

ArcGIS Enterprise Systems: Performance and Scalability

Amr Wahba awahba@esri.com

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Introductions

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

Agenda

- Definitions
- Process
- Requirements
- Performance Factors Software
- Performance Factors Hardware
- Capacity Planning
- Performance Tuning
- Performance Testing
- Using test results as input to Capacity planning

Performance

- The speed at which a given operation occurs
- E.g. Request response time measured in seconds



Scalability

- The ability to increase output and maintain acceptable performance
- Examples
 - Capacity 10 maps/sec and response time 1 second
 - Capacity 1000 cars/hrs and speed 55 mph



Capacity

• The maximum level of output the system can produce





Bottleneck

• Resource(s) limiting the performance or capacity





Low load

Think of : lanes - as CPU processor toll booths – as ArcGIS Server instances cars - as map requests

Step Load and Response Time



Throughput (request/hr)



Resource utilization: CPU, Memory, Network



ArcGIS Enterprise Systems:

Capacity



ArcGIS Enterprise Systems:



Esri Process and Tools

Holistic approach



Capacity Planning

Tools



Tools

- http://www.arcgis.com
- owner:EnterpriseImp
- Show ArcGIS Desktop Content

ArcGIS FEATURES PLA	INS GALLERY MAP HELP	SIGN IN owner:EnterpriseImp Q
Search Results	5	
Show	10 results	
All Results Maps Layers Apps Tools Files Show ArcGIS Des Content	System Designer Open ▼ Details sktop	Relevance Title Owner Rating Views Date System Designer A comprehensive tool for planning & designing complete enterprise GIS solutions, including hardware, software, deployment strategy, and capacity forecast. Image: Desktop Application Template by EnterpriseImp Last Modified: July 5, 2013 ★★★★☆☆ (2 ratings, 3 comments, 1,186 downloads)

Tools

- System Designer
- http://www.arcgis.com/home/item.html?id=8ff490eef2794f428bde25b561226bda.
- <u>http://www.arcgis.com/home/item.html?id=8e655b38f2fc4b778d07dd34f436a978</u> (MS 2013)
- System Test (Beta)
- http://www.arcgis.com/home/item.html?id=e8bac3559fd64352b799b6adf5721d81
- System Monitor (Beta)
- http://www.arcgis.com/home/item.html?id=848f48b0f88e4de7a036377197453efe
- System CPU
- http://www.arcgis.com/home/item.html?id=3e473b63a3254a6ab5f22e6f9608b209
- Network Test
- http://www.arcgis.com/home/item.html?id=2b8d4ac8b102453bb0437cdd7a07dd27
- Mxdperfstat
- http://www.arcgis.com/home/item.html?id=a269d03aa1c840638680e2902dadecac
- Database Trace Tools
- http://www.arcgis.com/home/item.html?id=24c7b251159149848acc9b81cccb8356
- ASlog
- http://www.arcgis.com/home/item.html?id=5dfe54f1e9fd48068c4ae0c2c4f459c9

Requirements Phase

Performance engineering addresses quality attributes.

Functional Requirements



- Visualization
- Analysis
- Workflow Integration

Quality Attribute Requirements



Availability
Performance & Scalability
Security

Requirements Phase

- Define System Functions
 - What are the functions that must be provided?
- Define System Attributes
 - Nonfunctional requirements should be explicitly defined.
- Risk Analysis
 - An assessment of requirements
 - Intervention step designed to prevent project failure
- Analyze/Profile Similar Systems
 - Design patterns
 - Performance ranges

Design Phase- Software

Application Types

sometimes connected scenarios.



sometimes connected scenarios.

<u>http://resources.arcgis.com/en/communities/enterprise-gis/01n20000023000000.htm</u>

Rich Client Applications Web Applications Services Mobile Image: Service in connected, and Image: Service in connected scenarios Image: Service in connected, and I

applications and systems.

and optionally leverage browser

plug-ins.

