Sun GlassFish Web Stack Deep Dive

Apache HTTP Server Performance

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What role can Apache play in the performance of the overall system

Alternatives (Lighttpd, Sun Web Server)

Tuning for capacity and performance

Agenda

- Why Apache
- Key choices to make
- Configuring Apache for capacity
- Configuring Apache for performance
- For more information

Why Apache

- First: Don't choose Apache over other web servers for performance reasons
- Consider also Sun Web Server and Lighttpd
  - Both use fewer system resources per client than Apache
  - Both can provide higher response rates than Apache
  - Both of these, in addition to Apache, are covered by GlassFish Portfolio support subscriptions

Why Apache

- If it is bloated and slow, why does it still matter?
  - Rich set of features, along with configurability
  - Multitudes of plug-in modules available from third parties
  - Extensive documentation
    - From the project itself
    - From the community
    - From traditional publishers
  - Multiple vendors investing in it
    - Sun, SpringSource, IBM, RedHat, etc.
  - Many people skilled in configuration/tuning
  - Analyzed extensively for security flaws
  - Long history of addressing security issues in a responsible manner

Why Apache

- Oh, and it can perform adequately in most circumstances

Why Apache

- From this point forward, we'll assume there's a good reason to use Apache

Key choices to make

- What Apache features can improve overall system performance

- Process model
  - Prefork vs. worker MPM
  - FastCGI vs. in-process script execution

Using Apache to improve application performance

- Not Apache tuning *per se*
- What Apache features can I use to improve overall application performance
  - Whether or not it makes Apache slower or makes Apache consume more resources

Using Apache to improve application performance

- Several common areas:
  - Cache
  - Compression
  - Load-balancing to back-end servers

Using Apache to improve application performance - Cache

- Manipulating cache headers for use by client and network caches
  - If application doesn't generate those
- Apache's cache
  - Request still reaches Apache but is served from static file on disk (VM) instead of forcing application to render again

Adding Expires headers

- If the application doesn't set Expires headers so that the browser (or cache) knows how long the response is valid, Apache can add these via mod_expires
  - Uh, only if the resource won't change for the configured time, or the browser doesn't actually need to see the changed version for the configured time

Adding Expires headers

- Here's what it looks like:

```
<Location /my-status-app/>
 ExpiresActive On
 # The response is valid for the next hour.  Browsers
 # don't have to request it again.
 ExpiresDefault "access plus 60 minutes"

 </Location>
```

Any of Apache's configuration containers can be used for this.

Adding Expires headers

- Special concern:
  - Once the response is sent, it can affect not just the client that requested it but also network caches.
  - If you really really need to start serving an updated version of the resource, some clients will just have to wait.

Apache's cache

- mod_disk_cache is the only actively developed cache bundled with Apache
  - mod_mem_cache probably *needs* active development
  - Other, simpler caching is of more limited use (e.g., mod_file_cache)
- Typically used for dynamic content
- Also useful when data is stored on slow (network?) disks and the cache can be kept on fast local disks
- You still need cache information from the application (or added by Apache as in the previous mod_expires example).

mod_disk_cache

- If you're using it to avoid requests to the application, you can get value from it with complete control over caching (i.e., retain ability to start sending new content immediately):
  - Use mod_expires to add the Expires headers so that it is cacheable (locally)
  - Remove this information with mod_headers before the response is generated.
  - If you have to start sending new content immediately, it is only cached locally via mod_disk_cache, so remove the cache files with htcacheclean.

mod_disk_cache – for more information

- http://blogs.sun.com/trawick/entry/caching_dynamic_content_with_apache

Using Apache to improve application performance - Compression

- Much of web traffic is highly compressible (HTML, JavaScript, style sheets)
- Spending CPU in the web server to compress output can significantly improve user experience
- Use mod_deflate's DEFLATE filter
  - Simple to configure; check the Apache docs at

    http://httpd.apache.org/docs/2.2/mod/mod_deflate.html

Using Apache to horizontally scale applications

- Reverse proxy to the application server (GlassFish, Tomcat, Mongrel, etc.)
- mod_jk is a traditional implementation
  - Well documented for use with Tomcat
  - Use with GlassFish is described in a number of blog articles
- Apache 2.2 brings
  - mod_proxy_ajp (AJP protocol, like mod_jk)
  - mod_proxy_balancer (balancer supports AJP protocol like mod_jk, but also supports traditional HTTP proxy too, for use with Mongrel or anything else)

