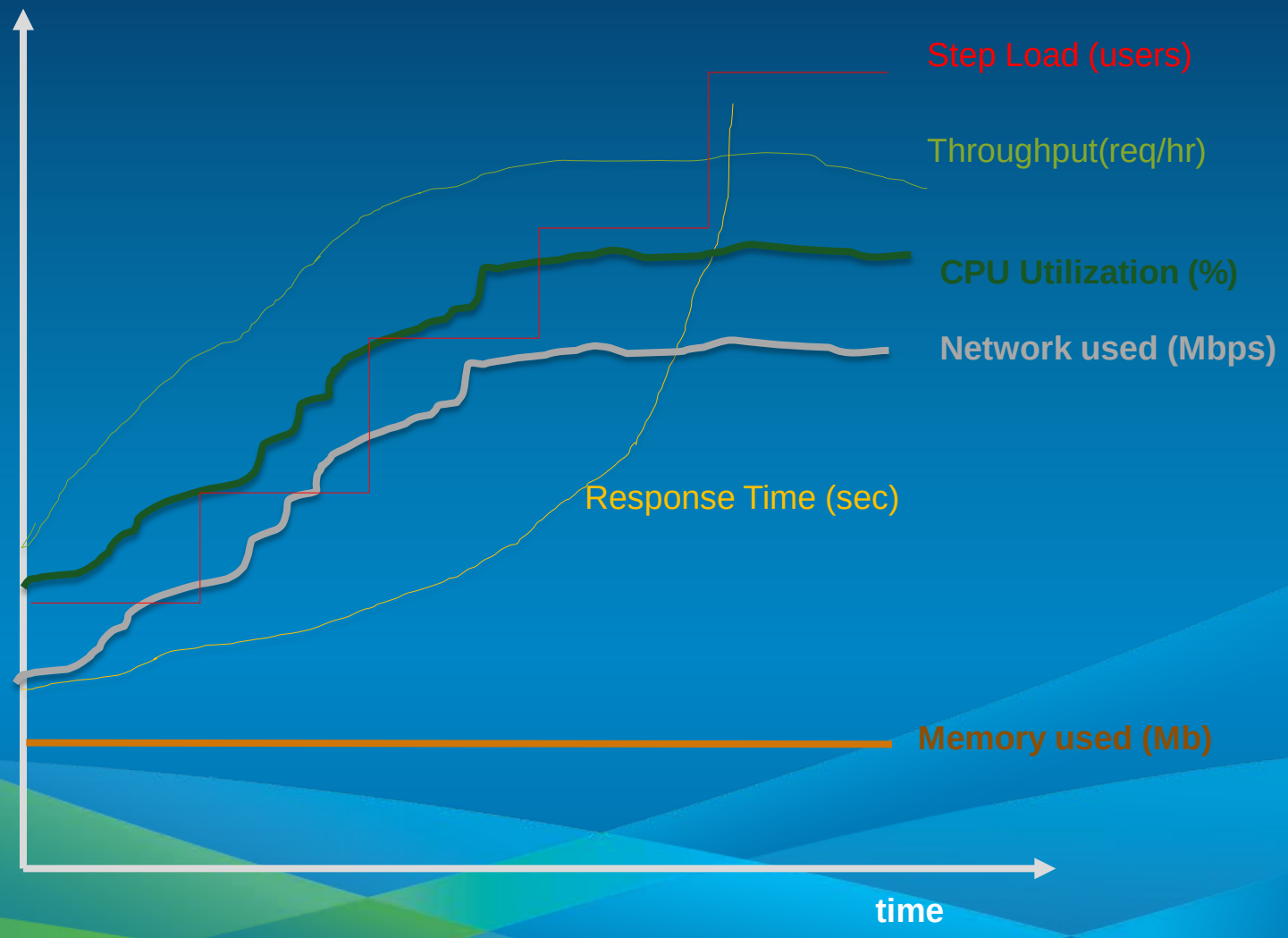


Load Test


Throughput (request/hr)
Step Load (users)
Throughput(req/hr)
Response Time (sec)
~85% Utilization
time