Design Phase - Software

GIS Services—Map Service

Source document (MXD) optimizations

- Keeping map symbols simple
 - Setting scale dependency
 - Avoiding multilayer, calculation-dependent symbols
 - Spatial index
 - Avoiding reprojections on the fly
 - Optimizing map text and labels for performance
 - Using annotations
 - Cost for Maplex and antialiasing
 - Using fast joins (no cross database joins)
 - Avoiding wavelet compression-based raster types (MrSid, JPEG 2000)

Design Phase - Software

Geodatabase

- Keep delta tables and versioning tree small
 - Reconcile and post
 - Compress
 - Synchronize replicas
- Rebuild indexes
- Update statistics

Hardware Resources

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



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

CPU Processor Speed – Specrate.org

Dell Inc.	SPECint®_rate200	6 = Not Run
PowerEdge 2950 (Intel Xeon processor X5355, 2.66 GHz)	SPECint_rate_base	2006 = 80.9
CPU2006 license: 55 Test sponsor: Dell Inc. Tested by: Dell Inc.	Test date: Hardware Availability: Software Availability:	Mar-2007 Dec-2006 Nov-2006
Copies 0 10.0 25.0 40.0 55.0 70.0 85.0 100 110 120 400.perlbench 8	130 140 150 160 170 180 143	190 200 22

http://www.cpubenchmark.net/cpu_list.php

Design Phase - Performance Factors

Hardware Resources—Memory

ltem	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%

Wide ranges of memory consumptions

Virtualization

 Performance depends on configuration and implementation

- 5-30%

Overburdened VMs will incur significant performance degradation

Network

1. Distance

2. Payload



3. Infrastructure



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 T	raffic Trans	sport 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	Мар	Vector		10	178.571	6.494	1.000	0.222	0.100	0.010
Citrix/ArcGIS	Мар	Vectror+Image	ICA Comp	1	17.857	0.649	0.100	0.022	0.010	0.001
Citrix/ArcGIS	Мар	Vector	ICA Comp	0.3	5.357	0.195	0.030	0.007	0.003	0.000
ArcGIS Server	Мар	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

All built into System Designer

Network Testing

Important for cloud based solutions



Cloud vendors offer multiple location. Which one is the best for your global solution?

Demo

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Network Speed Test Tool:

Design Phase—Capacity Planning

Uncertainty of input information



Design Phase—Capacity Planning

- Uncertainty of input information—Planning hour
 - Identify the Peak Planning Hour (most cases)



Design Phase—Capacity Planning

- CPU Factors
 - 1. User load: Concurrent users or throughput
 - 2. Operation CPU service time (model)—performance
 - 3. CPU SpecRate

$$\# CPU_{t} = \frac{ST_{b} \times TH_{t} \times 100}{3600 \times \% CPU_{t}} \times \frac{SpecRatePerCPU_{b}}{SpecRatePerCPU_{t}}$$

subscript t = target subscript b = benchmark ST = CPU service time TH = throughput %CPU = percent CPU

Demo System Designer

Development phase Tuning: A reproducible test cases

Tuning methodology

Profile each tier starting from the top



Fiddler

Fiddler measurement approximately 5.2 seconds

1 1	Fiddler Web	Debugger				
File	Edit Rule	es Tools	View He	elp GET /b	ak di se	
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					Web Sessions	<<
#	Result	Protocol	Host	URL		
	200	HITP	localhost	/arcos/rest/	rvices/TestCaseOrade/MapServer/export/dpi=96&transparent=true&format=png8&bbox==	183-1505499645257*

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193.10024330427231		15	25	3s	45	Ss	6s	7s
	export							

Server Logs

Analyze ArcGIS for Server
 Statistics & logs

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.CO	M
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	АТОМ

<

<

<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>

ArcMap Publish Tool



38

Mxdperfstat

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
1	167,935,665	SDE.GridPoint	4.75	run DBMS trace: oraCPU=4.74; run DBMS trace, check oracle execution plan: oraL1O=130936; check if index exist for query def attributes;	1,998		False	4.74	.00	4.56	4.74	130,936

DBMS LIO	DBMS PIO	Source	LayerType	Layer Spatial Reference	LayerQueryDef
130,936		esriDBMS_Oracle,asakowicz,sde:oracle\$asakowicz:1521/gis2,sde	esriGeometryPoint	GCS_WGS_1984	ID<1000

DBMS Trace



http://www.arcgis.com/home/item.html?id=24c7b251159149848acc9b81cccb8356

Oracle Trace

SQL ID : 71py6481sj3xu

SELECT 1 SHAPE, TAXLOTS.OBJECTID, TAXLOTS.SHAPE.points,TAXLOTS.SHAPE.numpts, TAXLOTS.SHAPE.entity,TAXLOTS.SHAPE.minx,TAXLOTS.SHAPE.miny,