More on mod_proxy_balancer

- Here's a detailed article on using mod_proxy_balancer, plain HTTP proxy, and Mongrel (for Rails):

  http://blog.innerewut.de/2006/4/21/scaling-rails-with-apache-2-2-mod_proxy_balancer-and-mongrel

Process model

- Prefork vs. worker MPM

Prefork MPM

- One single-threaded process per active connection
  - Matches Apache 1.3 processing model
- Most commonly used
  - Prefork is the default or only MPM provided by a number of vendors
- Compatibility with the most modules
  - Recommended for mod_php
  - Required for mod_perl if Perl interpreter doesn't support threads
- Avoids concurrency bugs in plug-in modules, or concurrency-related performance issues in libraries
- More limited damage from vulnerabilities or crashes
  - Complete isolation of client requests

Prefork MPM - drawbacks

- Uses the most resources
  - Requires a surprising amount of swap space on Solaris
  - Larger working set (physical memory)
- Poor utilization of per-process state, such as
  - Retained connections to other servers, such as
    - Java application server
    - LDAP server
  - Process-memory caches
- Requires more difficult shared memory + cross-process synchronization to effectively share computed information (e.g., APC)
  - So often not implemented

Worker MPM

- New with Apache 2.0
  - Extensively used in production environments since 2002
- Minimizes memory consumption
  - Unlike prefork, doesn't require surprising amounts of swap space on Solaris
  - Smaller working set
- Can allow effective utilization of retained state without more-difficult shared memory implementation
  - Increasing effectiveness with lower number of child process

Worker MPM, retained state

- In-memory caches
- Server connections
  - Application server
  - Database connection
  - LDAP server connection
  - All can be much better utilized by using worker instead of prefork
  - Ouch! if a connection retained by a prefork process (in hopes of handling a request again soon) consumes significant server resources

Worker MPM - drawbacks

- Occasional issues with releasing resources as child processes exit (more later)
- Maximum exposure to vulnerabilities and other bugs
  - Information for other users could be retrieved
  - If processing for one user triggers a crash, other users are impacted

    (can be mitigated somewhat by reducing the number of threads per child)

Tuning for capacity

- What does this cover?
  - How many clients can I support
  - How much of my system can Apache use?

Tuning for capacity

- How many clients can I support?
  - This is relatively simple (essentially MaxClients).

    (more later on that)

Tuning for capacity

- How much of my system can Apache use?
  - This is quite important, but Apache puts all the work on the system administrator
  - Administrator must set MaxClients low enough to avoid running out of
    - Swap space
    - Physical memory

    yet high enough to serve enough clients.
  - Observation required for new Apache or application deployments (mod_status, vmstat, etc.)

Tuning for capacity

- Special Solaris issue
  - Solaris allocates swap space based on the virtual memory size of each process, including code that is shared among the Apache processes
    - Removing code lowers the swap requirements (times number of child processes)
  - Comment out any unnecessary LoadModule directives before working on capacity
  - If using in-process PHP (mod_php), disable any unused extensions as well.

