The purpose of this Technical Note is to provide insight into the workings of certain aspects of the AWS 95 so that a person can make educated decisions on what and how to best configure and size the AWS 95 for better performance. Before getting into details about how to tune the AWS 95, the first section will discuss what kind of performance to expect from the AWS 95, as well as explain the benchmarks that were used at Apple to measure performance. The sections of this document which deal with the AppleShare Caches also apply for AppleShare 4.0 performance tuning.

AppleShare/Workgroup Server Performance Explained

There has been some confusion among many customers and Apple field personnel about the actual performance of AppleShare Pro and the Workgroup Server 95. The most common question seems to be, "How do I achieve the 'up to 4 times the performance of AppleShare 3.0' claim that Apple has made?"

The following is a discussion of server performance benchmarks and what they mean in terms of "real world" performance. This discussion will attempt to explain our performance claim and back it up with some benchmark results from our engineering teams.

Server Benchmarking

There are two ways to benchmark a server. You can measure the throughput of the

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August, 1993
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September, 1993

server (network I/O capacity) or you can measure user response time (how long it takes to perform an operation - like copy a 1 MB file to or from a server). Measuring throughput gives a very accurate measure of the server's capability to deal with data (either reading from disk or writing to disk). Measuring user response time is usually not as accurate as it can be skewed by the behavior of certain applications.

It's interesting to look at how various publications treat benchmarks in general. Macintosh-oriented publications like MacWeek and MacUser will primarily use user response time to measure everything from an accelerator card to an application to a server. Meanwhile, PC-oriented publications like PC Week and Infoworld will primarily use server throughput to measure performance.

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What We Did For The AWS 95

We chose to use server throughput to benchmark the AWS 95 so that we could tune it for performance. We didn't want to introduce any extraneous factors into our tests such as how HyperCard handles I/O or how the Finder buffers data before copying it. However, it seems that many of our customers use these applications to attempt to measure performance.

Our results showed the AWS 95 running AppleShare Pro to have a maximum aggregate throughput (for Sequential Read operations) of approximately 850 KB/Sec under significant load and about 585 KB/Sec with no load (because the server can take more load than one client can generate). AppleShare 3.0 running on a Quadra 950 came in around 210 KB/Sec under the same amount of load and about 400 KB/Sec with no load (3.0's overall throughput actually degrades with more users since the random nature of multiple users accessing the server causes the disk to lose any of its inherent read-

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ahead capability). Performance for Sequential Writes showed AppleShare Pro to be around 2.2 times the throughput of AppleShare 3.0 under load.

What Does This Mean For Users

Without getting too technical, throughput of 585 KB/Sec means that 1 user will see 585 KB/Sec. At about 5 users, the AWS 95 has reached its maximum throughput of 850 KB/Sec. So 5 users will see 170 KB/Sec each. 50 users will get 17 KB/Sec each. Our user studies have shown >15 KB/Sec to be adequate performance, which is why we chose 50 "active" (i.e., simultaneously reading from or writing to the server) as the limit for AppleShare Pro.

AppleShare 3.0 has 400 KB/Sec of throughput for 1 user. Then the throughput begins to degrade and by 5 users the throughput has hit 210 KB/Sec. So 5 users see about 42 KB/Sec each. AppleShare 3.0 reaches the point where users don't consider the performance acceptable at around 10 - 12 active users (210/12 = 17.5 KB/Sec).

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What Does This Mean In The Real World

Reading data from the AWS 95 (like playing a QuickTime movie or opening a PhotoShop document) under heavy load will show the performance to be roughly 4 times that of AppleShare 3.0 under the same load.

Writing to the AWS 95 is slightly slower than reads. This is due to the fact that the A/UX 3.0.1 was tuned for Read performance. The good news is that users tend to read from a server much more often than they write. Novell has been quoted as saying that the ratio of reads to writes is as high as 25 to 1. Consider an E-mail application. An e-mail memo may be written to the server once but then read many times by many users. In order to bring the product to market quickly, we chose to concentrate more on optimizing read throughput rather than write throughput.

AppleShare Pro is about 2 times faster under load than AppleShare 3.0 on a Q950 when performing a task which we call "enumerating". Enumerates occur when a client opens a window in the Finder (or an Open File dialog box) and when determining file

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sizes and modification dates. Therefore testbeds that cause a lot of enumerates to occur (i.e., many small files stored on the server) will not show as large of a differential between AppleShare Pro and AppleShare 3.0 performance. This is an area that we plan to address in the future.