TAXLOTS.SHAPE.maxx,TAXLOTS.SHAPE.maxy,TAXLOTS.rowid

FROM SDE.TAXLOTS TAXLOTS WHERE SDE.ST_EnvIntersects(TAXLOTS.SHAPE,:1,:2,:3,:4) = 1

call	count	cpu	elapsed	disk	query	current	rows
Parse	0	0.00	0.00	0	0	0	0
Execute	1	0.07	0.59	115	1734	0	0
Fetch	242	0.78	12.42	2291	26820	0	24175
total	243	0.85	13.02	2406	28554	0	24175

Elapsed times include waiting on following events:

Event waited on	Times	Max. Wait	Total Waited
	Waited		
SQL*Net message to client	242	0.00	0.00
db file sequential read	2291	0.39	11.69
SQL*Net more data to client	355	0.00	0.02
SQL*Net message from client	242	0.03	0.54
*****	· • • • • • • • • • • • • • • • • • • •		* * * * * * * * * * * * * * * *

SQL Profiler

hrcSDE_trace (ANDREWS2)

	EventClass	Login	Application	TextData	CPU	Duration	RowCounts	Reads
	Trace Start							
	Showplan XML Statistics P	sde	SDE:5932	<showplanoml http:="" schemas<="" td="" xmlns="http://schemas</td><td></td><td></td><td></td><td></td></tr><tr><td></td><td>SP:StmtCompleted</td><td>sde</td><td>SDE:5932</td><td>SELECT state_id,owner,creation_time</td><td>10</td><td>0</td><td>1</td><td>2</td></tr><tr><td></td><td>Showplan XML Statistics P</td><td>sde</td><td>SDE:5932</td><td><ShowPlanxML xmlns="><td></td><td></td><td></td><td></td></showplanoml>				
	SP:StmtCompleted	sde	SDE:5932	SELECT lineage_name, time_last_modi	0	0	1	2
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	ത്	Index Scan Scan a nondustered index, entirely range.	r or only a
	(SOE]. (SOE]. (#2). (#2,pk] (SHAPE]	Physical Operation	Index Scan
	COSCI 3 K	Logical Operation	Index Scan
		Actual Number of Rows	51629
		Estimated I/O Cost	1.11424
		Estimated CPU Cost	0.183394
		Estimated Operator Cost	1.29763 (63%)
		Estimated Subtree Cost	1.29763
		Estimated Number of Rows	21.77
		Estimated Row Size	59 B
		Actual Rebinds	0
		Actual Rewinds	0
		Ordered	False
		Node ID	3

Performance Testing

Testing Objectives

- Meet Service-Level Agreement (SLA)
- Bottlenecks analysis
- Capacity planning
- Benchmarking different alternatives

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

• Test Data



QueryString

	Name	Value
×	F	mage
	dpi	96
	transparent	true
	format	png8
	bbox	{"xmin":6219593.737018972,"ymin":2303862.765275147,"xmax":6231478.566248391,"ymax":2311468.277924415,"spatiaReference": {"wkid":2230}}
	bboxSR	2230
	imageSR	2230
	size	1222,782

Selected Extent From HTTP Debugging Proxy

Attribute Data

S ArcToobox	1
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Conversion Tools	
🕀 🌍 Data Interoperability Tools	
B ata Management Tools	
🗄 🍓 Editing Tools	
🖲 🌍 Geocoding Tools	
🖲 🏐 Geostatistical Analyst Tools	
Inear Referencing Tools	
Multidimension Tools	
Retwork Analyst Tools	
Parcel Fabric Tools	
- 🎯 Samples	
Schematics Tools	
🖲 🌍 Server Tools	
Spatial Analyst Tools	
😑 🚳 Spatial Statistics Tools	
Analyzing Patterns	
Happing Clusters	
Measuring Geographic Distributions	
Hodeling Spatial Relationships	
E-S Rendering	
🖻 🗞 Utilities	
S Calculate Areas	
— S Calculate Distance Band from Neighbor Count	4
-S Collect Events	
— S Convert Spatial Weights Matrix to Table	
Sport Feature Attribute to ASCII	



- Test Scripts
 - Record user workflow based on application user requirements.
 - Create single user web test.
 - Define transactions.
 - Set think time and pacing based on application user requirements.
 - Parameterize transaction inputs.
 - Verify test script with single user.

Development Phase—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.