Tuning for capacity - Keep-Alive

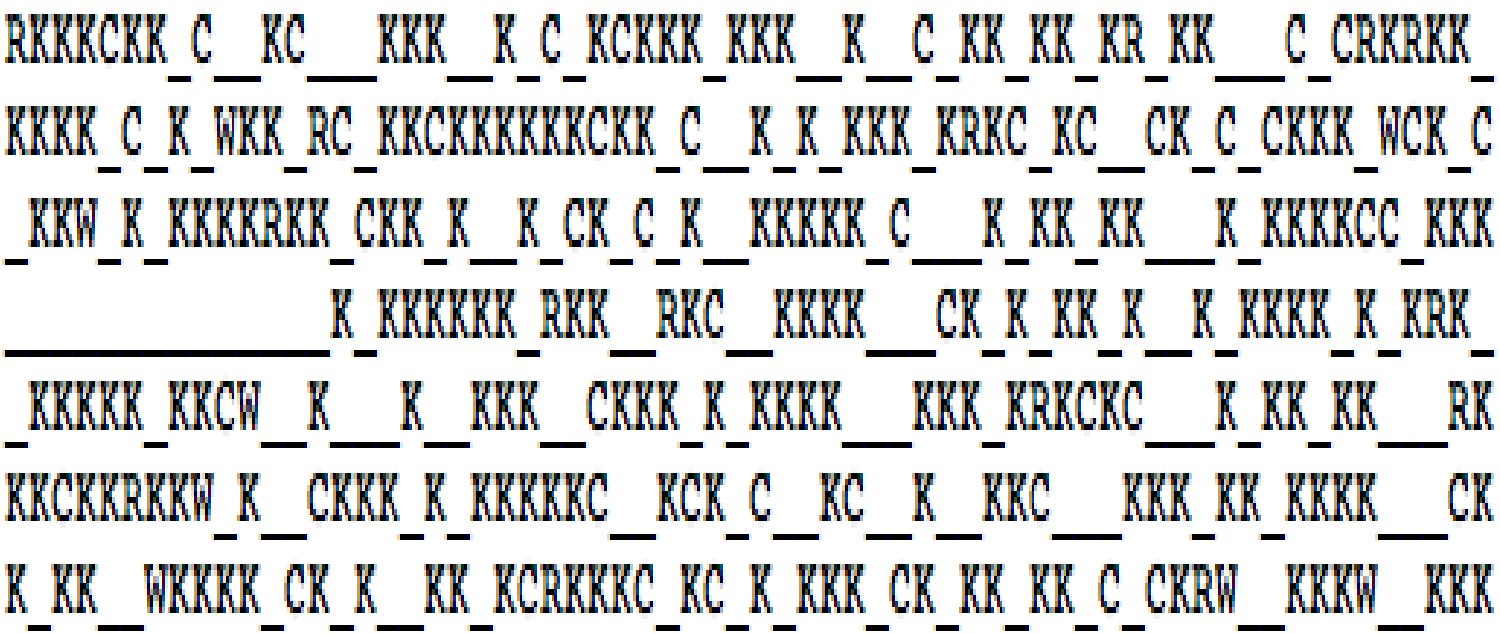
- KeepAlive {On|Off}
- KeepAliveTimeout [timeout-in-seconds]

- Because Apache* dedicates a processing thread to connections in keep-alive state, this is a capacity concern in addition to a performance-tuning issue

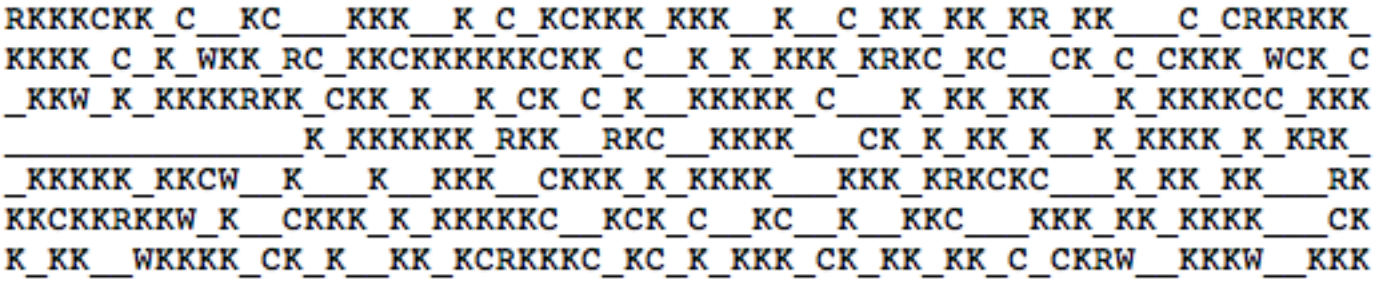
- Reduce the number of processes (prefork) or threads (worker) required by reducing KeepAliveTimeout to a small value (e.g., 2 seconds)

  *The Event MPM handles Keep-Alive state without a dedicated thread. (Event as default MPM for 2.4?)

