2008 ESRI Developer Summit

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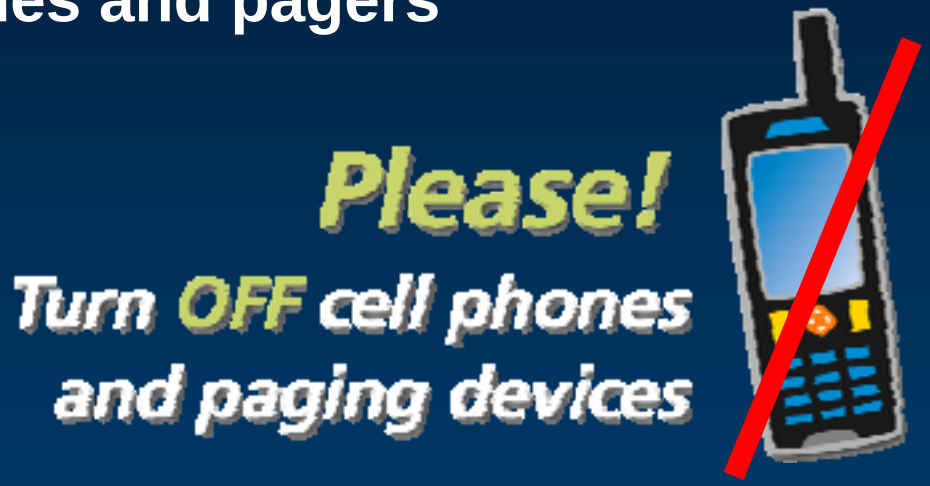
Architecting ArcGIS Server Solutions for Performance and Scalability

Dave Wrazien

Eric Miller

Schedule

- 75 minute session
  - 60 – 65 minute lecture
  - 10 – 15 minutes Q & A following the lecture
- Cell phones and pagers



- Please complete the session survey – we take your feedback very seriously!

Introductions

- Who are we?
  - Dave Wrazien – Solution Architect
  - Eric Miller - ArcGIS Server Framework Product Engineer
- Who are you?
  - New to ArcGIS Server?
  - Currently deploying ArcGIS Server 9.2?
  - Currently deploying ArcIMS?

Topical Outline

- Preparing GIS documents
- Publishing GIS services
- Creating and Configuring GIS applications
- Deployment Architectures

Preparing GIS Documents

General Overview

- Understand application requirements
- Design specifically for server deployment
  - Maps
    - Dynamic – *"operational" data*
    - Cache – *"basemap" data*
  - Geoprocessing Models
    - Preprocessing
    - Limit inputs
  - Mobile Applications
    - Devices
    - Environment
  - Geocoding
    - Locator locations

Preparing GIS Documents

Dynamic Map Services: General Information

- **Show relevant information**
  - **Start simple (additional layers can be toggled on by user)**
  - **Use field visibility (hide unnecessary attributes)**
- **Use scale dependencies**
  - **Use data appropriate for the given scale (generalize if necessary)**
  - **Display similar number of features at all scales for consistent user experience**

Preparing GIS Documents

Dynamic Map Services: Feature Rendering

- **Points**
  - **Use single layer Simple or Character markers for best performance**
  - **Use EMF instead of bitmaps**
  - **Use Integer (vs. character) fields for symbol values**
  - **Avoid halos, complex shapes, masking**
- **Line & Polygons**
  - **Use ESRI_Optimized style**
  - **Avoid cartographic lines (also includes polygon outline!)**

http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?id=305&pid=297&topicname=Creating_fill_symbols

Preparing GIS Documents

Dynamic Map Services: Text and Labeling

- **Use annotation instead of labels**
- **Use indexed fields (reduce label SQL query number and complexity when possible)**
- **Use label and feature conflict weights sparingly**
- **Avoid special effects (fill patterns, halos, callouts, backgrounds)**
- **Avoid very large text size (60+ pts)**
- **Avoid Maplex for dynamic labeling**
- **Avoid Highway symbols**
- **Avoid overuse**

Preparing GIS Documents

Geoprocessing Services

- **Understand Performance Expectations**
- **Simplify Models and data**
  - **Preprocess steps in advance.**
- **Use in-memory data**
- **Use fast-access data (uncompressed).**
- **Two instances cannot update the same data at the same time.**

Preparing GIS Documents
Mobile Services

- **Design for Purpose**
  - Understand workflow and tasks
  - Understand user skills & familiarity
  - Deliver only relevant content
- **Design for Environment**
  - Changes in lighting impact colors
  - Contrast (use gray scales)
  - Simplicity (avoid polygon fills)
- **Design for Form Factor**
  - Resolution (Smartphone = 320x240 & Tablet PC =1024x768+)
  - Storage (keep background data small)

Preparing GIS Documents
Geocoding Services

- **Single address geocoding**
  - **ArcSDE address locators for single address geocoding**
- **Batch address geocoding**
  - **File-based address locators for batch geocoding**
    - **Use local locator files instead of UNC**
- **All geocoding**
  - **Take locator defaults**

Topical Outline

- Preparing GIS documents
- Publishing GIS services
- Creating and Configuring GIS applications
- Deployment Architectures

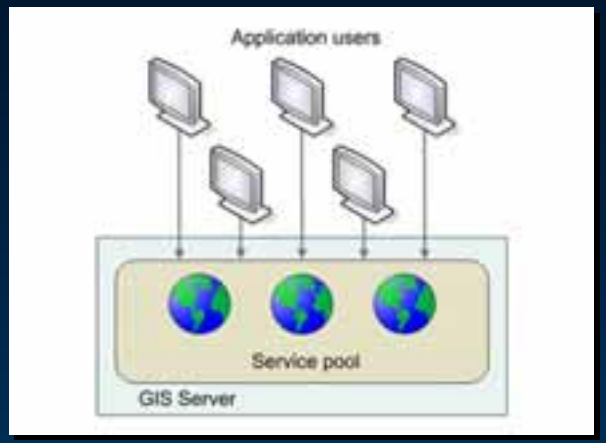
Publishing GIS Services

- Object Pooling and Instances
- Process Isolation
- Mapping
  - Caching
  - Output Image Types
- Mobile Caches
- Geoprocessing
- Geocoding

Publishing GIS Services

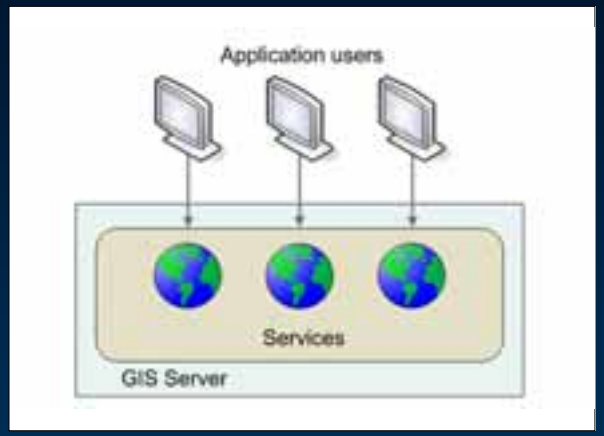
Object Pooling

Pooled Services



- State information (e.g., Current extent, layer visibility, etc.) maintained in web server / browser
- Scales better

Non-Pooled Services

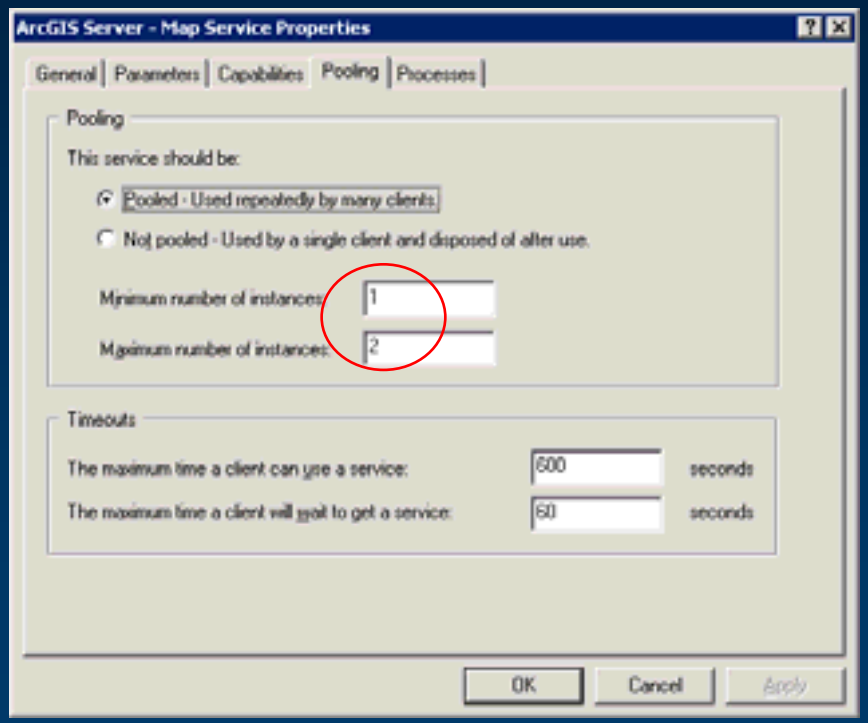


- Typically holds its reference to the service for the duration of the application's session
- Number of users on the system can have no more than a 1:1 correlation with the number of running service instances
- Required for Editing Task
- Computationally expensive – New instances are started for each session

Publishing GIS Services

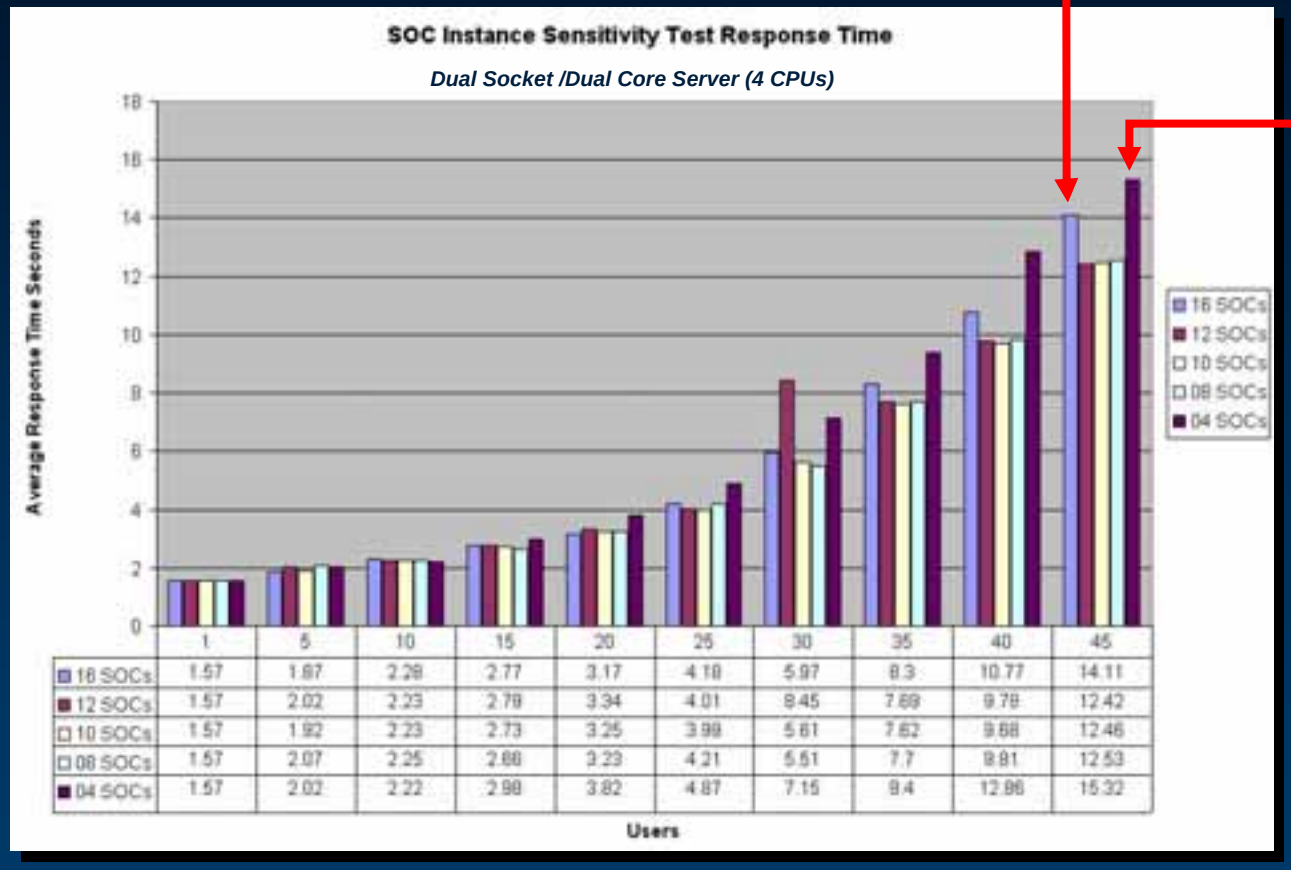
Object Pooling

- **Define Min-Max instances**
- **Instances are distributed across all host servers**



Publishing GIS Services

Object Instances



	1	5	10	15	20	25	30	35	40	45
16 SOCs	1.57	1.87	2.29	2.77	3.17	4.19	5.97	8.3	10.77	14.11
12 SOCs	1.57	2.02	2.23	2.79	3.34	4.01	8.45	7.69	9.79	12.42
10 SOCs	1.57	1.92	2.23	2.73	3.25	3.98	5.61	7.62	9.68	12.46
08 SOCs	1.57	2.07	2.25	2.66	3.23	4.21	5.51	7.7	9.81	12.53
04 SOCs	1.57	2.02	2.22	2.98	3.82	4.87	7.15	9.4	12.86	15.32

Too many instances creates CPU competition

Too few instances creates resource deficiency

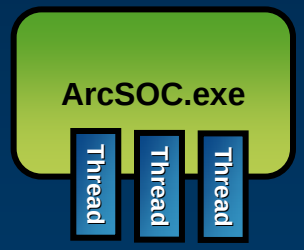
Recommendation: Limit the number of service instances to 2-4 instances per CPU (typical).

