Implementing and Optimizing ArcGIS Server Map Caches

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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?
  – Sterling Quinn: ArcGIS Server Product Engineer
  – Jeremy Bartley: ArcGIS Server Product Engineer
  – David Wilcox: ArcGIS Online Product Engineer

• Who are you?
  – Who’s created a map cache before?
  – Who’s created large map caches (more than a few hours to create)?
  – Who doesn’t know what a map cache is?
What to expect in this session

• Basic to advanced topics
• 9.2 and 9.3 solutions

• Outline
  – What is map caching?
  – Why should I cache?
  – How to create a cache
  – Common caching questions
  – Case study: ArcGIS Online
  – 9.3 improvements
  – Q & A
What is map caching?
What does it mean to cache a map service?

- A cached service has a set of map images that have been pre-rendered for rapid display.

- You create map and globe service caches at pre-determined scale levels.
The cached images are stored on disk
Why cache a map service?

- Which is faster?
  - Let the server draw the map   OR   
  - Get the image from a prebuilt cache

- By caching, you only have to render the map once: When you create the cache.

- Caching is an investment.
Industry Standard

- Google Maps and Google Earth
- Microsoft Virtual Earth
- Yahoo! Maps
- ArcGIS Online
- others…

- You want performance, scalability, and high quality!
Keep Cartographic Quality and Performance with ArcGIS
Server cached map services

- Shaded Relief
- Transparent Layers
- Maplex Labeling

- Low-res relief
- Solid colors
- Annotation
Demo

- Viewing a high-quality cached map service
Why should I cache?
“Pre-cached map days”

- Dynamic maps
  - Not scalable
  - Will NEVER be as fast as cached maps

- “Simple” Cartography
  - Simple maps to aid in performance
  - Not simple in map authoring--defined by XML (ArcIMS)
“Pre-cached map days”

- Map authoring was for the developer
  - Complicated map authoring led to the disconnect between GIS Analysts and GIS Developers
  - Caching encourages non GIS developers to get involved in putting maps on the web

- Hated by Cartographers
  - Simple cartography for performance was not aesthetically pleasing
Maps on the web in today's world

- Maps for general public consumption MUST be cached

- Cache + Dynamic services in web applications (while improved at 9.3) is not as scalable for mass consumption
Maps on the web in today's world

• Data that is truly dynamic (query and geoprocessing results, changing data) should be treated as graphics in the client application

• Dynamic maps are for:
  – INTRANET applications
  – Applications with a small, highly-focused audience
Other caching solutions

- **Microsoft MapCruncher**
  - Cuts up an existing single scale map

- **OSGEO WMS-C Tile Caching**
  - Prototype spec for building cache from WMS services

- **KaMap pre-caching system**
  - Works off of Minnesota MapServer

- **Etc.**
Why can’t you just cut an existing single scale thematic map?
The ArcMap advantage

• The most challenging part of a cached map services solution is in the map authoring
  – Not orthos or imagery…that is easy
  – But…Street, Topo, Relief (see Google Maps), Landuse, etc. maps
  – A street map service cached at 20 levels is not one map, but 20 different maps integrated together

• ArcMap allows you to create a high-quality map at many scale levels.
Example...

• You are the GIS Analyst at a county government. Your boss would like you to build a cached map service of your county. She would like you to build this map so that it can be viewable from 1:1,000,000 down to 1:10,000.