Tuning for capacity - Keep-Alive



What does this mean?



- If we need to increase the number of clients we can handle, and/or reduce system resources:
  - Reduce KeepAliveTimeout

Tuning for capacity

- Capacity of Apache vs. capacity of back-end servers
  - There's almost never a 1:1 mapping between Apache and a back-end server
    - Either Apache off-loads certain types of requests or loadbalances to multiple back-ends (*usually*)
      - Apache will be handling more clients than a particular back-end server
  - Be aware that increasing Apache's capacity beyond that of back-end server(s) can use extra system resources without much benefit (under heavy load and/or when the application isn't responding)
    - Example trade-off: Browser reports that the site is unavailable, vs. application renders a page indicating that there are too many database connections in use (the latter exacerbating the capacity problem)

Cleaning up Apache child processes (Capacity?)

- "Set MaxSpareServers/MaxSpareThreads kind-of low so Apache doesn't use so many processes/memory/whatever"
  - What's missing here? Apache essentially "owns" or has reserved enough system resources to run at maximum capacity 24x7.
  - If user load increases or an application slows down, Apache can very rapidly reclaim the resources. In other words, you can't use them for anything else.
  - But there's a valuable side-effect to idle process termination that affects other servers: Any retained connections (app server, DB, LDAP) will be cleaned.
    - Very important with prefork, since such connections are so poorly utilized to begin with. (not so important with worker unless ThreadsPerChild is low)

Cleaning up Apache child processes

- How?
  - MaxSpareServers (prefork), MaxSpareThreads (worker)
    - Reduce process count when load subsides
  - MaxRequestsPerChild
    - Special purpose: work around memory or other resource leak
  - Graceful restart

Worker MPM and child process exit

- Maybe it is helpful for us to terminate excess processes (e.g., to terminate retained back-end connections)
- Worker has a special problem:
  - A child can't exit (i.e., *release resources*) until the last client connection handled by the process has finished.
  - The occasional hung or very long running request is not uncommon in some environments.
    - Worst case: Because of trying to keep the process count low in presence of hung requests, you can accumulate a huge amount of processes with only 1 or 2 active threads. The bulk of system resources is still used.
- Ouch! You need to use MaxRequestsPerChild to work around a leak, but a small number of requests take a very long time.

Prefork MPM and child process exit

- A child process only handles one client connection (if not idle), so no special issues surrounding child process exit

(well, third-party modules can create some havoc in their child exit handlers, but I haven't seen that in a while)

Tuning for performance

- What does this cover?
  - After establishing the big picture (what role does Apache play, what MPM is used), minimize system resources used and/or improve response times.

Tuning for performance – Prefork MPM

- StartServers, MinSpareServers, MaxSpareServers
- StartServers can speed up the rate at which Apache can start handling high load (useful if behind a load balancer which can suddenly divert a lot of traffic)
- If StartServers > MinSpareServers and there's no initial burst of traffic, Apache will create a bunch of children at startup then start terminating them (waste)
- If you don't get a burst of traffic initially, don't worry about StartServers (but don't set it real high).

Tuning for performance – Prefork MPM

- Keep in mind the proportions of MinSpareServers and MaxSpareServers to MaxClients
- Some people scale up MaxClients drastically, but don't scale up MinSpareServers/MaxSpareServers.
  - Apache ends up terminating/creating child process when the server load changes by a very small amount
  - Consider MaxSpareServers 100 and MaxClients 8192
    - If load decreases by just over 1% of the overal max, Apache will terminate child processes (and likely have to create more soon after).

Tuning for performance – Prefork MPM

- Is this bad?

  MaxClients 1024
  MinSpareServers 256
  MaxSpareServers 256

- Yes; constant termination/creation of child processes

- Mind the gap (between Min and Max).