Publishing GIS Services

Process Isolation

- **High Isolation:** each service instance runs as a single thread in a dedicated ArcSOC.exe process.
- **Low Isolation:** many service instances run as separate threads in each ArcSOC.exe process.
- **Recommendation:** Use high isolation
  - A failed instance is "isolated" to one ArcSOC.exe process

High Isolation of 3 service instances

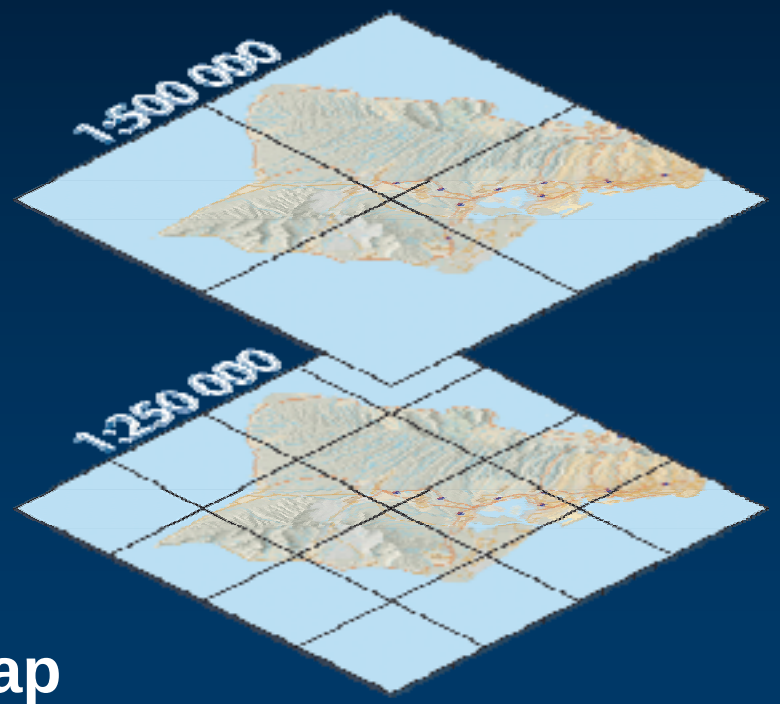


Low Isolation of 3 service instances

Publishing GIS Services

Caching

- **Pre-rendering and storing of map images (tiles) for rapid, high performance display.**
- **Clients can still access the underlying data of the cached map service**
  - **Identify, Query, Highlight feature geometry**

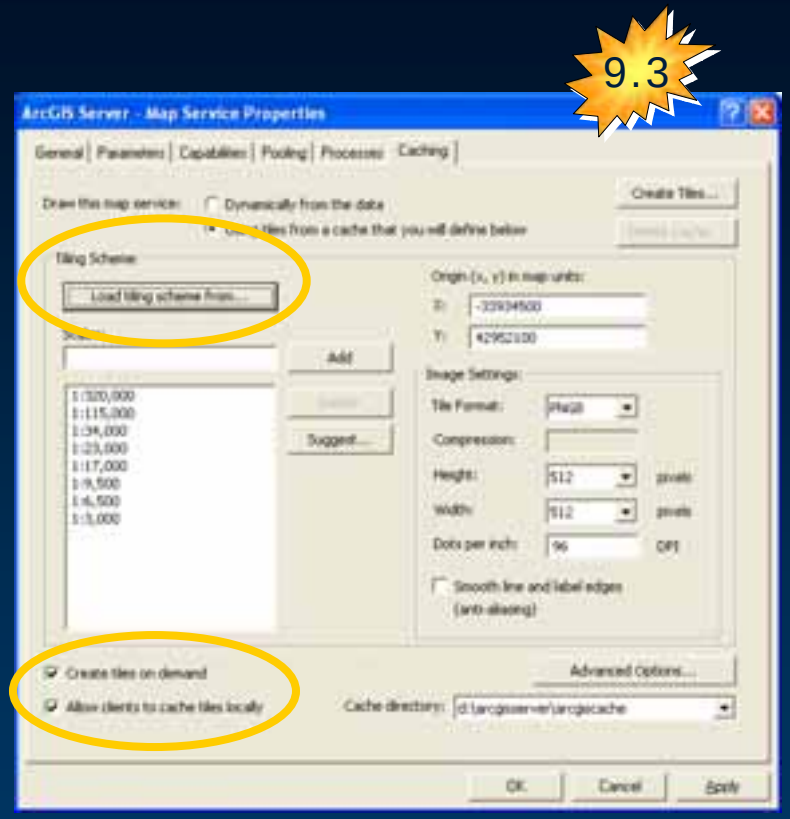


Recommendation: Use Cache map services whenever possible… especially for basemaps.

Publishing GIS Services

Cache Creation

- Can be a very time consuming
  - Build it for a small area to test
  - Use "Cache On Demand" 9.3
- For cache tile sizing – use default 512 x 512. Smaller tiles sizes increase end-user network traffic & consume more disk space.
- For higher aesthetics, use Anti-Aliasing.



Tile Size	Files	Size on Disk	Creation Time
512x512	19,000	0.2 GB	1 hour
128x128	311,000	1.2 GB	5 hours

Publishing GIS Services

Cache Creation

No Anti-aliasing

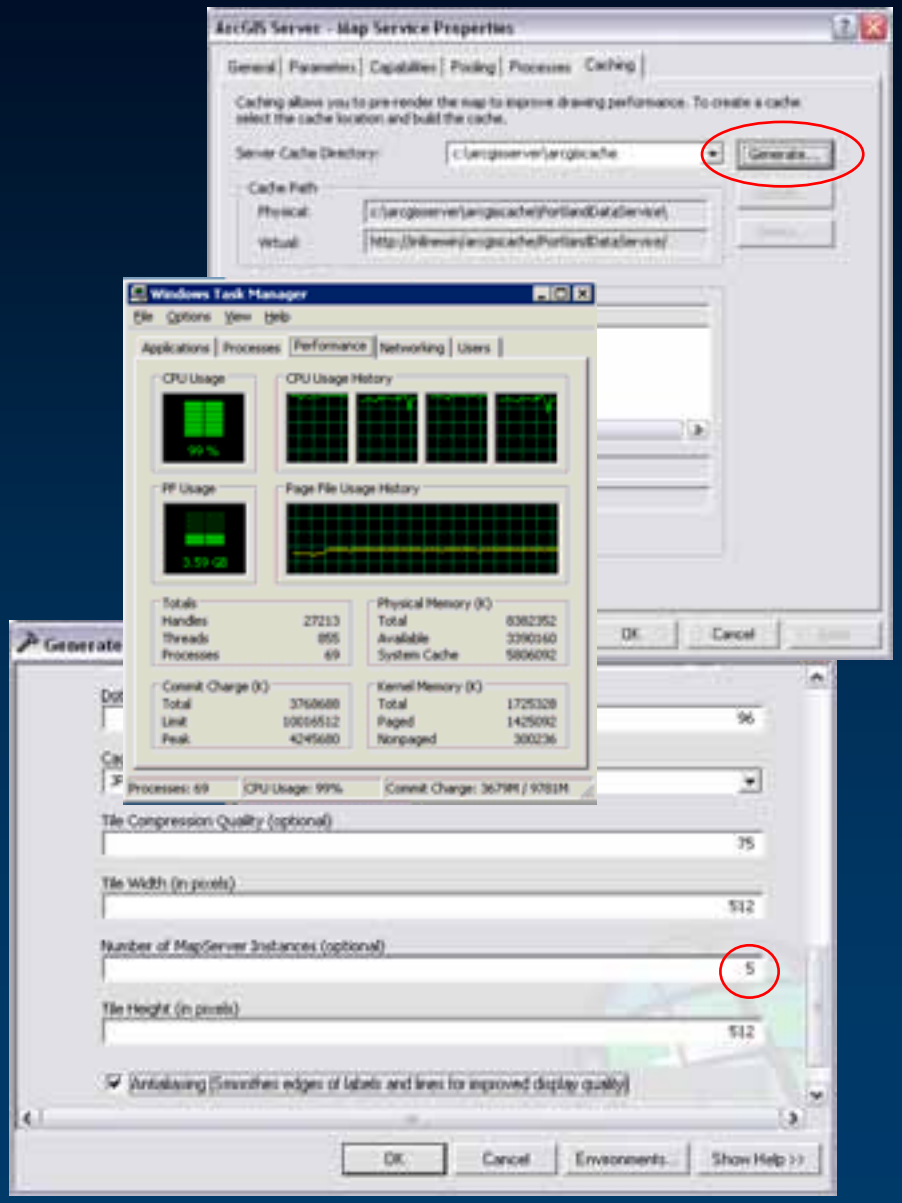
Anti-aliasing

- **Anti-aliased tiles are rendered at finer resolution followed by down sampling**
  - **Smoothes the edges of labels and lines by blending them with the background.**
  - **The resulting screen display quality is better than standard rendering in ArcMap.**
  - **Cache generations times can double with Anti-aliasing enabled.**

Publishing GIS Services

Cache Creation

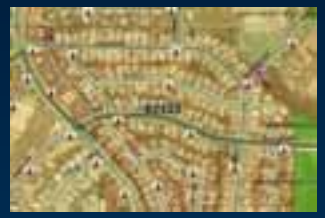
- Cache generation runs as a "batch process" and for the most part consumes a CPU.
- Recommended number of SOC processes is **N+1**, where N is the number of available CPU cores.
- The additional SOC will consume any "left-over" CPU cycles while busy SOCs are waiting on data.
- **Too many SOC processes will cause CPU competition.**



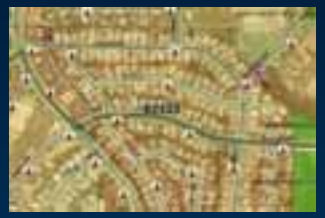
Publishing GIS Services

Output Image Types

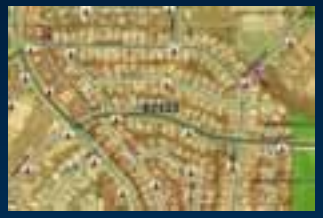
- **Output image size varies by format and underlying data type. Examples of 600 x 400 pixel images**



JPEG = 76 KB



PNG24 = 316 KB



BMP = 703 KB

Raster and Vector Data

JPEG = 70 KB

PNG24 = 30 KB

BMP = 703 KB

Vector Only Data

- **Recommendation:**
  - **Use appropriate output type to support applications while minimizing impact to network. Generally, raster data is best served in a JPEG format, while vector data is best served in a PNG format. Use PNG32 to support transparency.**

Publishing GIS Services

Mobile Cache

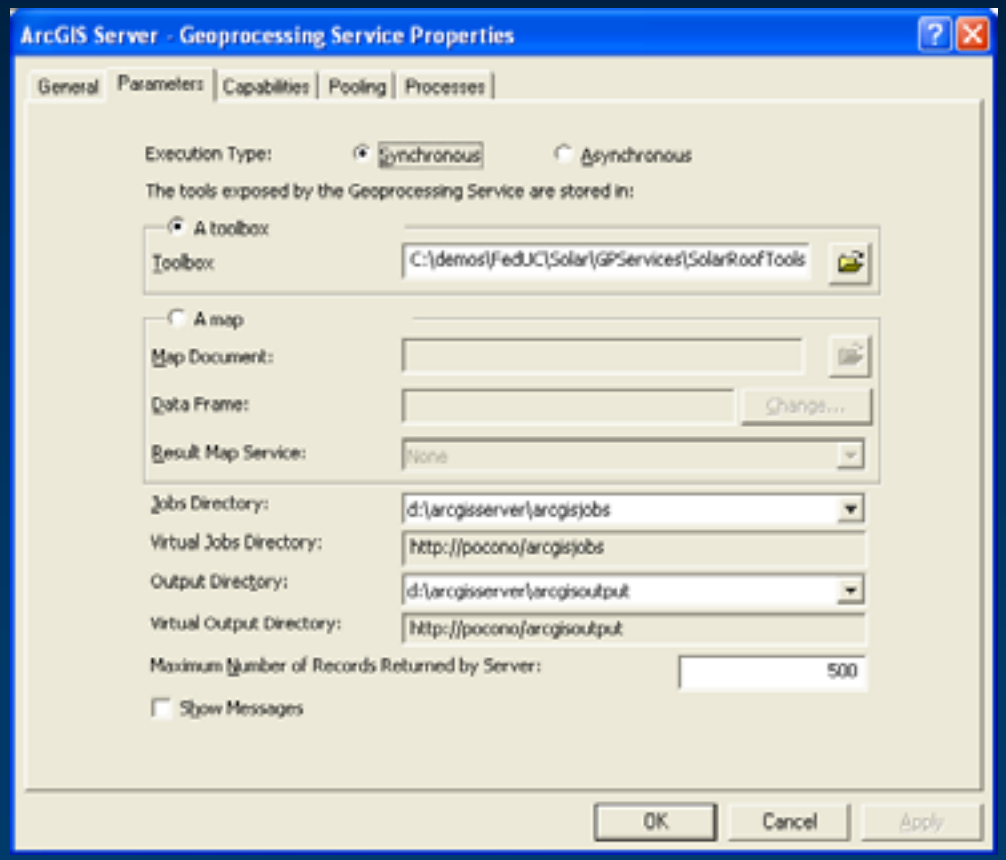
- **Build map cache slightly larger than the extent your field worker will be working at.**
- **Build cache for the entire extent of your background layers (avoids synchronization)**
- **Keep background data as small as possible (device storage issues)**
- **Load cache onto devices before going out into the field.**

Publishing GIS Services

Geoprocessing

9.2

- **If using ArcSDE data sources, be sure to install SP4.**
- **If possible use Execution Type = Synchronous**



Publishing GIS Services

Geocoding

- Default batch size is 10. Change to 100. 9.2
- If batch size is more than 400 serialization/deserialization may have negative performance impact
- At 9.3 default batch size is 1000 and 9.3 serialization/deserialization limit will be set to 2000.