So, making claims about server performance is obviously very complicated. There are no standards for benchmarks for file/print service and everyone has an opinion about what constitutes good server performance. With the AWS 95, we feel that we have provided a high-performance, scalable (i.e., can handle many users simultaneously) server that will significantly outperform AppleShare 3.0 and be competitive with offerings from the other major server vendors.

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AppleShare/Workgroup Server Configuration & Sizing Specifics

Overview of tunable parameters

The following is a description of each of the components of the AWS 95 which can be adjusted to maximize server performance.

UNIX buffer cache Overview

In order to optimize disk I/O performance the A/UX operating system manages a pool of memory which functions as a cache for recently used disk blocks. This memory is known as the A/UX buffer cache. A full discussion on the implementation of the A/UX buffer cache is beyond the scope of this document, but it's basic function can be described as follows.

When a request is made to read/write a block to/from the disk, A/UX first checks to see if the requested block is currently in the buffer cache. If so, the data is either copied to the buffer in the case of a write, or handed back to the requesting process in the case of a read. In either case no disk I/O is required. On the other hand, if the disk block requested is not in the buffer cache, A/UX must first free up a buffer from the buffer cache in which to read/write the data. If there are no buffers available for

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use, A/UX uses a Least Recently Used (LRU) algorithm to determine which buffer to evict from the buffer cache. If a buffer has been chosen for eviction, and the buffer is marked as dirty (the data in the buffer has changed since it was read in from disk) then it is written out to disk and the buffer is available for use. Using this type of policy, A/UX can satisfy approximately 80-85% of read/write requests without actually performing disk I/O.

UNIX buffer cache Sizing

1. On a machine whose primary purpose is serving files, the size of the A/UX buffer cache should be maximized. A rule of thumb to be used is to reserve 4 megabytes for the Unix kernel and the size of the Macintosh emulator environment (by default, 16 megabytes). Thus if a machine has 32 MB of physical RAM, about 12 MB should be allocated to the A/UX buffer cache.Using this algorithm should prevent paging from occuring, which would significantly reduce the performance of the system,
2. In Database server configuration it is possible for the database application to store it's data on a raw disk partition as opposed to on a partition which has a UFS file system. This means that the database data will not be cached in the A/UX buffer cache, thus the size of the buffer cache can be reduced.

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AppleShare File Read-ahead/Write-behind Buffers

Overview

When transferring sequential data to/from a disk, throughput is much higher if a single, large read/write is issued to the disk as opposed to many, smaller reads/writes. The reason for this is that the bottleneck in disk I/O is not the raw transfer speed of the device, rather, it is the time it takes to seek to a given spot on the disk and the time wasted waiting for the target sector to rotate beneath the read-write head (rotation latency). To optimize performance AppleShare Pro and AppleShare 4.0 utilize a read-ahead and write-behind strategy. This means that when a read request is received from a client, instead of simply reading in the requested block(s) and handing them to the client, the knowledge that most files are stored contiguously on the disk is used to anticipate that the next read issued from this client will most likely be for the next block on the disk. Thus the number of separate disk requests can be minimized by simply issuing a larger disk request initially and storing the data in a buffer until the data is actually requested. This same logic

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applies for writing to the disk; the data from many small writes is collected and saved in a buffer before one large write is finally issued to the disk.

AppleShare Pro and AppleShare 4.0 allow the administrator to specify the number of read-ahead/write-behind buffers available, and also the size of each of these buffers.

Sizing

The "Rules Of Thumb" for setting these values are as follows.

1. Allow 1 file buffer for each simultaneous ACTIVE user on the system. An active user is a user who is currently accessing a file, not merely logged into the server.
2. If there are no large files being shared then the size of the file buffers need not be any bigger than the size of the largest file being shared.
3. If there are large files being shared then the size of the buffers should be as large as possible considering the memory available for AppleShare 4.0. On AppleShare Pro, however, setting the size greater than 64K will not improve performance.

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AppleShare Directory/Icon caches

Overview

AppleShare Pro and AppleShare 4.0 maintain two separate caches. the Directory cache and the Icon cache. The Directory cache stores data obtained from directory enumeration's. The Icon cache stores the bitmaps of specialized Icons.