• Easy right?
How to create a cache
Author the map

- Choose a set of scale levels and design at those
  - ArcGIS Online, Google Maps, VE scales, or your own?
  - Add the scales to the ArcMap dropdown list
  - Make the map look good at each scale
Authoring tips

• Copy layers
  – Can set a different scale range and symbology for each copy

• Group layers by scale level
  – Only have to set the scale range at the group layer level
More authoring tips

• Set the Full Extent to the area that you want to cache
  – ArcMap allows a custom Full Extent

• Use the Maplex labeling engine
Tips for the background color

- Transparent color defaults to near-white (253, 253, 253)
- Avoid using a background color that’s already in your map
Anti-aliasing

- Smooths edges of labels and lines by blending them with the background
  - Choose background color carefully!
- Improves display quality (over standard rendering in ArcMap)
- Cannot set this up in ArcMap. Use the caching tools.
- Takes longer to cache
Publish the map as a service

• Use either ArcCatalog or Manager

• Raise the default Maximum Number of Instances if necessary
  – Access this setting in the Service Properties
  – Default is 2 instances max. If you have more server power, you can raise it.

• Must start the service before caching
Create the cache

- Must do this from ArcCatalog or ArcToolbox
- Use the Caching tab of the Service Properties
Caching jobs are defined by...

- Cache tiling scheme
- Full extent of the map service (derived from the data frame full extent in the source MXD)

For example:
- Tiling origin is -180, 90
- Map service extent is the bounding box of Colorado
- Tiles will only be generated within and around the bounding box of Colorado

- The tile rows and columns will be referenced from the tile origin (-180, 90)
Demo

- Basic cache creation
Two types of caching scenarios

1. Small scope: Cities, Counties, etc.

2. Large scope: The continental United States down to 1:10,000

- The geographic extent and the levels of detail (scale levels) of the area of your caching job directly influence the amount time you will need to devote to the caching process
Generating a large map cache

• Can be time consuming

• **Tip:** Create the cache for a small area before building the whole thing.
  1. Set a custom Full Extent on your map to a small area.
  2. Build the test cache
  3. Examine appearance of symbology, labels, etc.
  4. Test the performance of the cache in your preferred client application
  5. Make necessary adjustments and build again
Factors that influence cache creation time

- Geographic extent
- Number and choice of scale levels
- Complexity of the map
  - If it takes a long time to draw in ArcMap, it will take a long time to cache.
- Anti-aliasing
  - Generally twice as long to generate
- Data source type
  - Enterprise geodatabase vs. local copies of data
- Server resources
  - For example, SOC machines and available service instances
- Network bandwidth between SOC machine and cache directory
Tile size influences cache creation time

• Larger size produces fewer tiles
  – Less disk space (block size)
  – Faster creation
  – Easier to manage

• Smaller size produces more tiles
  – Allows partial update of the display

• Takes approximately 5X as long and takes up 1Gb more of space when creating a cache at 128x128 tile size versus 512x512 tile size with the same data (Hawaii)

• ArcGIS Online uses 512 X 512
• Google Maps and Virtual Earth use 256 X 256
Tips for large scope caching jobs

• When caching very large geographic areas break up caching job to distinct areas.
  – Use UpdateMapServerCache to cache each area
  – You can use a script if you have many areas
  – See blog post: Strategies for large caching jobs
Using the cache

• Map caches can be used in
  – ArcMap
  – ArcReader
  – Web Mapping Applications
  – ArcGlobe
  – ArcGIS Explorer
  – Google Maps
  – Virtual Earth
  – Etc.
Using map caches in ArcMap

• Gives you a high level of control of how you view the cache

• Continuous zoom
  – Associates current view with a level of detail in the map cache and then resamples up to match the current view
  – Image quality can vary depending on how far away you are from a cached scale

• Can easily blend with other services and data

• Reprojection supported
  – ArcMap reprojects an existing tile instead of generating a dynamic map. Some performance lost.
ArcMap creates a local cache

- Improves performance for areas you’ve already visited
- Can get out of sync with server side cache
- Cache administrator must notify clients to clear their caches when an update is available
- Clear cache in layer Properties
ArcGIS Server Web mapping applications

- 9.2 Service Pack 2 or above *highly recommended*
  - Allows for easier overlay of caches

- To get the performance benefit of the cache:
  - Navigation is limited to the cached scales
  - Cached tiles cannot be projected on the fly

- Use a common tiling scheme when overlaying caches
  - Don’t have to cache at all scales
Using map caches in 9.2 Service Pack 2 and above

• Internet Explorer 6 with transparent PNG images.
  – IE 6 and earlier does not honor transparency in PNG24
  – Best practice is to use PNG8 or PNG32

• In .NET Web mapping applications with IE 6
  – If you try to use PNG24 for an overlay cache, the Web application will generate the image dynamically, thereby slowing performance.