Topical Outline

- Preparing GIS documents
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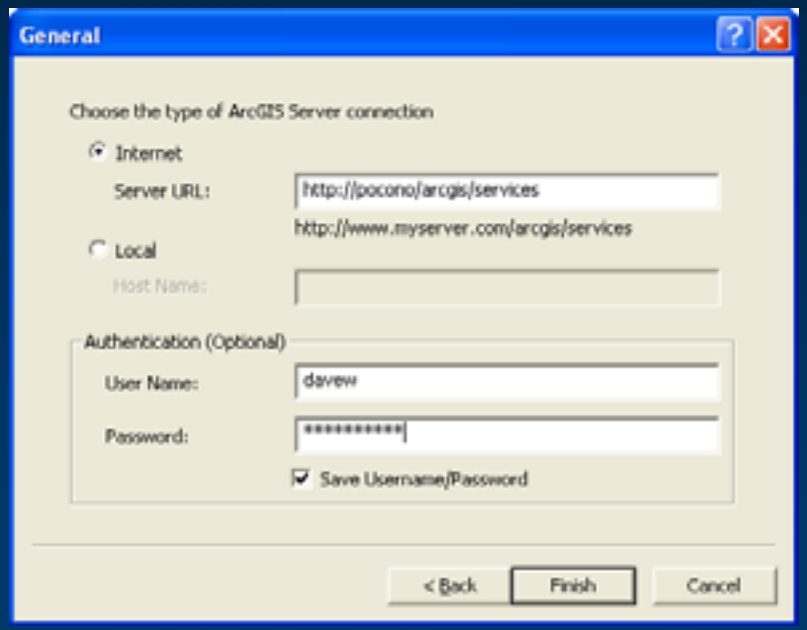
- Deployment Architectures

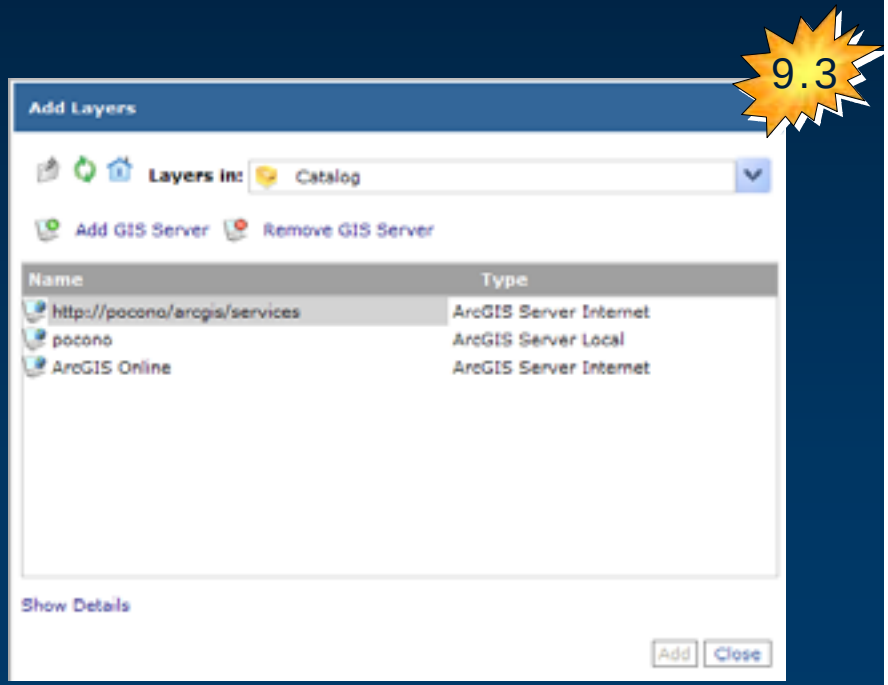
Creating & Configuring GIS Applications

Connecting to ArcGIS Server

- **Clients Applications should use Internet Connections to ArcGIS Server unless Local Connections are required (e.g. Web Editing Task).**



ArcGIS Desktop Dialog



ArcGIS Server Manager Dialog

Creating & Configuring GIS Applications

Web Map Viewer Application

- **Between SP2 and SP3, .NET memory utilization has been improved.** 9.2
- **Between SP2 and SP3, .NET TOC issues have been resolved.** 9.2
- **The Overview Map provides the most significant performance impact. (omit if possible or use static Overview Map in SP4)** 9.2
- **If building a custom application that does not require seamless pans, set the EnableTileCaching = FALSE and EnableContinuousCallback = FALSE (default values are TRUE) properties of the Map Control. 33% increase in overall throughput can be achieved.**

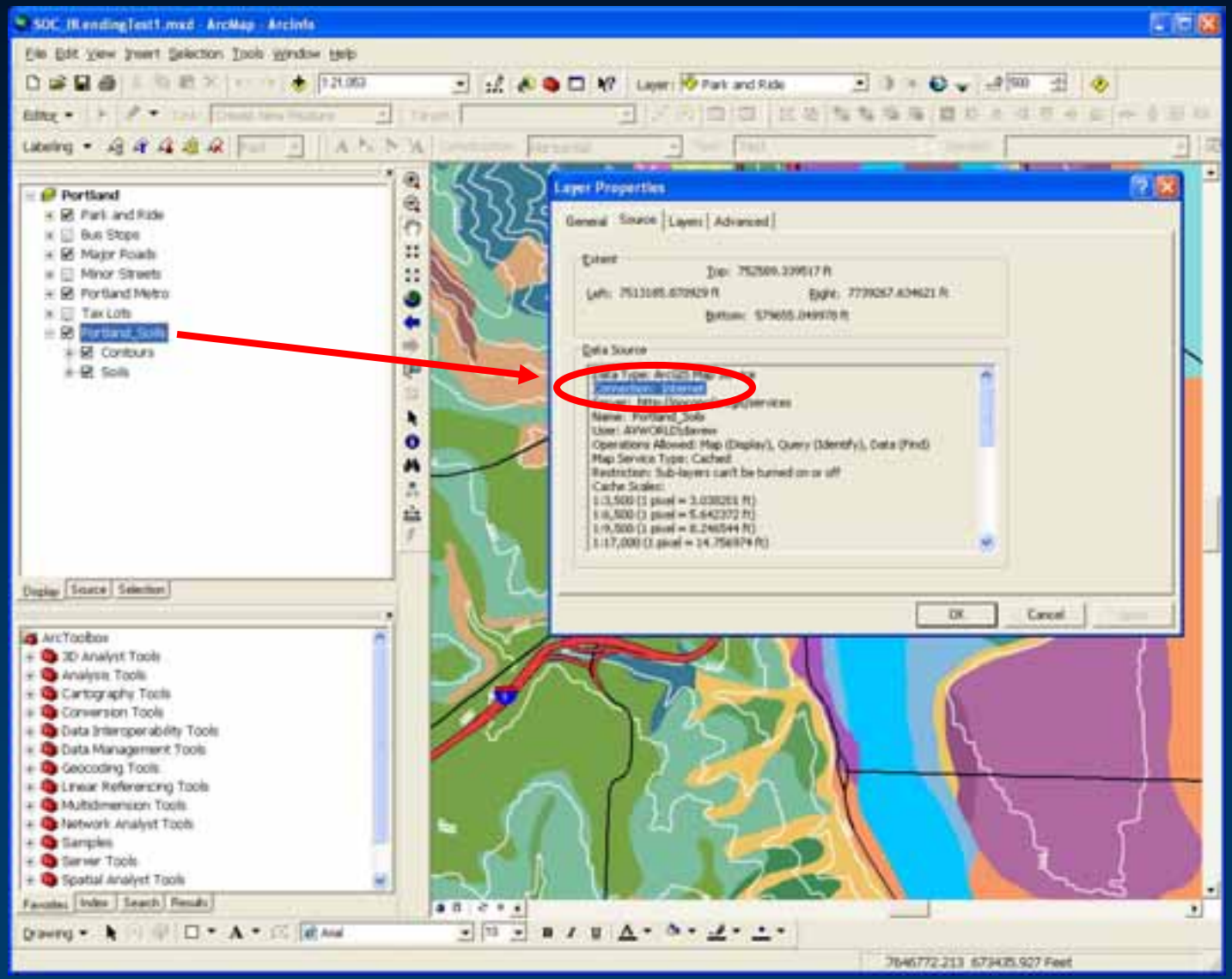
Creating & Configuring GIS Applications

Blending of Cache and Dynamic Services

- **Performance for browser blending in .NET is slow for 9.2 (Java does not have this issue).** 9.2
- **For 9.2, server-side blending in the SOC is more stable and supports more concurrent users.** 9.2
- **For 9.3, browser-side blending is the recommended approach and much higher performing.** 9.3

Creating & Configuring GIS Applications

9.2 Server-side Blending



Authored MXD

Creating & Configuring GIS Applications

Delivery to Applications

- **Consider HTTP Compression for faster file download…. (IIS) http://www.microsoft.com/technet/prodtechnol/WindowsServer2003/Library/IIS/d52ff289-94d3-4085-bc4e-24eb4f312e0e.mspx?mfr=true**
  - **UseDefaultWebResources = False**
  - **WebResourceLocation = <*virtual directory*>**
- **MIME Data… by default UseMimeData = TRUE, can set to FALSE if a public virtual directory is permissible.**

Topical Outline

- Preparing GIS documents
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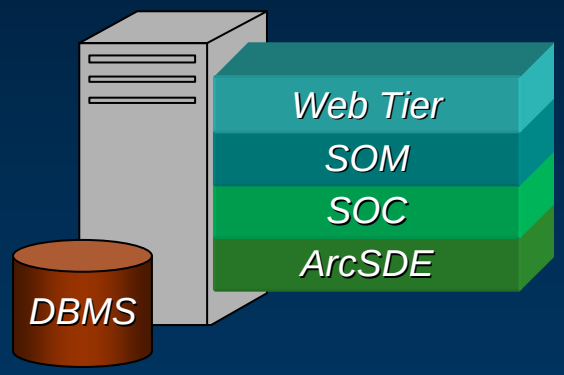
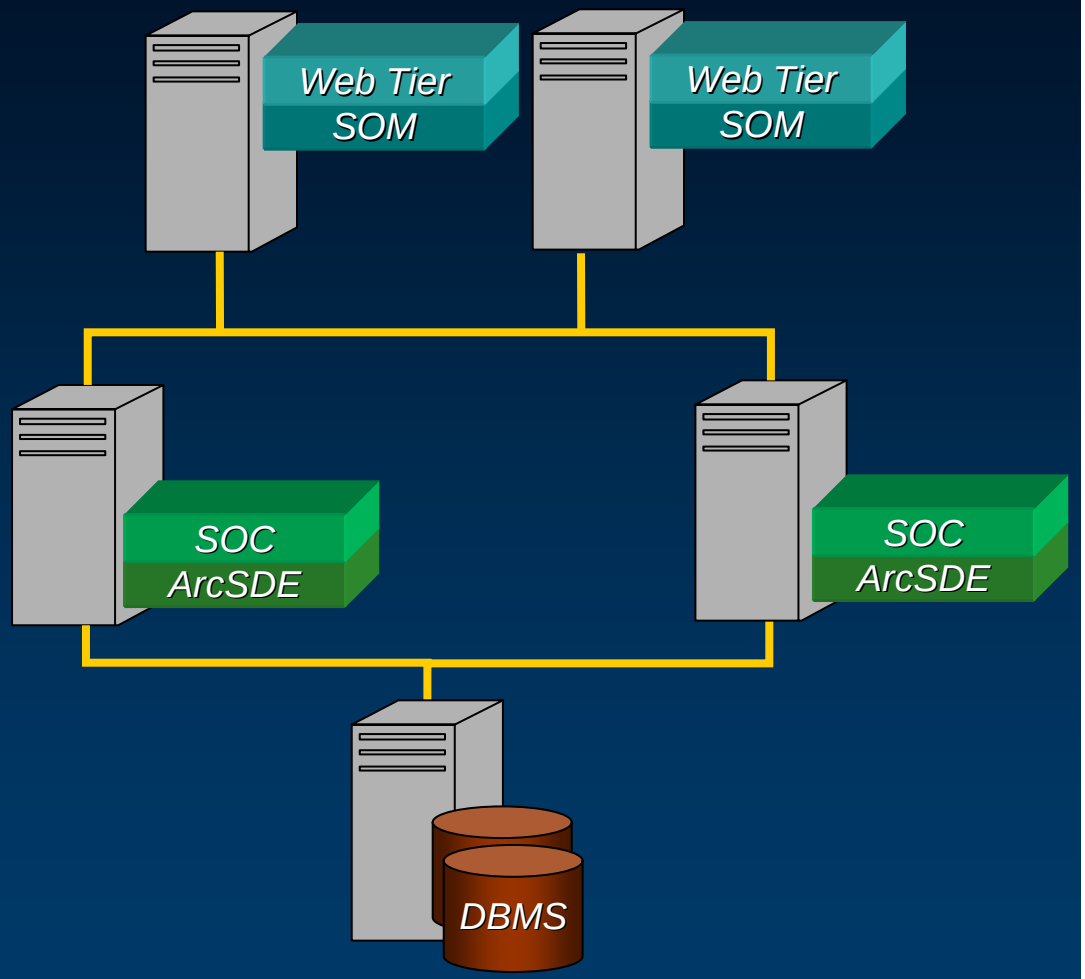
Deployment Architectures