AppleShare Pro and AppleShare 4.0 allow the administrator to control the size of each of these caches.

Tuning the Directory Cache

1. A rule of thumb to use is .2 KB of Directory cache space times the total number of files and folders being shared. Thus if a file server is sharing a total of 10000 files and folders, the Directory cache should be set to 2 MB.
2. If it is known that only a certain percentage of the files and folders being shared are usually active then the Directory cache size can be adjusted according to this percentage.

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Tuning the Icon Cache

1. If no actual Finder browsing is being done (or other type of action which displays icons) on the shared volume(s) then the Icon cache should be eliminated.
2. If there are large numbers of 32-bit color icons on the volume(s) being shared the size of the Icon cache should be maximized. To support 100 sets of full color icons, you should use 256K of Icon cache.

Virtual Macintosh Memory Partition

Overview

Under A/UX, Macintosh application services are provided by a set of UNIX processes. This means that all Macintosh applications, including the File and Print servers, run in this virtual Macintosh environment. A/UX allows the administrator to specify the amount of memory to allocate as available for use by the Macintosh applications running in this virtual Mac environment.

Tuning

The default setting for the virtual Macintosh memory partition is 16 Megabytes. Enough memory

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should be allocated to allow for the File Server, including all of it's cache memory

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requirements, the Print Server if applicable, as well as any other Macintosh applications which may be running.

Physical RAM

Adding more physical RAM to the AWS 95 will allow more memory to be allocated to the A/UX buffer cache, virtual Macintosh environment and to the various AppleShare caches, which will usually yield a noticeable performance improvement. It should be noted that adding more physical RAM to a system will not ALWAYS increase the system's performance. A given system's performance may be restricted by other factors besides I/O, such as the CPU, depending on how the server is being utilized. Also, certain file usage patterns may result in inefficient utilization of the various caches, such that increasing the size of the caches will have no effect. As a general rule, physical RAM should be added to the system when it is known that performance is being limited by it's absence.

PDS Card Level 2 Cache

The cache on the AWS 95 PDS card is a Level 2 (L2) hardware cache. In plain English, the cache on the PDS card is simply very fast RAM, all data normally stored in the machine's main memory is first cached in the PDS L2 cache. Just like the A/UX buffer cache acts as a cache for data stored on disk, the PDS L2 cache acts as a cache for

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data stored in RAM.

The PDS card allows us 3 different configurations of L2 cache, 128K, 256K and 512K.

Increasing the size of the L2 cache on the PDS card will usually, but not always, increase overall system performance. We have found a typical performance increase of about 5% per 128K of cache memory. If, for example, a server is primarily used to serve very large files, adding more L2 cache memory may not have a noticeable effect on performance due to the fact that the performance is being limited by how fast data can be read from the disk, but on a database server, the way data is accessed allows the cache to have a bigger impact, so we recommend that database servers use as much cache memory as possible.

As a general rule, the more L2 cache you have, the better your system will perform.

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Interrelationship of tunable parameters

Basic Formula

In order to optimize the performance of a given AWS 95 it is necessary to make intelligent decisions as to where to allocate available memory. The following formula should be used as a rough map of memory allocation and then adjusted according to the specific usage patterns of the server.

1. The A/UX kernel uses approximately 4 megabytes of the total available RAM.
2. RAM should be reserved for the virtual Macintosh environment and other Unix processes.
3. Half of the remaining RAM should be allocated to the A/UX buffer cache.

A/UX Buffer Cache vs. AppleShare Caches

The A/UX buffer cache is the primary disk cache on the AWS 95. It caches all data accessed on both UFS and HFS file systems. It is possible, and sometimes probable that directory and icon data present in the AppleShare caches will also be present in the A/UX buffer cache. For these reasons, if memory constraints require the reduction of any of these caches below their default settings, in most situations, reducing the cache size of the AppleShare Directory or Icon cache would have a better effect on performance than reducing the size of the A/UX buffer cache. This may not be the case in scenarios where the Directory or Icon caches are being utilized very well and

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other file activity is going on which causes the A/UX buffer cache to not cache the directory or icon data as efficiently as the more specific AppleShare caches.