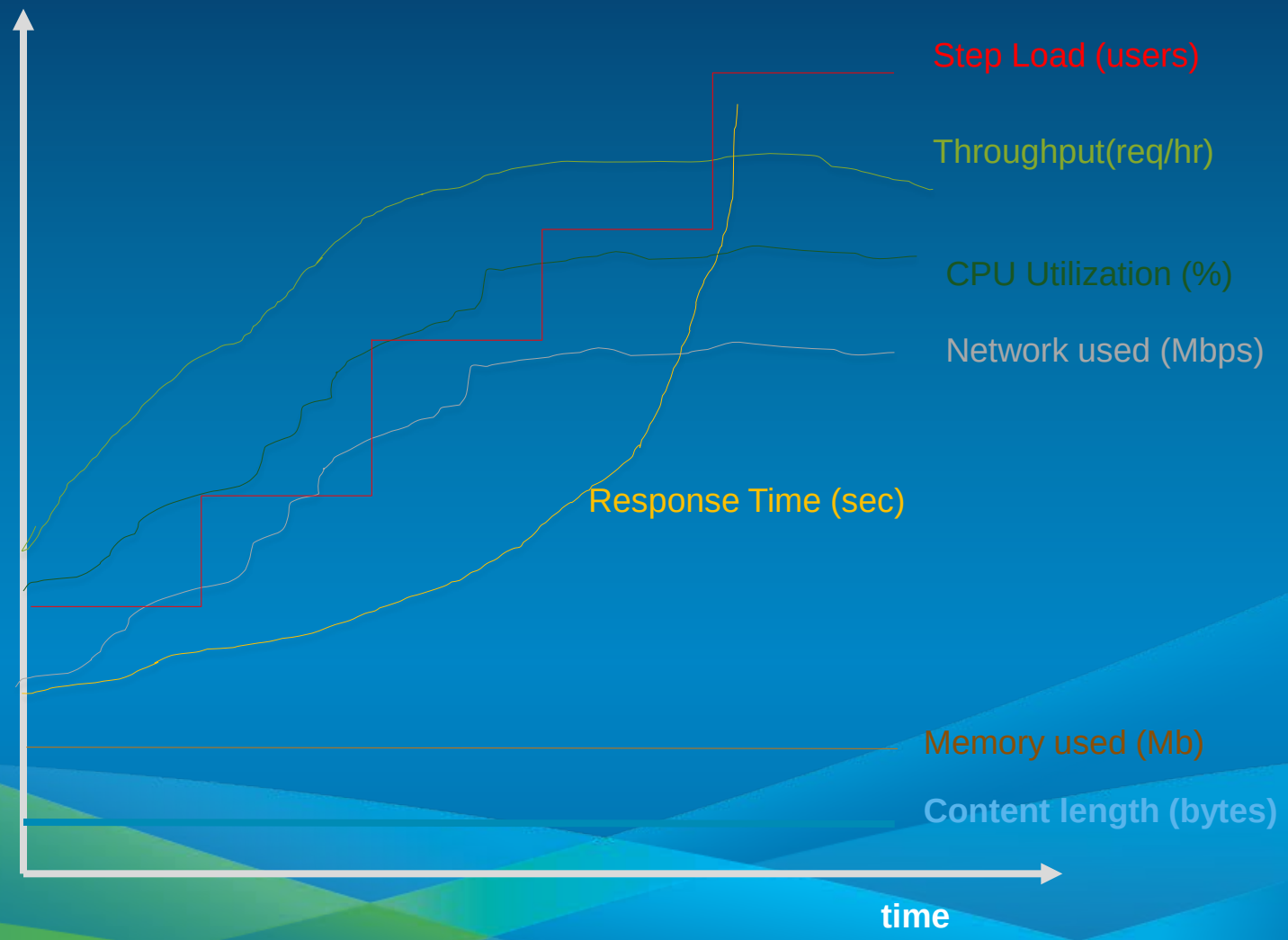
Load Test

Resource utilization: CPU, Memory, Network



Load Test

Validation: stats correlation, steady content length, failed requests=0

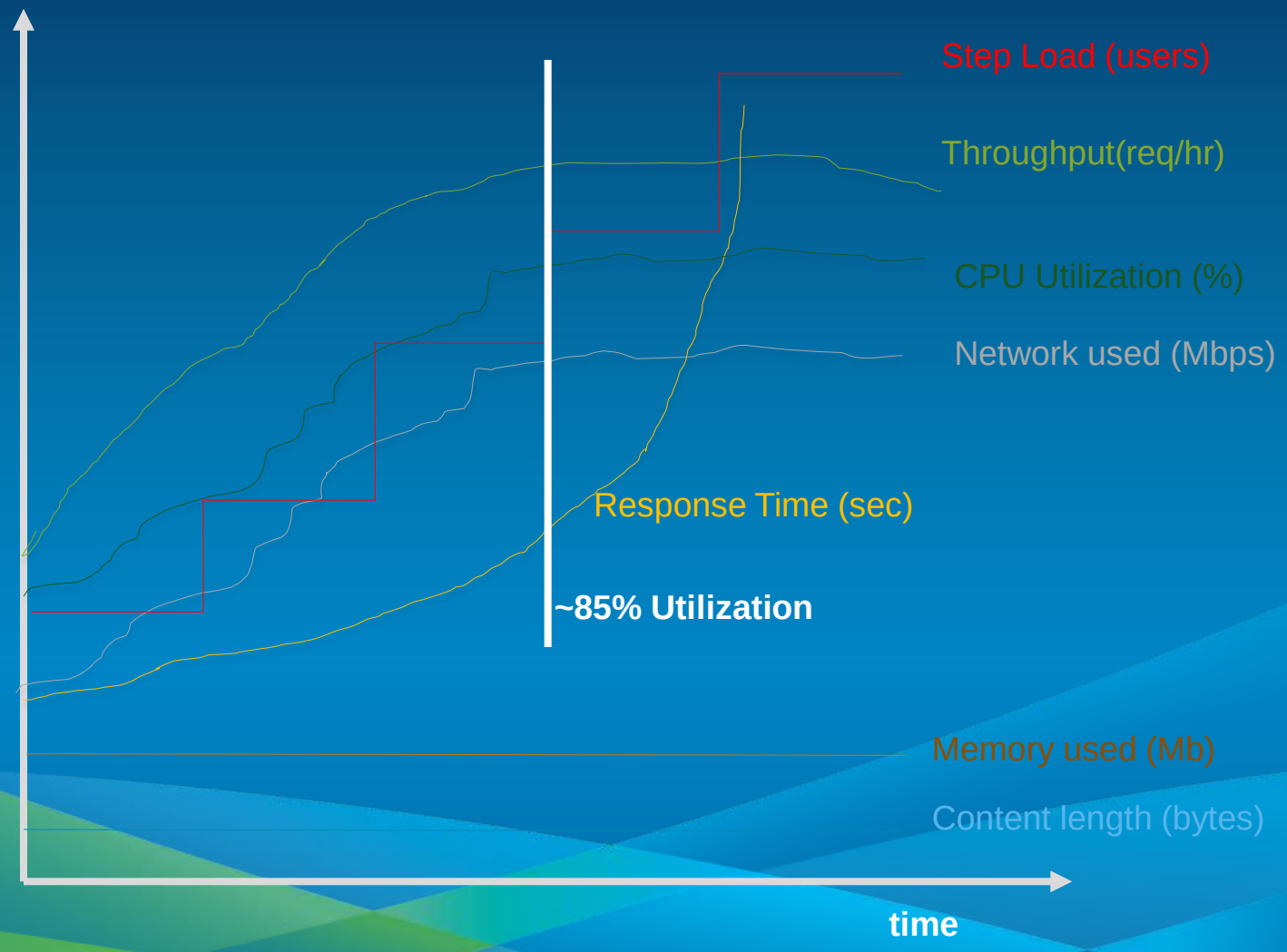


Testing

- Analysis—Compare and correlate key measurements
  - Most counters and utilization should be <u>increasing</u> with increased load:
    - Throughput
    - Response time
    - Metrics
      - CPU
      - Network