Adding Capacity



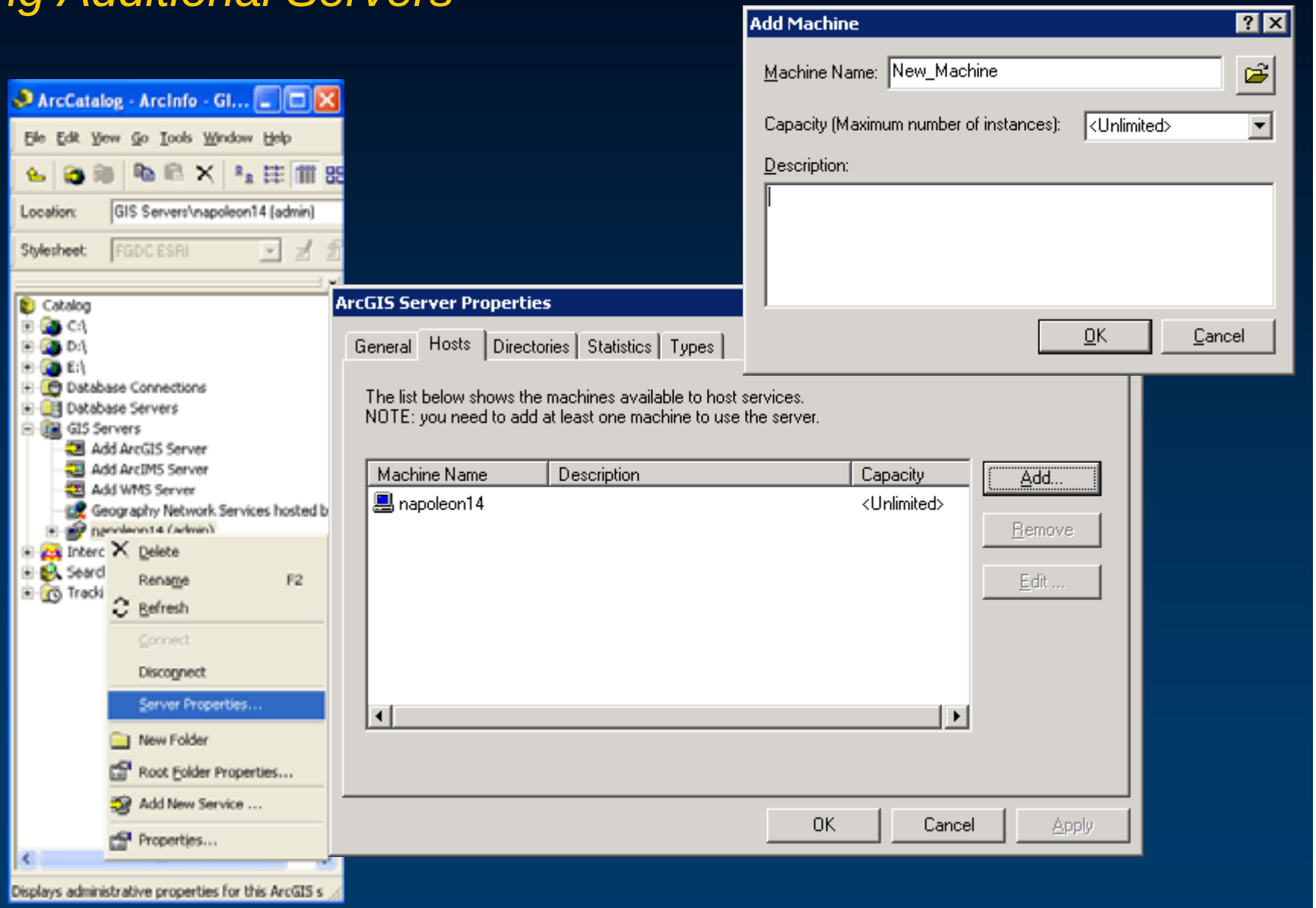
Single Machine Scenario



Multiple Machine Scenario

Deployment Architectures

Adding Additional Servers



Deployment Architectures

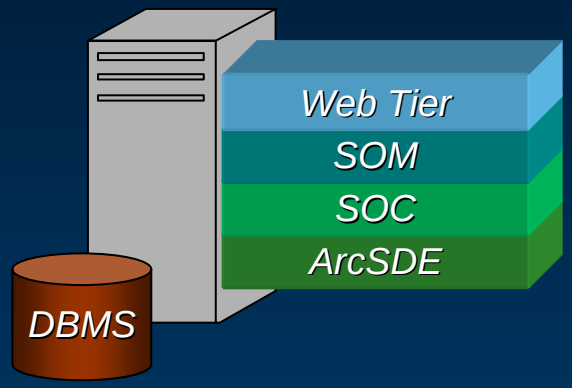
Firewalls

- **ESRI does not recommend firewalls between ArcGIS Server components but rather recommends the use of a Reverse Proxy web server for securing access to Trusted systems** ***For example:***

More Information at:
http://webhelp.esri.com/arcgisserver/9.2/dotNet/manager/administration/firewalls_and_server.htm

Deployment Architectures

Recommended Deployments

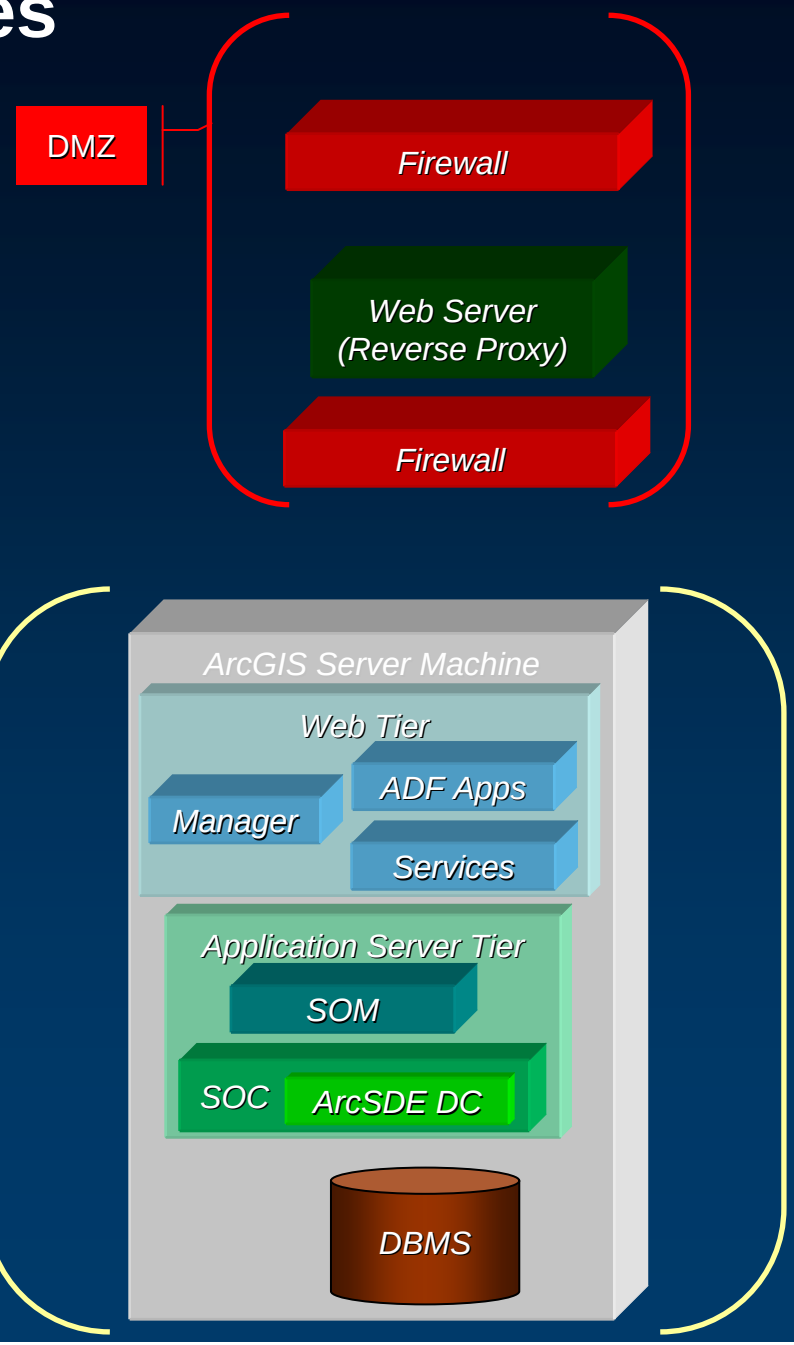


Workgroup

Deployment Architectures

Recommended Deployments

- **Configuration**
  - **ArcGIS Server Workgroup**
  - **Reverse Proxy**



Deployment Architectures

Recommended Deployments

- **Configuration**
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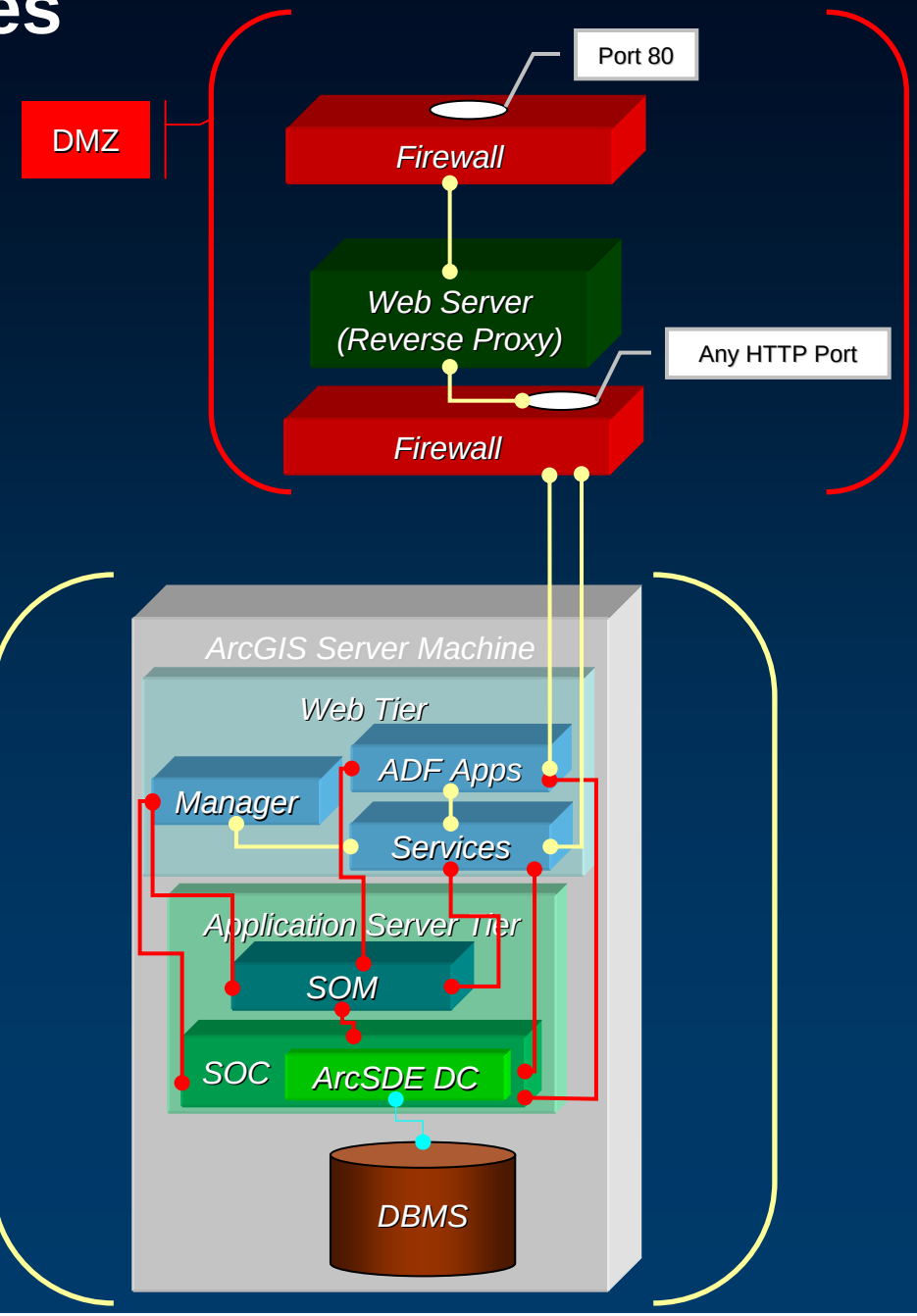
  - **Reverse Proxy**