• In Java Web mapping applications with IE 6
  – If you try to use PNG24 for an overlay cache, you will not be able to see what’s below it.
Updating the cache

• Necessary if you want to see changes in your data

• Gives you the performance benefit of caching, even with changing data
Will updating allow me to cache my data?

• How up to date does my map need to be?
  – Determines update frequency
  – If real-time display is not required, you may be able to cache with scheduled updates
  – If real-time data display is required, use graphics layer or dynamic map

• How big is my cache?
  – Determines update time
  – What is the acceptable amount of time that my cache update can take before it becomes inefficient?
How to update a cache

• Manually: Launch update tool from Caching tab of the Service Properties

• Automatically: Use scripting to call the update tool
  – Schedule a job on your operating system to run the script
  – See the ArcGIS Server Development Blog for an example Python script

• Note: Users must clear local cache to see updates
  – ArcGIS Desktop and ArcGIS Explorer maintain these local caches
Common Caching Questions
How do I choose the best cache settings?

• Choose your closest scale level carefully
  – Zoom in just as far as you need without getting any closer

• Use fused caches whenever possible
  – Create logical groups of layers and overlay the fused caches to get a multi-layer effect

• Choose one tiling scheme for all your caches
  – But you don’t have to create tiles at all of the scale levels
How do I create tiles for only some of the levels in my tiling scheme?

1. Cancel Generate Map Server Cache while in progress
2. Run Update Map Server Cache and check only the desired scales
Case study:

Creating caches for ArcGIS Online
ArcGIS Online is…

- A set of GIS services hosted by ESRI

- Includes a variety of maps
  - Imagery
  - Street map
  - Shaded relief
  - Etc.

- All map services on ArcGIS Online are cached

- Demo...
Planned scales and tiling scheme ahead of time

- Chose one tiling scheme for all caches
  - Chose scales that wouldn’t overlap at 180 degrees longitude
  - This tiling scheme is available on the ArcGIS Server Development Blog

- Cartographers designed the maps around these chosen scales

- Cached each map only at the scales appropriate for its intended use
Chose cache settings carefully

- Used anti-aliasing with lines and text

- PNG8 format for overlay services
  - Boundaries, Street network for overlaying imagery, etc.

- Used JPG image format for base maps
  - Street map, imagery, etc.
Set “Tile Compression Quality” = 90 for JPG tiles

• Higher quality than default JPGs
  – Default quality is 75
  – Increasing to 90 removes “chatter” around text and linework

• Tile sizes about 30% greater than default JPGs
  – A reasonable increase
Image Format comparison

JPG90
Made small test caches of a known area

- Chose Salt Lake City for its mix of landscapes
  - Urban and rural
  - Flat and mountainous

- Used test caches to verify map design choices
  - Did the maps look good at all scales?

- Ran code to report the rows and columns in the test caches
  - This gave an estimate of the size of the final cache
  - See blog post Working with map caches programmatically to get the code
Monitored the caching jobs

- Used Windows Performance Monitor (perfmon) to see where hardware was being stressed during caching
Copied caches to production server

• Windows Copy/Paste inefficient for moving large numbers of files
  – Large caches contain millions of files
  – Windows indexes files before copying

• SecureCopy a more reliable option
  – Reports if there are failures

• Experimented with other methods (xcopy, RoboCopy, imaging software, scripting zip file creation, etc.)