Tuning for performance – Prefork MPM

- What about ServerLimit?
  - Most people can sleep well not knowing the details and simply setting ServerLimit = MaxClients.
  - ServerLimit is the number of process slots in the Apache scoreboard, which can't be reallocated across graceful restart.
  - Thus, if you want to change MaxClients across graceful restart, you can't make it higher than ServerLimit (and you can't change ServerLimit).

Tuning for performance – Worker MPM

- Much the same as prefork, but with an added dimension – threads per child.

- Higher ThreadsPerChild:
  - Lower overall memory use
  - Better utilization of per-process resources like reusable back-end connections
  - (Potentially) Higher thread contention
  - Higher risk of information leaking from another thread
  - More clients impacted if one client triggers a crash

Tuning for performance – Worker MPM

- Special file descriptor-based issues with higher ThreadsPerChild
  - Traditionally some third-party modules used select() on back-end connections, and blew up with fds > 1024
    - Limit ThreadsPerChild to 500 or so
      - 500 client connection sockets
      - 500 backend connection sockets
      - Log files, listening sockets, etc.
  - Traditionally some third-party modules or libraries used used fopen() on Solaris failed unless a free fd under 256 was available.
    - Web Stack's Apache delivery resolves that

Tuning for performance – Worker MPM

- Similar to prefork MPM, but “Thread” instead of “Server”
  - Pay attention to the proportion of MinSpareThreads and MaxSpareThreads to MaxClients, and to the difference between them
  - MaxClients 8192, MinSpareThreads 96, MaxSpareThreads 192
    - Probably means endless work
  - For MaxSpareThreads (cleaning up extra processes), remember worker's special issue when some occasional requests are long-running

Tuning for performance

- Other usual suspects
  - Avoid DNS lookups
    - HostnameLookups Off
    - Allow/Deny from IP address (instead of hostname)
  - Don't force Apache to look for .htaccess files in every directory down to the file
    - AllowOverride None
    - If you must use .htaccess, allow in minimal set of directories.
  - Don't load modules you don't need
  - Avoid excessive logging
  - Don't force Apache to check if parts of the path down to the file are symlinks
    - Use option FollowSymLinks
    - Don't use option SymlinksIfOwnerMatch (what about about untrusted users?)

Tuning for performance

- Concerns with untrusted users managing part of the web space
  - You don't want Apache blindly following symlinks
    /export/home/joeuser/public_html/index.htm → /etc/xxx
    - Disabling FollowSymLinks will force Apache to use lstat() on each directory/file under the user's control
  - They can't control httpd.conf, but maybe they need to control mod_autoindex or mod_rewrite or XXX
    - The AllowOverride will force Apache to look for .htaccess files

Memory-related tuning

- ThreadStackSize
  - Worker MPM only, and only for worker threads
    - use ulimit for prefork stack size or worker main/listener threads
  - On Solaris, it is rare that you need to *increase* it
  - You can decrease it from the default
  - A good place to start: ThreadStackSize 131072

Memory-related tuning

- Apache retains memory obtained during request processing to be used on future requests on the same thread
- If some relatively infrequent requests consume significantly more memory than usual, releasing this extra memory at the end of the connection can lower overall process memory usage
- MaxMemFree number-of-kbytes
  - Release any additional memory beyond this amount back to the heap
- Most effective with worker, since memory released to the heap can be utilized by another thread

KeepAlive and KeepAliveTimeout

- Discussed previously because of its capacity ramifications
- Important to have KeepAlive On because of typical application behavior with client fetching images, stylesheets, and javascript files on the same connection
- Decrease KeepAliveTimeout to a few seconds to get the most benefit without using too many processes/threads