Communications Legend:

HTTP
DCOM
Pure TCP/IP

Deployment Architectures

Recommended Deployments: ArcGIS Server Workgroup

- **Advantages**
  - **Fully functional**
- **Disadvantages**
  - **Reverse Proxy must be configured with filters for optimal security.**
  - **Internal users must be able to resolve the external URLs otherwise two sets of services are required (one internal and one external).**
  - **Single points of failure exist.**

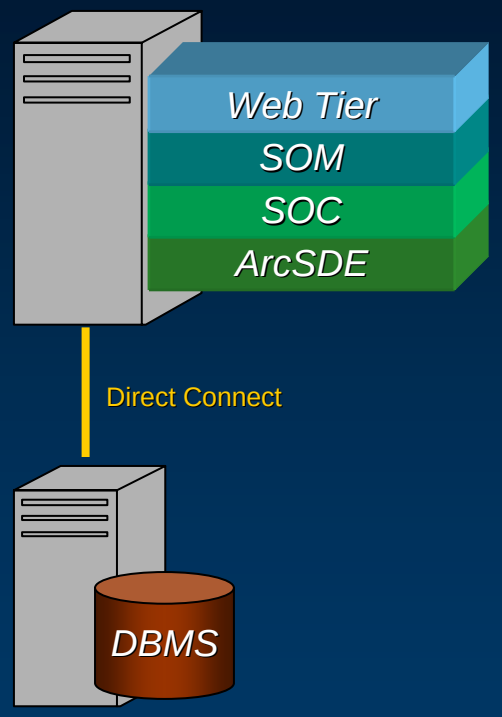
Deployment Architectures

Windows Workgroup Configuration

- **If installing in a Windows Workgroup (not a Domain)**
  - **Simple File Sharing must be "*Off*" on XP.**
  - **Core ArcGIS Server accounts must be local users.**
  - **Local Security Policy Setting**
    - **For "*Network access: Sharing and security model for local accounts*" Set to "*Classic – local users authenticate as themselves*".**

Deployment Architectures

Recommended Deployments



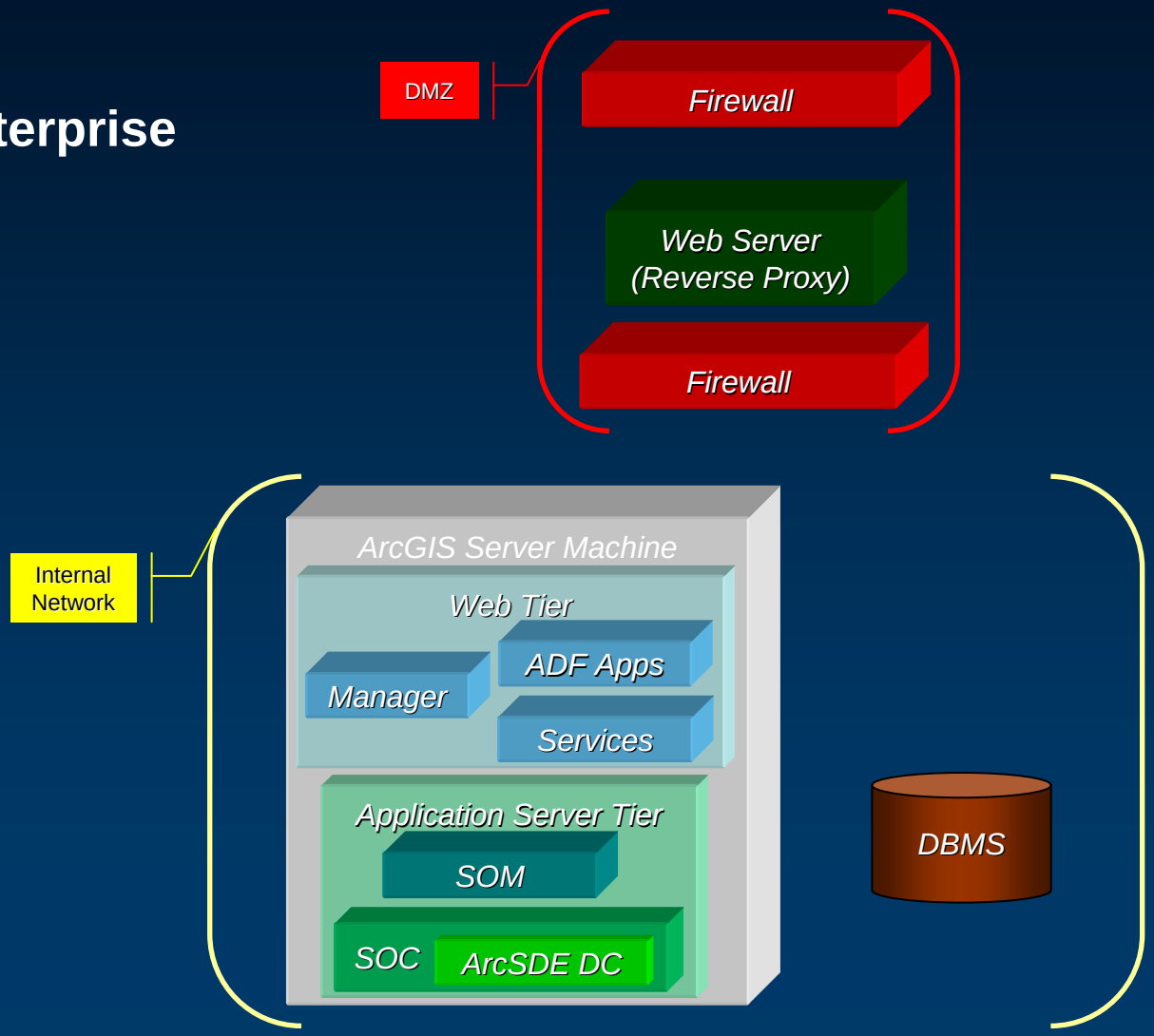
Small Capacity Enterprise

or Standard Development/Testing Environment

Deployment Architectures

Recommended Deployments

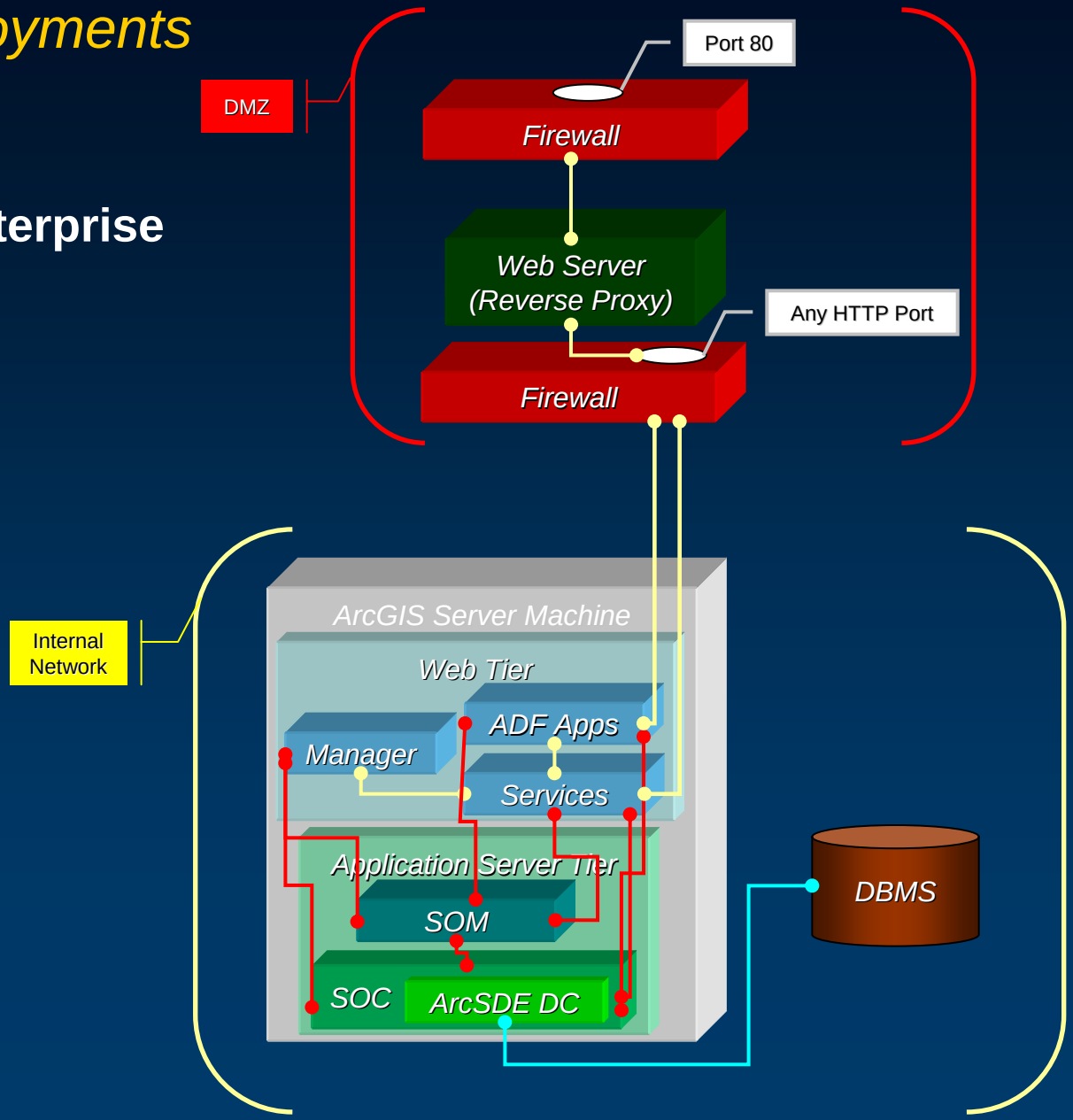
- **Configuration**
  - **Small Capacity Enterprise**
  - **Reverse Proxy**



Deployment Architectures

Recommended Deployments

- **Configuration**
  - **Small Capacity Enterprise**
  - **Reverse Proxy**



Communications Legend:

HTTP
DCOM
Pure TCP/IP

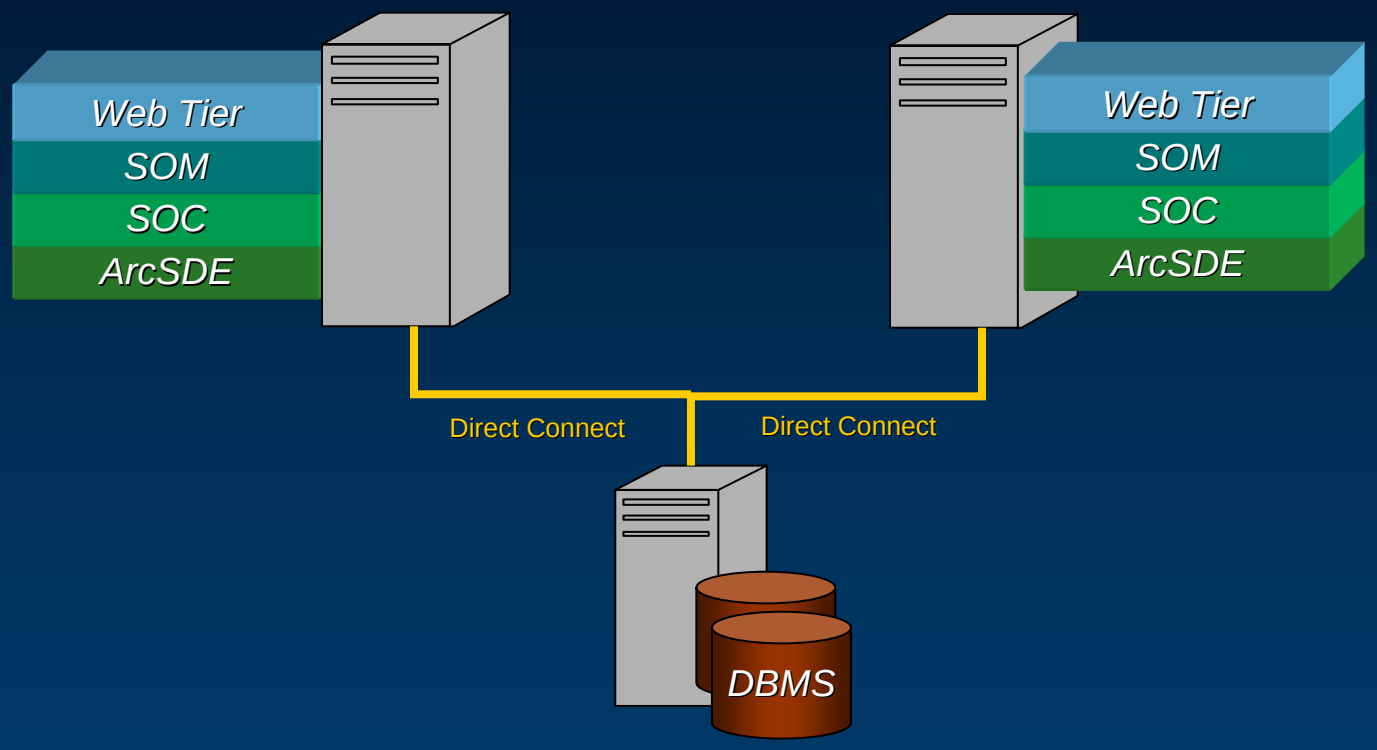
Deployment Architectures

Recommended Deployments: Small Capacity Enterprise

- **Advantages**
  - **Fully functional**
  - **Improved performance by moving RDBMS to additional machine.**
- **Disadvantages**
  - **Reverse Proxy must be configured with filters for optimal security.**
  - **Internal users must be able to resolve the external URLs otherwise two sets of services are required (one internal and one external).**
  - **Single points of failure exist.**