      - Disk
      - Memory
    - Errors

Load Test

System capacity



Load Test

System capacity

- System capacity can be defined as a user load corresponding to
  - Maximum throughput
  - Threshold utilization (e.g., 80)
  - SLA response time

Testing

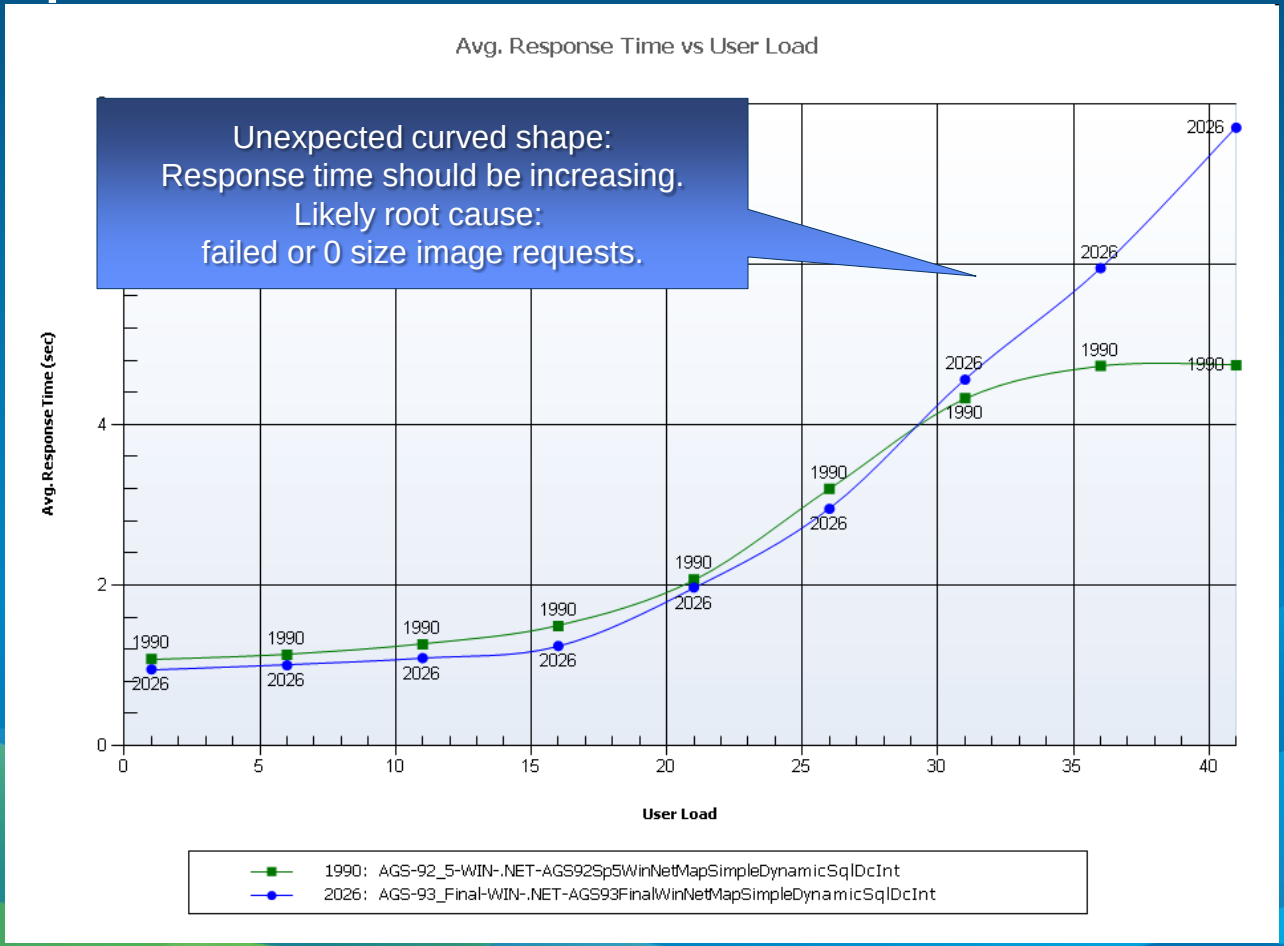
Analysis—Valid range

- Exclude failure range (e.g., failure rate > 5%) from the analysis.
- Exclude excessive resource utilization range.