KeepAlive and KeepAliveTimeout

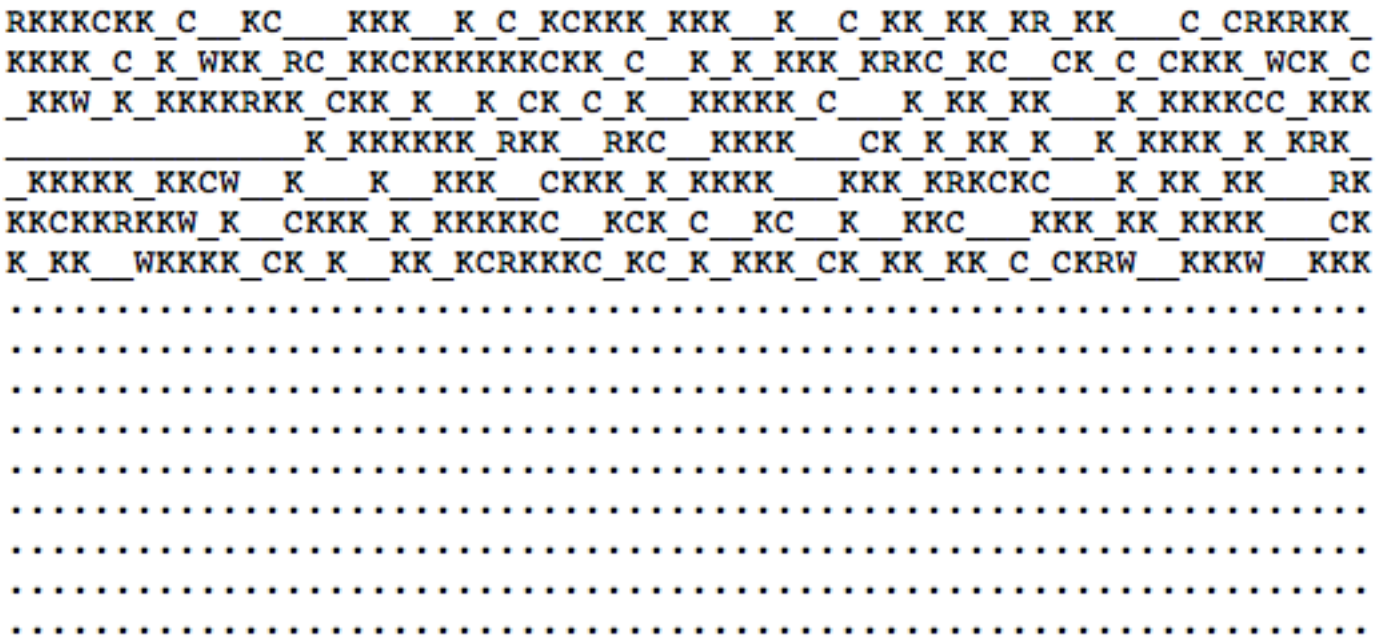
- SSL-enabled virtual hosts
  - A higher KeepAliveTimeout can be beneficial here, since extra processing is required even when an existing SSL session is resumed.
    - Not effectively resuming (reusing) SSL sessions? Fix that first.

ExtendedStatus

- ExtendedStatus is a directive of mod_status
- When On, Apache core saves more information in the shared-memory scoreboard for use (display) in the mod_status report (or retrieval by some third-party modules)
- As is often noted, it does increase CPU utilization
  - Typically < 1%
  - The detailed status reports are important for debugging
  - Set ExtendedStatus On and don't worry about the performance hit (assuming you use mod_status reports).

ExtendedStatus

- Information available with ExtendedStatus Off



ExtendedStatus

- Information available with ExtendedStatus On
  - The map on the previous slide, plus

Srv	PID	Acc	M	CPU	SS	Req	Conn	Child	Slot	Client	VHost	Re
0-54	25189	0/104/789374	R	33.94	32	2	0.0	0.39	165512.81	?	?	..reading..
0-54	25189	1/82/792723	K	45.65	2	2	6.3	7.87	165845.25	64.0.193.26	httpd.apache.org	GET /docs/2.0/images/feather.gif HTTF
0-54	25189	1/199/795400	K	45.44	4	75	9.2	1.57	164337.11	116.48.4.7	archive.apache.org	GET /dist/ HTTP/1.1
0-54	25189	1/99/797657	K	45.36	4	2	0.6	3.41	162550.19	65.55.106.206	beehive.apache.org	GET /docs/1.0/apidocs/classref_netui/in
0-54	25189	1/197/800017	C	45.22	1	3	1.6	0.50	164994.16	117.32.175.233	commons.apache.org	GET /dbcp/guide/index.html HTTP/1.1
0-54	25189	1/82/795696	K	45.46	3	226	0.1	0.40	163812.33	92.103.136.180	httpd.apache.org	GET /docs/2.2/images/down.gif HTTP/
0-54	25189	2/73/800799	K	45.69	2	2	9.3	5.72	166740.20	15.203.233.79	incubator.apache.org	GET /images/apache-incubator-logo.pn
0-54	25189	0/91/799160	_	43.37	17	7	0.0	3.70	169419.78	115.102.39.34	archive.apache.org	GET /dist/struts/binaries/struts-2.0.12-al
0-54	25189	1/91/806100	C	45.24	1	10	6.0	1.14	163802.28	62.177.71.161	geronimo.apache.org	GET /style/default.css HTTP/1.1
0-	25189	0/86/809149		44.49	11	3	0.0	5.26	171098.64	61.247.222.55	activemq.apache.org	GET /robots.txt HTTP/1.1