• Always looking for new alternatives...
Additional work

• Created globe caches
  – Overlayed map cache on globe and then cached the globe
  – This factored into original choice of scales
  – See blog post: Creating a 3D globe cache from a 2D map cache

• Configured web server to return a “No data” tile for uncached areas
  – See blog post: Configuring your server to return a “Data not available” tile for empty map cache areas
Caching improvements in ArcGIS Server 9.3
New workflow

• Set the tiling scheme, then create the tiles
  – Uses Manage Map Server Cache Tiles tool for both Create and Update
Caching tab is also available in Manager

- You can use it to:
  - Define the tiling scheme for a service
  - Enable cache on demand
- You cannot use it to launch the caching tools
Easier to select tiling schemes

- Select tiling scheme from common mapping solutions:
  - ArcGIS Online, Microsoft Virtual Earth, Google Maps
  - Allows for successful overlay of caches
  - Your map must match the coordinate system of the service whose tiling scheme you’re using (WGS 84 for ArcGIS Online, WGS 84 Web Mercator for VE/Google)
Other tiling scheme options

• Select tiling scheme from an existing service

• Browse to a tiling scheme file (9.2 solution)
Cache on demand

How We Watch the City: Popularity and Online Maps
Danyel Fisher
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Figure 1: A heat map of popularity of tiles over the US at level 12 (approximately 40 meters per pixel scale). The brightest points have on the order of half a million hits, while the dimmest visible points show closer to a thousand hits. Note that usage patterns at this scale seem to follow population. Inset: mapping imagery at the level (but not size) represented by one pixel.
On-demand caching

- Creates tiles as they are visited by users and adds them to your cache
- First visitor to an area must wait for the tiles to be created

- Enable in ArcCatalog or Manager
  - Use the Caching tab of the Service Properties
Performance tips for on-demand caching

- Use with ArcGIS Server Internet connections

- Tip: Pre-create tiles for areas that you anticipate will be most popular, then create the rest on demand
Cache by feature class

- Cache only within boundary of features you supply
  - You can supply a feature class with just one feature
  - Avoid numerous features or geographically small features

- Saves time and disk space

- California example:
Cache by feature class

- Set the feature class in the Manage Map Server Cache Tiles tool

- Optionally, track the status of which features have been cached

- Tip: Create the rest of the tiles on demand
Fixed memory leak / locking situations

- Affects caching scenarios with:
  - SDC data
  - Compressed File Geodatabase data
  - TIFF images
  - MrSID images
Add and remove scales from an existing cache

• Use the Manage Map Server Cache Scales tool

• Edits the cache configuration and the cache folders on disk
Improvements to ArcMap as a client

- Improved display of resampled cached tiles
  - Improves the look of ArcGIS Online Street Map
  - Helps eliminate issues like “disappearing boundaries”:
Improvements to ArcMap as a client

- Zooming in past the lowest level uses a resample of the last available resolution

- New Caching tab on the layer properties
Client-side caching improvements

- Clients can opt out of caching locally
- Server administrators can prohibit local caching of tiles on client
  - Set in Caching tab of Service Properties
  - Use this option if you’re updating your cache frequently
WMS services take advantage of cache

1. Enable the WMS capability on a cached map service
2. The WMS service will use the cached images instead of generating an image on the fly

• Only uses cached images when there is no need to change projection, layer order, layer visibility, background, etc.
Updated documentation

- Caching Help greatly expanded between 9.2 and 9.3

- Web help is constantly updated
  - Web Help is available at 9.3 Beta (requires a login):
    [http://webhelp.esri.com](http://webhelp.esri.com)

- [ArcGIS Server Development Blog](http://webhelp.esri.com) posts address specific problems and are later moved to the web help
9.3 caching demo

1. Open ArcMap and show projection
2. Build a full cache for small scales (zoomed out)
3. Create the rest of the tiles on demand
In Conclusion...

- Slides and code will be available on EDN
- Please fill out session surveys!
- Still have questions?
  1. Tech talk, Meet the Team
  2. “Ask a Developer” link on web page