- Analysis—Compare and correlate key measurements
 - Expected counters correlation: increasing user load, CPU utilization, response time



Analysis—Compare and correlate key measurements

• Memory leak example



Root cause: Web Server process

Demo System Test – Enterprise GIS testing tool

Capacity planning: using test results

- 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

• Load Test Results - Key Indicators

Summary Graphs Tables Detail Contexts Summary Graphs Tables Detail Image: Context Completed Vehiculations Counters Image: Context ContextC	RiversideElectricRandomData [12:34 PM] >	RiversideElectricRandomDa	ta.loadtest	Riverside_Multi_Servic	e.webtest Riv	versideElectric.webtest			-
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Counters Key Indicators Image: Counters Image: Counters Image: Counters Image: Counters <t< td=""><td>Test Completed <u>2 threshold violation</u></td><td><u>ns</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	Test Completed <u>2 threshold violation</u>	<u>ns</u>							
 Overall Page Request Avg. Connection Wait Time Avg. Context Length Avg. Context Length Avg. Response Time Cached Requests Failed Requests Failed Requests/Sec Passed Requests/Sec Passed Requests/Sec Passed Requests/Sec Transaction Scenariol Scenariol	Counters	Key Indicators							•
	 Overall Page Request Avg. Connection Wait Time Avg. Content Length Avg. First Byte Time Avg. Response Time Avg. Requests Cached Requests Failed Requests Failed Requests Passed Requests/Sec Passed Requests/Sec Requests/Sec Requests/Sec Requests/Sec Requests/Sec Total Requests Scenario Test Transaction Scenario1 Computers Errors 	100 ecco e	C200 C230	Category Compute LoadTest:S FPIZZI7 LoadTest:R FPIZZI7 LoadTest:R FPIZZI7	20 0500 0530 er Color R 0 0500 1	Cosco osiso conco coniso Range Min 1 0 2.00 1 0.21	0800 0830 Max 1 0 4.60 0.41	Avg 1 0 3.89 0.25	

Load Test Results - System Metrics



- 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

1.10

- .25 seconds
- Average CPU Utilization
 - 20.8%
 - Mb/request = 1.25 Mb

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- 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

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

Target values

1. Server SpecRate/core=10.1



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

- System Designer
 - Input:

Model Review

Selected Model

Model Function

Client

WebService

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

Model Assigned

Service Type: Map Model Name: ExportMap

Tier

Client

Web Services

		100/01/01/02/01 10:00			
	Select Site.	Workflow Name			
	Class	 Web request 			
	Select a Workflow	Total Users:	Active Users	Wokfoe Fe	ing (sec)
	4 Web texpetit	0		18	
			put (Nokfoechd)	a (•
	+ Ant - Deate Workfor Operations	_		bi (see	S Doord
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	Web request	A111-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-			
		#75dast.(jarej)	Stated Delay (sec)		
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		4	1	(Configured)	
		Notes			
		10.00			
Man	Service 9.3.1				
anop	Contra Trade A	0	CD11 C C	1- 11- 17- I	10.7
affied	Service Time(sec)	Queue Time(sec)	CPU Cores Ca	aic Modified	Mb/Tr
		0.000	0	00 0	1 4-94
		0.000	N N		

System Designer

Input

- Hardware=80.9 Spec

Hardware Dialog						
Site:	Role:			Category:		
ls/Server	 WebServer 			Server	*	
Switch:	Vendor	Processor		Operating System:		
<:Switch0	* Dell Inc.	*	*	Windows Server 2008 R	2 64-bit 💌	
Select Hardware Item	[Cores] [SPEC/Core] Hardware:					
Desktop	[8] [10.11] PowerEdge 2950	0 (Intel Xeon processor X5355, 2.66	GHz)		*	
WebServer	Processor Name:	Processor Speed (MHz):		CPU Cores:		
	Intel Xeon X5355	2666.00		8		
	SPIC introde per Core:	SPEC im cate:		%Max Utilization:		
	10.11			80		
	RAM (UR)	Storage (G8):				
	0	0		1		
	Platform Virtualization			-		
		Vendor:		CPU Cores Allocated:		
	Virtual Environment		*		*	
	Notes					
+ Add - Delete	Configured			₩ Save	B Djscard	
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0						

- System Designer
 - Review results

Vodel P	leview Mode	Assigned								
Selecte Service	d Model e Type: Map	Model Name: Expo	ortMap REST MapS	Service 9.3.1						
Model	Function	Tier	Modified	Service Time(sec)	Queue Time(sec)	CPU Cores Calc	Modified	Mb/Tr	Mbps Calc	Transport(sec)
0	Client	Client	0		0.000	0.00	0	1.250	10.42	0.00
0	WebService	Web Services	S	0.210	0.045	7.57	0	1.250	10.42	0.04
					2			21	11	



Understanding our world.