Testing

Analysis—Compare and correlate key measurements

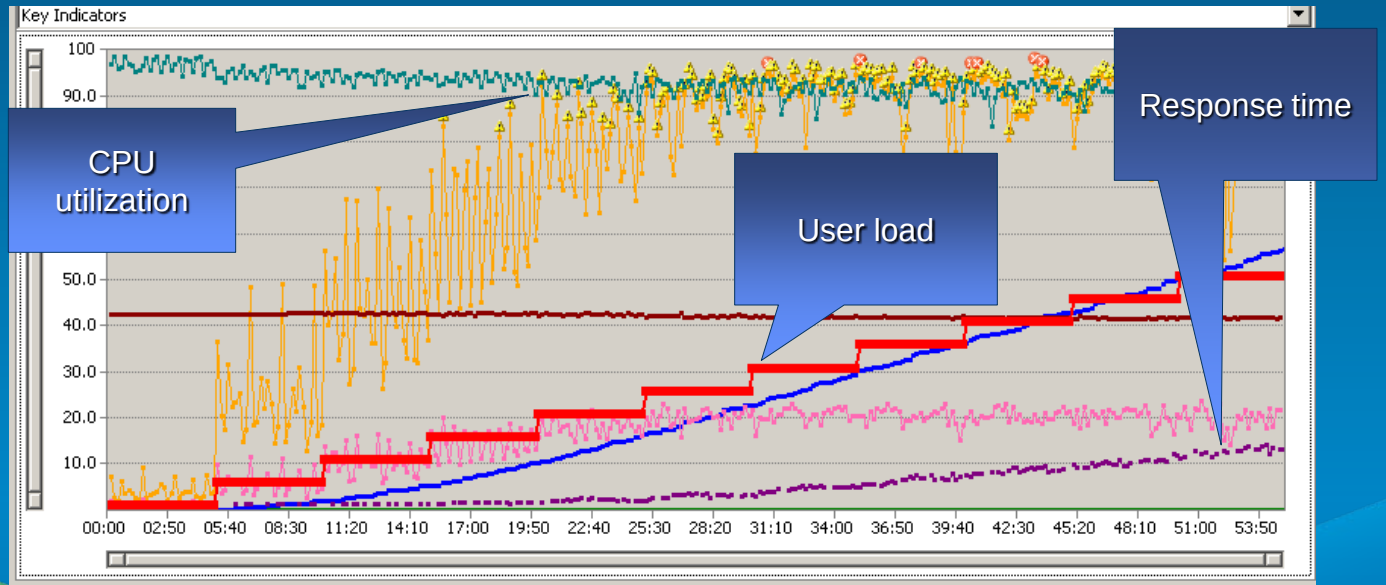
- **Unexpected curve**



Development Phase—Testing

Analysis—Compare and correlate key measurements

- **Expected counters correlation: increasing user load, CPU utilization, response time**

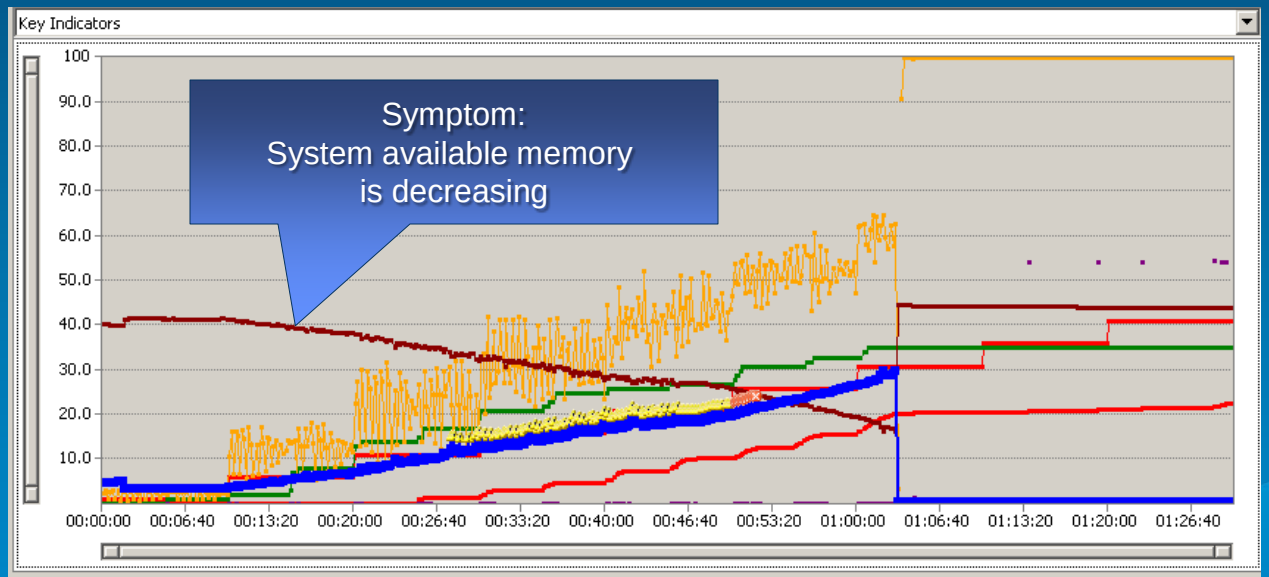


Counter	Instance	Category	Computer	Color	Range	Min	Max	Avg
User Load	_Total	LoadTest:Scenar	ESLWS9		100	1	51	26
Failed Tests	_Total	LoadTest:Test	ESLWS9		0	0	0	0
Passed Tests	_Total	LoadTest:Test	ESLWS9		1,000	0	568	223
Avg. Response Time	_Total	LoadTest:Transa	ESLWS9		100	1.27	14.2	6.13
% Processor Time	_Total	Processor	ESLSRV9		100	2.27	96.2	68.4
% Idle Time	_Total	PhysicalDisk	ESLSRV9		100	82.6	98.9	93.0
Bytes Received/sec	Broadcom BCM57	Network Interfac	ESLSRV9		1,000,000	6,632	238,324	158,332
Available MBytes	-	Memory	ESLSRV9		10,000	4,172	4,320	4,242