Deployment Architectures

Recommended Deployments



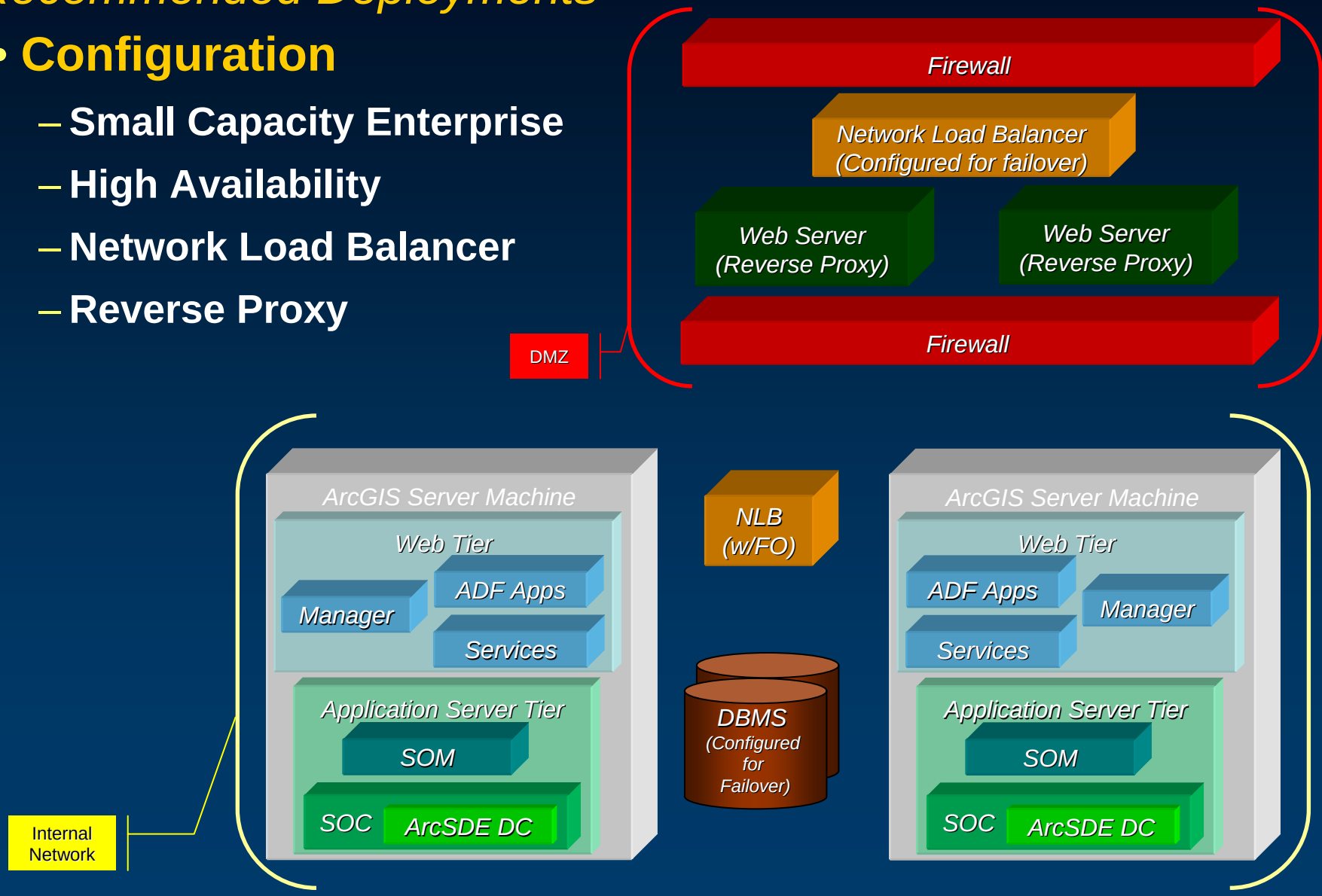
Small Capacity Enterprise, High Availability

or Standard Production Environment

Deployment Architectures

Recommended Deployments

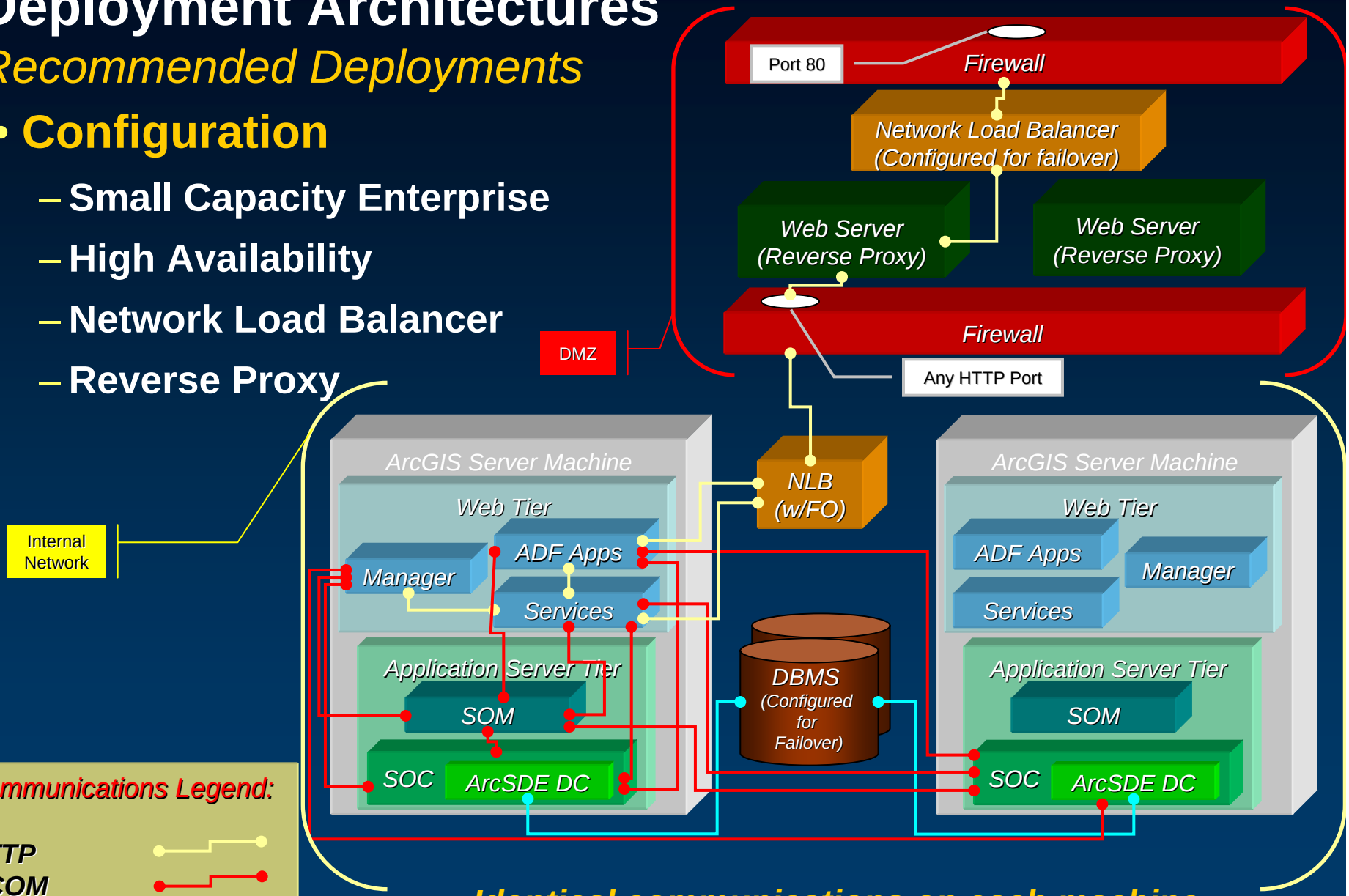
- **Configuration**
  - **Small Capacity Enterprise**
  - **High Availability**
  - **Network Load Balancer**
  - **Reverse Proxy**



Deployment Architectures

Recommended Deployments

- **Configuration**
  - **Small Capacity Enterprise**
  - **High Availability**
  - **Network Load Balancer**
  - **Reverse Proxy**



Identical communications on each machine.

(not shown on additional machines for clarity)

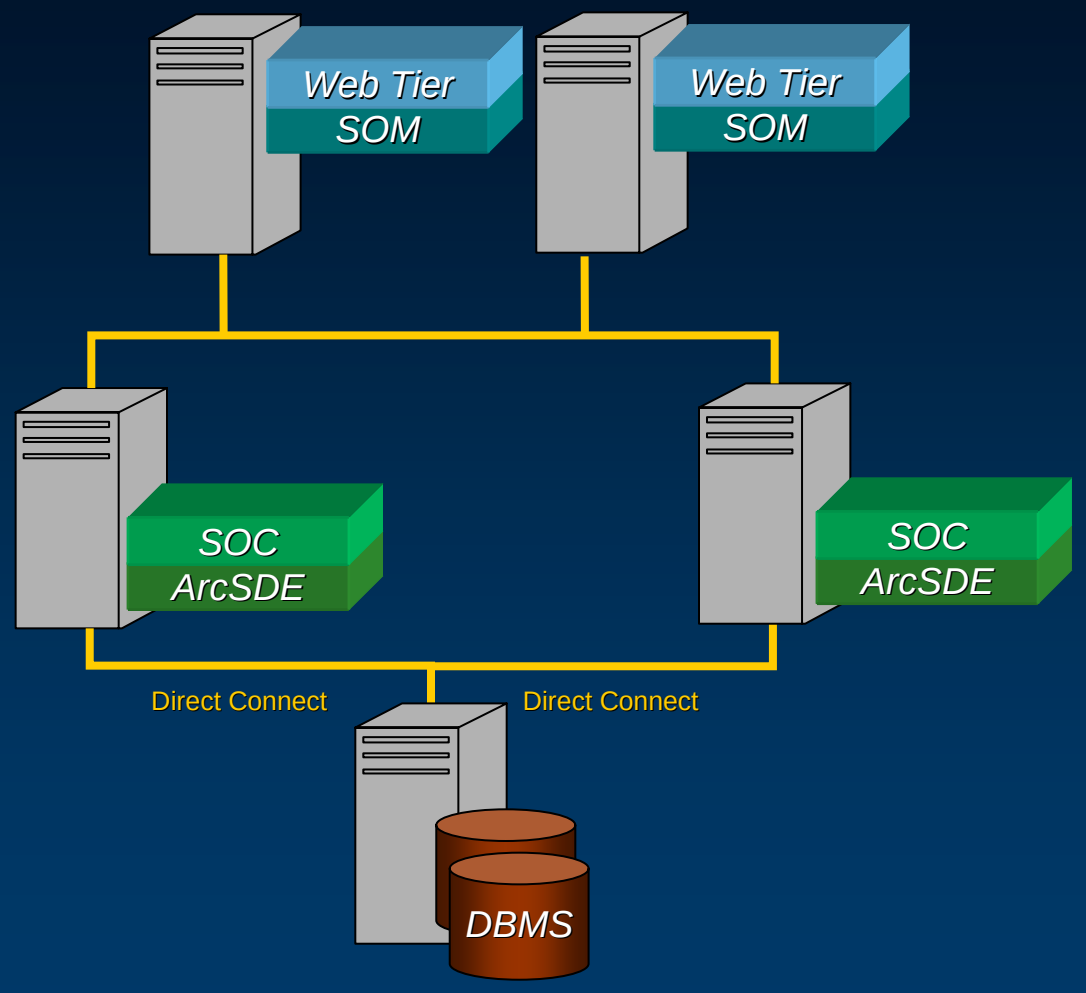
Deployment Architectures

Recommended Deployments: Small Capacity Enterprise, High Availability

- **Advantages:**
  - **Fully Functional**
  - **Failover safe**
  - **Full SOC resource utilization (each SOM uses both machines as Service Hosts) even after failure of a SOM or WebTier component.**
  - **No single points of failure**
- **Disadvantages:**
  - **Web Tier gets heavily loaded after failover.**
  - **Reverse Proxy configuration must be duplicated on each DMZ web server.**
  - **Reverse Proxy must be configured with filters for optimal security.**
  - **Internal users must be able to resolve the external URLs otherwise two sets of services are required (one internal and one external).**
  - **Services must be duplicated for each SOM.**
  - **ADF web applications must be duplicated on each Web Tier.**