SSI (Server Side Includes)

- This type of document requires expensive processing to parse and evaluate SSI tags (e.g., for including a header or footer)
  - mod_include implements SSI for Apache
- Many examples show SSI documents with a special file extension – .shtml instead of .html
- What if you don't want to expose that odd extension?
  - Naïve implementation: Just pass all .html files through mod_include
    - Needless processing for non-SSI files
  - Better performance: Set XbitHack On and run “chmod u+x” on just the files that have SSI tags
    - No parsing of non-SSI files

Sendfile*v*

- The idea: let the kernel do more of the work to send file contents to the client
  - Fewer syscalls (no explicit read of file or write of socket)
    - Can be fewer user space dispatches too
  - VM magic
- Controlled by EnableSendfile {On|Off}
- Currently disabled in Web Stack's Apache delivery
  - Past system issues with sendfilev
  - Past performance issues
- Need to revisit
  - A lot of sendfile work went into 2009.06

Mmap-ed files

- The idea: let the application reference file contents like memory
  - Fewer syscalls (no explicit read of file; still must write to socket)
  - VM magic
- Apache generally uses mmap-ing when reading files, such as for SSI processing or just sending the contents as-is (when sendfile isn't used)
- In a number of cases, performance has improved on Solaris after disabling this (EnableMMap Off)

TCP-related tuning

- SendBufferSize
  - Solaris defaults to a fairly large value (1MB?), which is usually sufficient
  - Large values prevent Apache from waking up often to pass more data to the TCP layer (as the client ACKs previous data)
- This setting specific to Apache avoids needing to change the global Solaris default, which is often recommended.

TCP-related tuning

- ReceiveBufferSize
  - Same as SendBufferSize, but for large request bodies sent by clients (e.g., uploaded files)
- This setting specific to Apache avoids needing to change the global Solaris default, which is often recommended.

TCP-related tuning

- tcp_conn_req_max_q0, tcp_conn_req_max_q, and ListenBacklog
- Don't bother setting a high ListenBacklog without also adjusting tcp_conn_req_max_q (and don't bother setting that high without setting _q0 at least as high).
  - Jeff's recommendation: Leave these alone until you see connections getting dropped.
    - Run 'netstat –s | fgrep –i listendrop'. If tcpListenDrop is non-zero, increase tcp_conn_req_max_q. If tcpListenDropQ0 is non-zero, increase tcp_conn_req_max_q0.

http://blogs.sun.com/terrygardner/entry/solaris_tcp_ip_parameters_tcp

Further topics to explore

- Effects on performance when switching from in-process interpreter (e.g., mod_php) to FastCGI mode
  - FastCGI apps can be multi-instance but don't handle concurrent connections, thus avoiding potential problems with the worker MPM, and thus allowing system resource use to be decreased via MPM choice
- SSL tuning, including Solaris' Kernel SSL

For more information

- Apache's performance tuning guide
  http://httpd.apache.org/docs/2.2/misc/perf-tuning.html

  (But some out of date information, or hints for build-time tweaks)

- Yahoo's “Best Practices for Speeding up your Web Site”
  http://developer.yahoo.com/performance/rules.html

  (Mostly in the application domain)

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