Testing

Analysis—Compare and correlate key measurements

- **Memory leak example**



Counter	Instance	Category	Computer	Color	Range	Min	Max	Avg
☑ User Load	_Total	LoadTest:Scenar	ESLIBMBL4		100	1	41	21
☑ Failed Tests	_Total	LoadTest:Test	ESLIBMBL4		1,000	0	226	99
☑ Passed Tests	_Total	LoadTest:Test	ESLIBMBL4		100	0	35	23
☑ Avg. Response Time	_Total	LoadTest:Transa	ESLIBMBL4		1,000	0.31	546	1.84
☑ % Processor Time	_Total	Processor	ESLSRV15		100	0.94	100	49.6
☑ Available MBytes	-	Memory	ESLSRV15		10,000	1,629	4,485	3,575
☐ Avg. Content Length	ESRI-ArcGIS-ADI	LoadTest:Reque:	ESLIBMBL4		1,000,000	5,442	105,690	98,554
☑ Private Bytes	w3wp	Process	ESLSRV15		10,000,000...	46,809,088	3,000,823,808	951,365,184

Root cause:
Web Server process

Test Results as Input into Capacity Planning

Load Test Results—Riverside Electric

- Baseline Test with Single Thread
  - Note* Service Time Is Load Independent
- Think Time=0
- Evaluate Key Metrics
  - Throughput
  - Response Time
  - QA Check
- Evaluate System Under Test.
  - CPU, Network, Memory, and Disk

Test Results as Input into Capacity Planning

Load Test Results—Key Indicators

RiversideElectricRandomData [12:34 PM] | RiversideElectricRandomData.loadtest | Riverside_Multi_Service.webtest | RiversideElectric.webtest

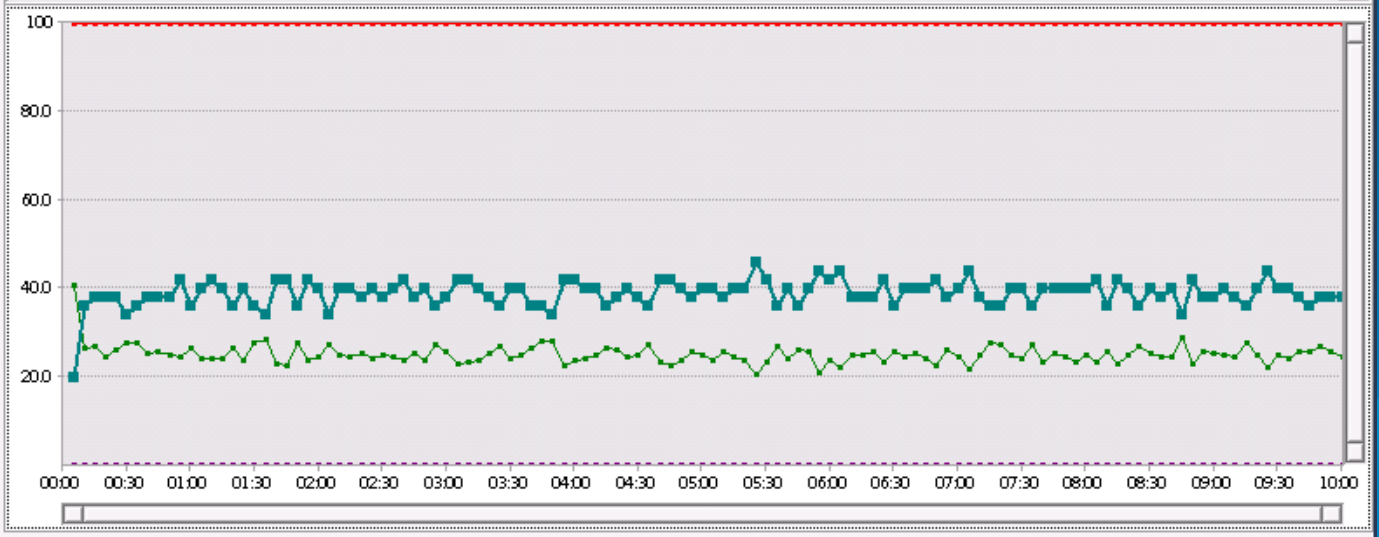
Summary | Graphs | Tables | Detail

Test Completed 2 threshold violations

Counters

- Overall
  - Page
  - Request
    - Avg. Connection Wait Time
    - Avg. Content Length
    - Avg. First Byte Time
    - Avg. Response Time
    - Cached Requests
    - Failed Requests
    - Failed Requests/Sec
    - Passed Requests
    - Passed Requests/Sec
    - Requests/Sec
    - Total Requests
  - Scenario
  - Test
  - Transaction
- Scenario1
- Computers
- Errors