Deployment Architectures

Recommended Deployments

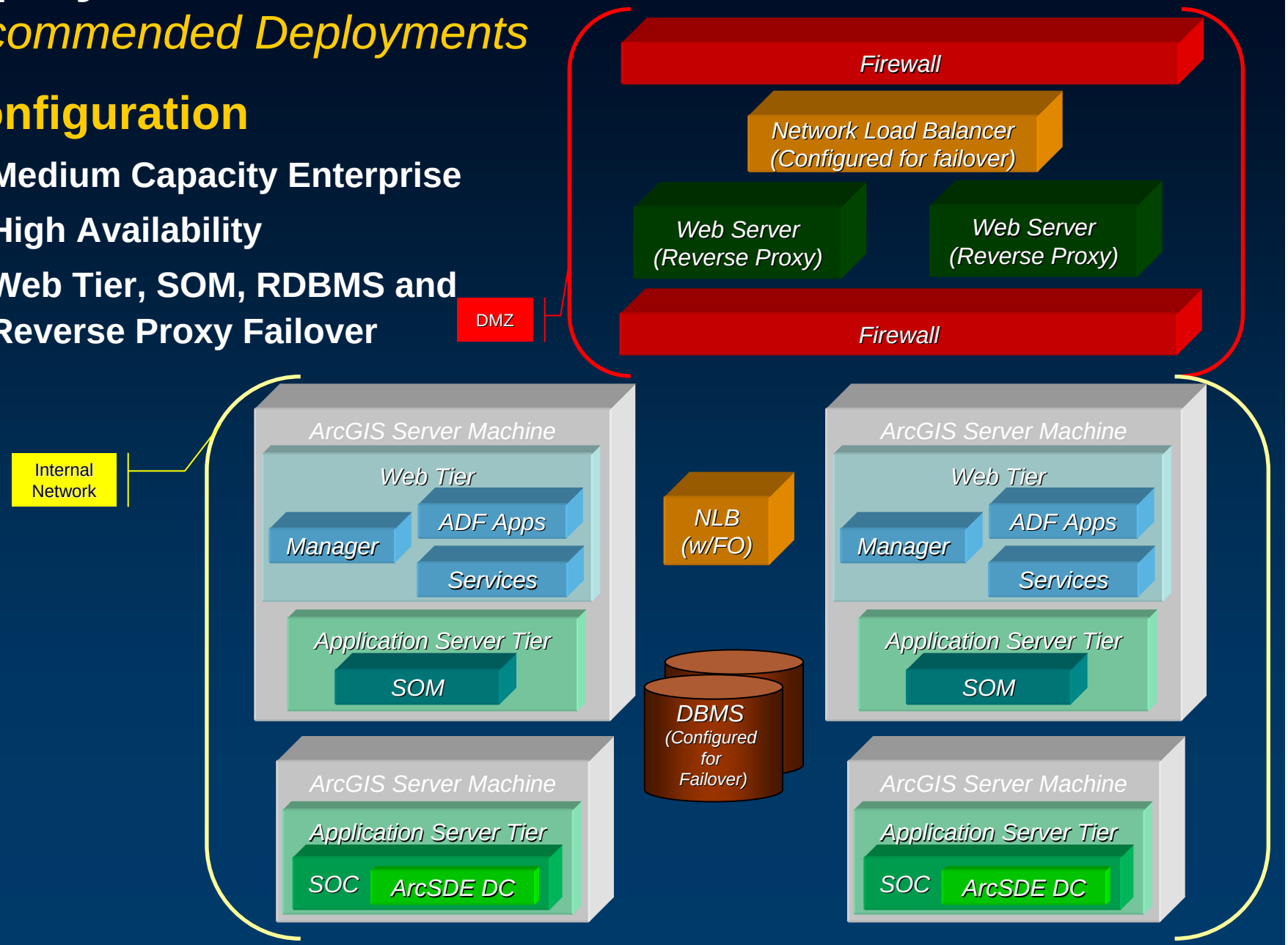


Medium Capacity Enterprise, High Availability

Deployment Architectures

Recommended Deployments

- **Configuration**
  - **Medium Capacity Enterprise**
  - **High Availability**
  - **Web Tier, SOM, RDBMS and Reverse Proxy Failover**



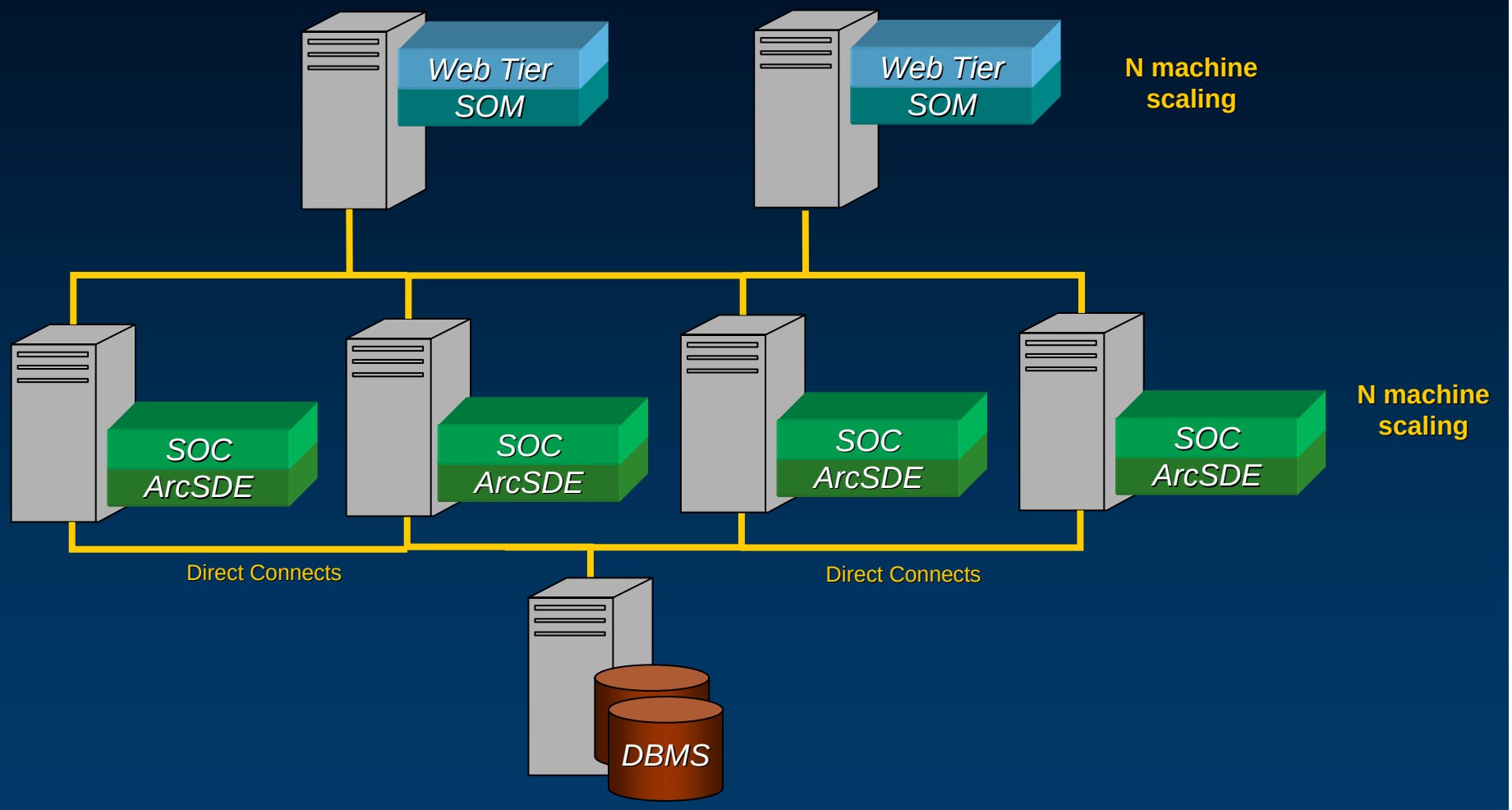
Deployment Architectures

Recommended Deployments: Medium Capacity Enterprise, High Availability

- **Advantages:**
  - Fully Functional
  - Failover safe
  - Full SOC resource utilization (each SOM uses both machines as Service Hosts) even after failure of a SOM or WebTier component.
  - No single points of failure
- **Disadvantages:**
  - Web Tier gets heavily loaded after failover.
  - Reverse Proxy configuration must be duplicated on each DMZ web server.
  - Reverse Proxy must be configured with filters for optimal security.
  - Internal users must be able to resolve the external URLs otherwise two sets of services are required (one internal and one external).
  - Services must be duplicated for each SOM.
  - ADF web applications must be duplicated on each Web Tier.

Deployment Architectures

Recommended Deployments

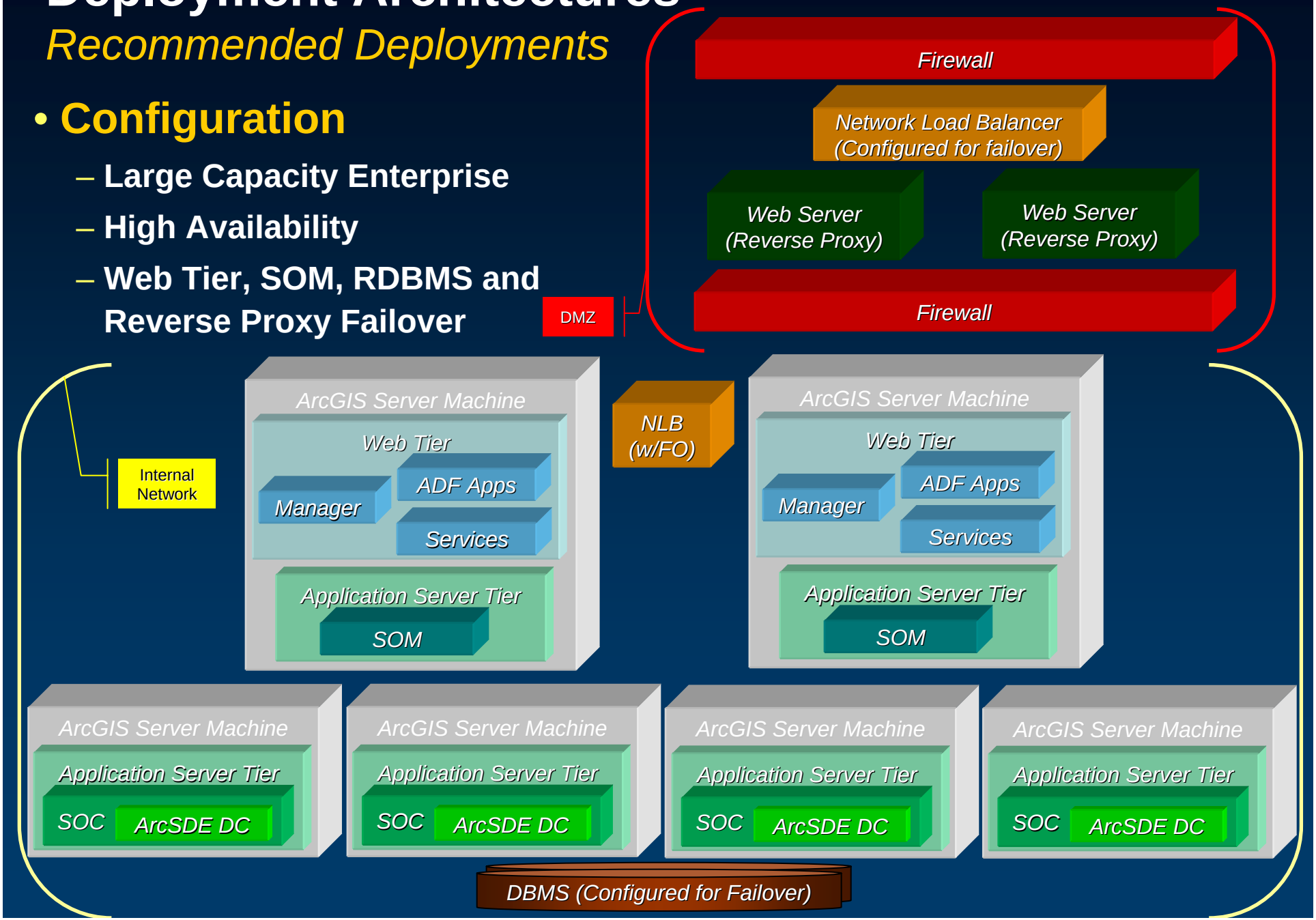


Large Capacity Enterprise, High Availability

Deployment Architectures

Recommended Deployments

- **Configuration**
  - **Large Capacity Enterprise**
  - **High Availability**
  - **Web Tier, SOM, RDBMS and Reverse Proxy Failover**



Deployment Architectures

Recommended Deployments: Large Capacity Enterprise, High Availability

- **Advantages:**
  - **Fully Functional**
  - **Failover safe**
  - **Full SOC resource utilization (each SOM uses both machines as Service Hosts) even after failure of a SOM or WebTier component.**
  - **No single points of failure**
- **Disadvantages:**
  - **Web Tier gets heavily loaded after failover.**
  - **Reverse Proxy configuration must be duplicated on each DMZ web server.**
  - **Reverse Proxy must be configured with filters for optimal security.**
  - **Internal users must be able to resolve the external URLs otherwise two sets of services are required (one internal and one external).**
  - **Services must be duplicated for each SOM.**
  - **ADF web applications must be duplicated on each Web Tier.**

Deployment Architectures

Predicting Capacity

Goal: How many users can my service support on a single SOC machine?