Key Indicators



Counter	Instance	Category	Computer	Color	Range	Min	Max	Avg
User Load	_Total	LoadTest:S...	FPIZZI7		1	1	1	1
Errors/Sec	_Total	LoadTest:E...	FPIZZI7		0	0	0	0
Requests/Sec	_Total	LoadTest:R...	FPIZZI7		10	2.00	4.60	3.89
Avg. Response Time	_Total	LoadTest:R...	FPIZZI7		1	0.21	0.41	0.25

Test Results as Input into Capacity Planning

Load Test Results—System Metrics

Test Results as Input into Capacity Planning

Load Test Results – Input into capacity models

- Throughput = 3.89 request/sec ~ 14,004 request/hour
- CPU Utilization=20.8%
- Mb/request = 1.25 Mb

Test Results as Input into Capacity Planning

Load Test Results – Input into CPU capacity model

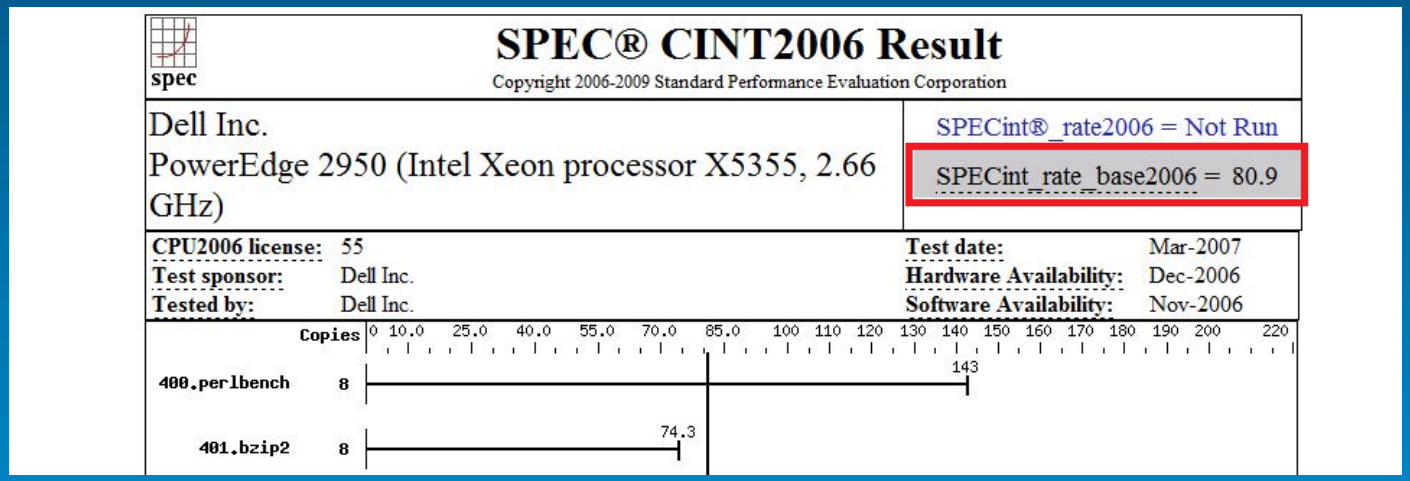
- Input from testing
  - #CPUs = 4 cores
  - %CPU = 20.8
  - TH = 14,004 requests/hour
  - SPEC per Core of machine tested = 35
- ST = (4*3600*20.8)/(14,004 *100) = 0.2138 sec
  - Note: Very close to Average response time of 0.25

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

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 = 0.2138 sec
  - TH = Throughput desired = 30,000 requests/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 requests/hour**

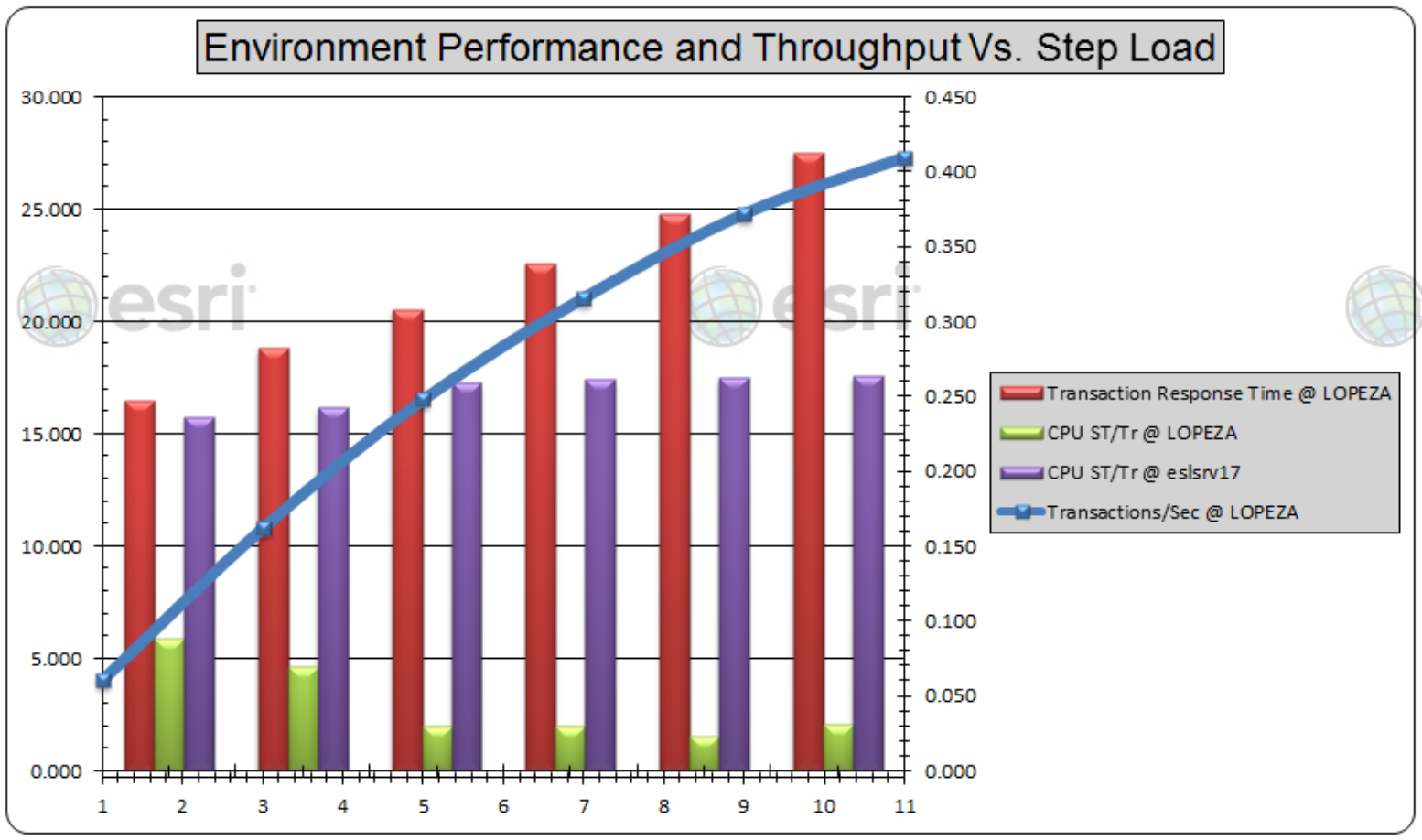
$$Mbps = \frac{TH' \; Mbits/req}{3600}$$

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

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

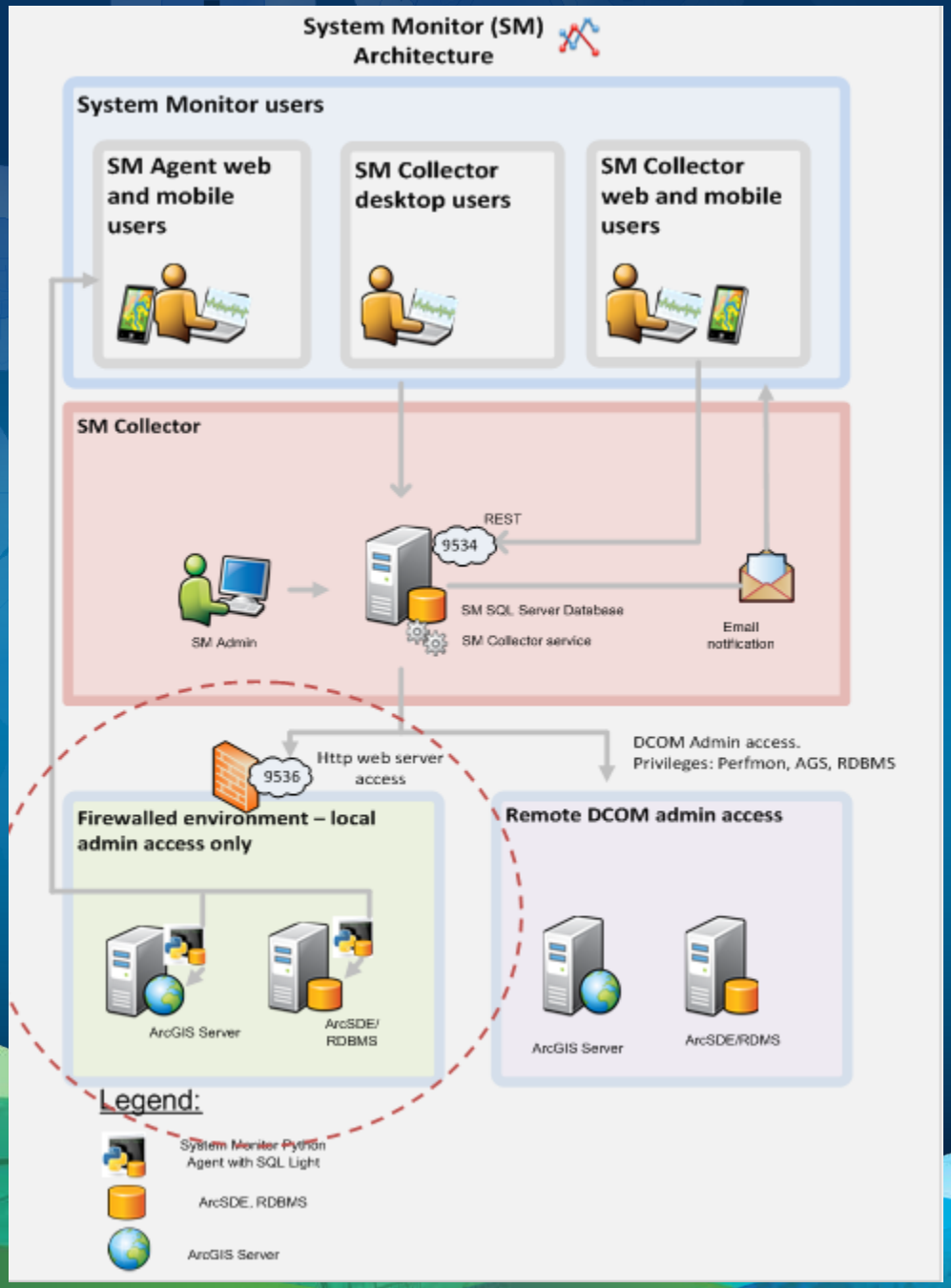
Test Results as Input into Capacity Planning