Procedure:

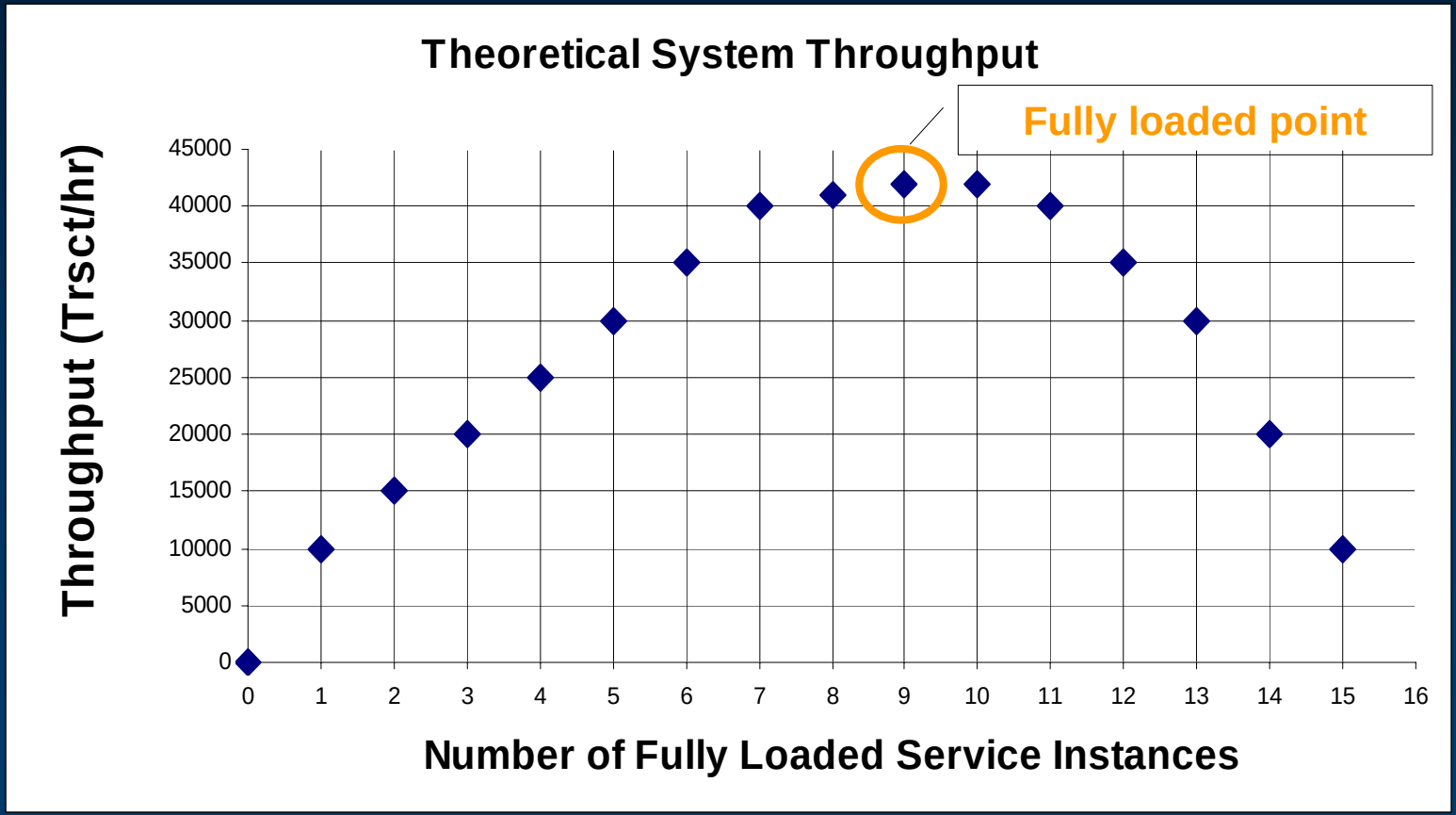
- Create a system load model
  - 500 users
  - 10% peak concurrency
  - 50 concurrent users (10% of 500)
  - User workflow of 6 GIS transactions (displays) per minute – implies transaction time + client think time = 10 seconds
    - Assuming clients need 5 seconds to process an image, client think time is 5 seconds
    - Implies transaction time cannot be more than 5 seconds
- Determine maximum throughput of a single SOC machine for your service.
- Determine maximum number of concurrent clients supported on a single SOC machine with a maximum acceptable transaction time.
- Multiply this out to the number of concurrent clients you need to support.

Deployment Architectures

Determining Throughput

Goal:

Determine the throughput of a representative service at the point where the system becomes fully loaded.



Deployment Architectures

Determining Throughput

Procedure:

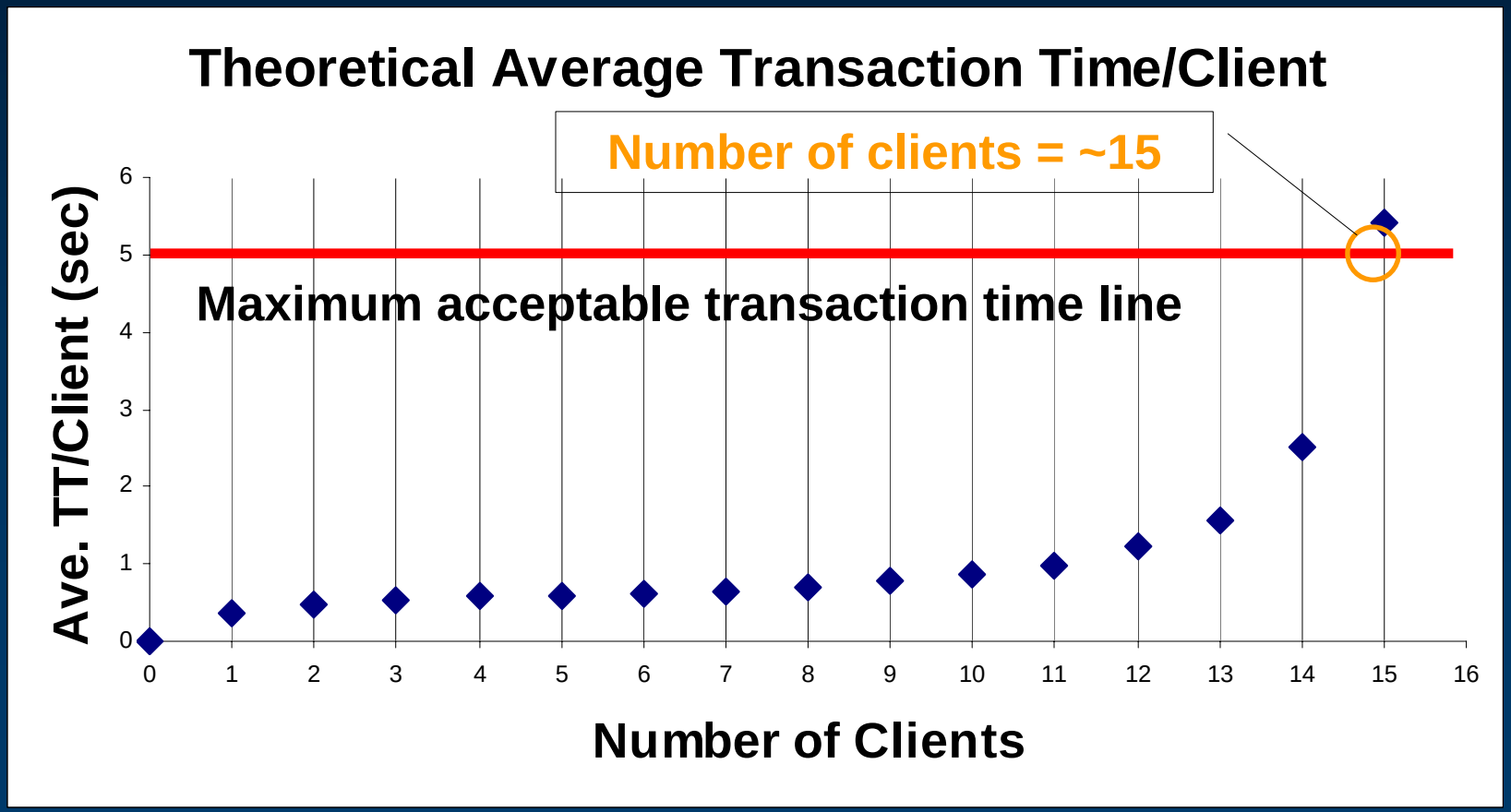
- **Fix Minimum and Maximum instances to an initial guess of 3-4 instances per CPU core.**
- **Load the service with constant load clients.**
  - **Start with one client loading one service instance and collect 50-100 transactions (extrapolate to transactions/hour).**
  - **Repeat until clients equal the number of service instances.**
  - **Produce curve of Throughput vs loaded service instances.**
  - **Pick point after throughput plateaus as the maximum number of instances the service can support.**
- **Refine Minimum/Maximum instances if machines are over or under loaded.**

Deployment Architectures

Determining Number of Clients Supported with Acceptable TT

Goal:

Determine the maximum number of clients a single SOC machine can support with a maximum acceptable transaction time.



Deployment Architectures

Determining Number of Clients Supported with Acceptable TT

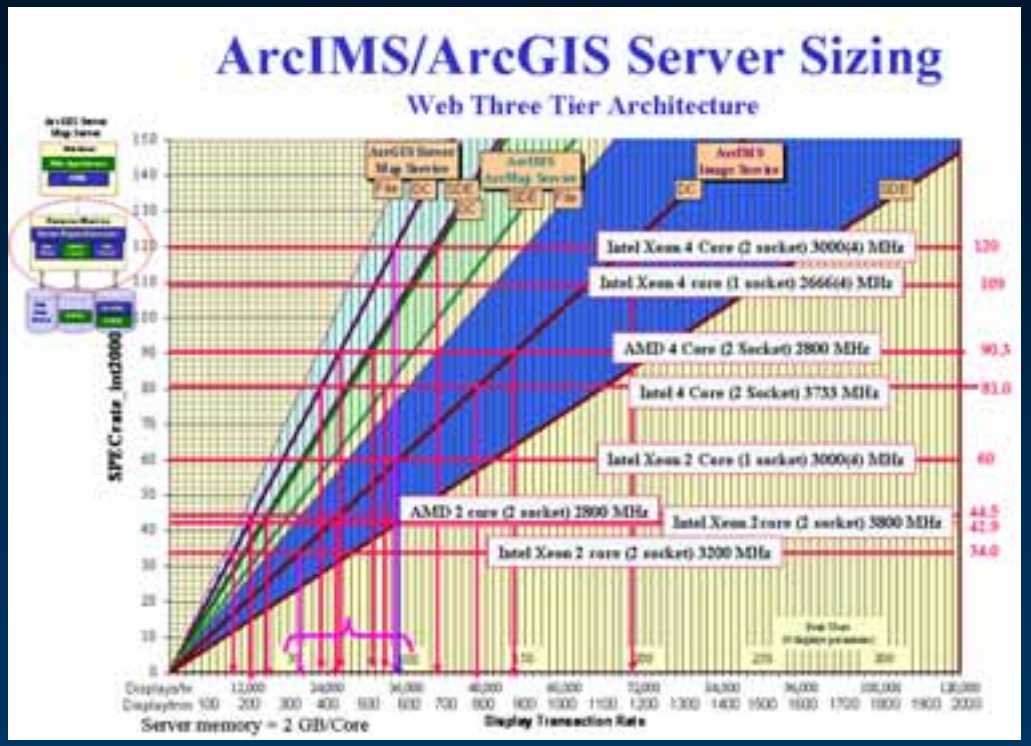
Procedure:

- **Set the min/max instances of your service to the number determined in the Throughput Test.**
- **Increase client load (with think time) one instance at a time until the average response time exceeds what the user can tolerate. This is the number of real-world clients your machine can handle.**
- **Scale your system by adding machines until you have enough to meet expected peak concurrent user load.**

Deployment Architectures

Capacity Planning

- **ESRI Professional Services Enterprise Consulting**
- **System Design Strategies Technical Resource Document**



http://www.esri.com/systemsint/kbase/strategies.html

Conclusions

- ArcGIS Server offers a powerful and flexible platform for server-based GIS, but it needs to be architected correctly.
  - Preparing GIS documents
  - Publishing GIS services
  - Creating and Configuring GIS applications
  - Defining a deployment architecture

More Information

- **Other recommended sessions and meetings:**
  - ***"Implementing and Optimizing ArcGIS Server Map Caches"***
  - ***"Building and Optimizing Geoprocessing Services for ArcGIS Server"***
  - ***"Implementing Security for ArcGIS Server .NET Solutions"***
  - ***"Implementing Security for ArcGIS Server Java Solutions"***
  - ***"Architecting ArcGIS Server Solutions for Linux and Solaris"***
- **All sessions are recorded and will be available on EDN**
- **Still have questions?**
  1. **Tech talk, Demo Theatres, Meet the Team**
  2. **"Ask a Developer" link on web page**
     - **http://www.esri.com/devsummit/techquestions**
- **Please fill out session surveys!**

Thank You
and
Enjoy the Conference!