System Test Report



Monitoring Enterprise GIS

- Hardware (perfmon)
  - CPU, Memory, Network, Disk
  - Uptime
- GIS Services (ArcGIS for Server Stats, IIS logs)
  - Response Time
  - Throughput
  - Uptime
- Geodatabase (ArcPy)
  - Number of connections
  - Feature class count
- DBMS (system views)



Demo: System Monitor

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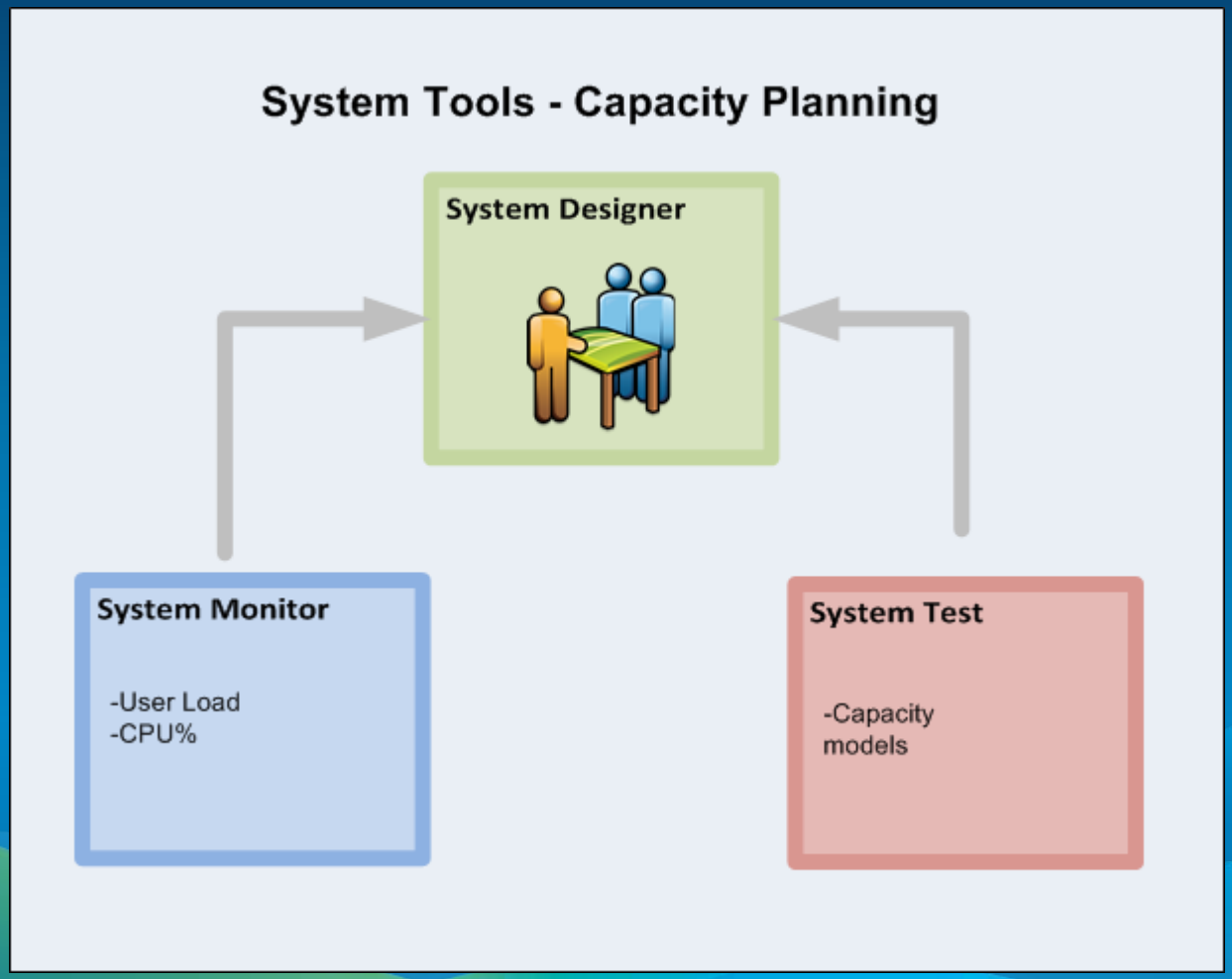
Performance Engineering throughout Project

- Tools



Download Tools

- Open Windows Explorer (not browser).
- In the Address Bar enter **ftp://ftp.esri.com/**.
- Right-click and select Login As (or click Alt F and select Login As from the File).
- Enter your user name and password:
- User name: **eist**
- Password: **eXwJkh9N**
- Click Log On.
- Follow **Installation Guide**.
- **Report bugs and provide feedback:**
  - **SystemDesigner@esri.com**

- Thank you for attending
- Open for Questions

Frank Pizzi, fpizzi@esri.com
Andrew Sakowicz, asakowicz@esri.com

- Please fill out the evaluation:

www.esri.com/ucsessionsurveys

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