Variables which affect parameter tuning

Running Other UNIX Services

If the AWS 95 is used to provide other UNIX based services (NFS, Mail, News, General use, etc.), dramatic performance degradation may result if the tunable parameters are not adjusted to compensate. As stated earlier, all memory not used by the A/UX kernel and the A/UX buffer cache is available for all other UNIX applications, including the virtual Macintosh processes. If the memory requirements of the UNIX processes and the currently executing Mac applications (including the AppleShare caches) exceeds the amount of memory allocated to them, then paging will occur and performance will suffer. In this type of scenario either the A/UX buffer allocation or the AppleShare cache allocation should be reduced to provide the extra memory required by the additional UNIX services running.

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Performance Pitfalls

Paging

A/UX implements a virtual memory model for memory management. Under A/UX each process is allocated a large virtual address space which is divided into pages. At any given point in time a page of the virtual address space may be either in physical RAM or on secondary storage (the swap device). If the amount of memory left for A/UX processes (memory not directly used by the kernel or allocated to the A/UX buffer cache) is too little, heavy paging may result, incurring lots of disk I/O which in turn degrades overall performance.

If A/UX processes (including core UNIX services, the virtual Macintosh environment, as well as additional UNIX services: X-Windows, FTP, Telnet and general system use) require much more memory than allocated in physical RAM, performance will suffer and the amount of memory allocated should be increased, either by decreasing the memory allocated to the A/UX buffer cache, decreasing the memory allocated to the AppleShare caches, or by adding more physical RAM to the system.

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How To Adjust Tunable Parameters

A/UX Buffer Cache

The A/UX Buffer Cache can be adjusted via the Memory Control Panel (shown below)

• Open the Memory Control Panel
• Adjust slider to desired value
• Restart your Workgroup Server for the change to take effect

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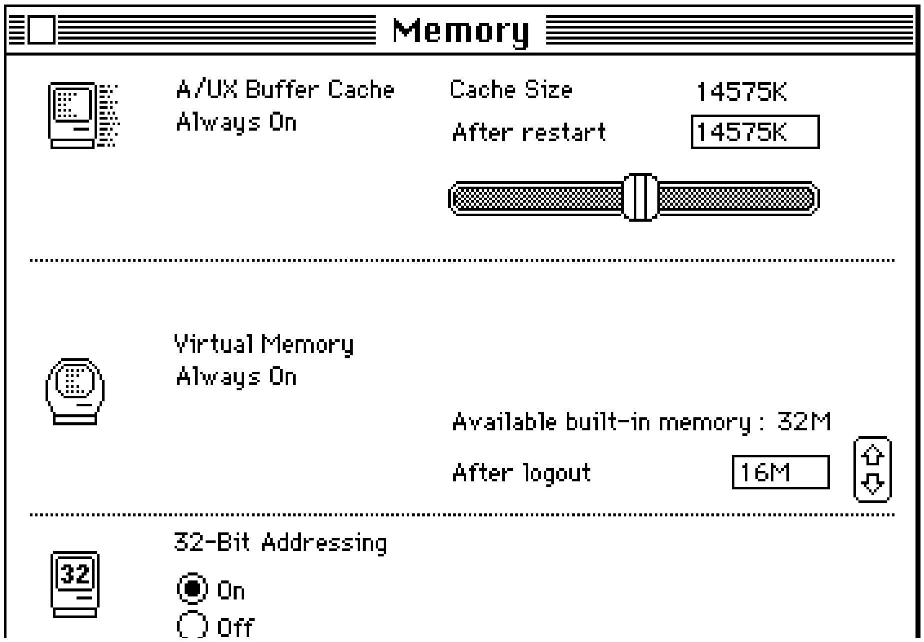

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Figure 1: Memory Control Panel

Virtual Macintosh Memory Partition

The amount of memory allocated to the virtual Macintosh environment can also be set via the memory control panel. Under the virtual memory portion of the Memory Control Panel (See Figure 1), the value contained "After logout" box represents the size of the virtual Macintosh environment. A/UX emulates a Macintosh running System 7 as though the machine has the amount of memory you define in this dialog box.

- Open the Memory Control Panel
- Adjust the "After logout" value to the desired size
- Logout and log back in for the changes to take effect

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AppleShare Caches

The AppleShare Caches: read-ahead/write-behind buffers, Directory cache and Icon cache, can be adjusted via the "Cache Preferences" dialog in the AppleShare Admin program.

- Launch the AppleShare Admin program
- Select the "File Server Cache Preferences" item under the "Server" menu.
- Set caches to desired sizes.
- Restart the AppleShare FileServer for the changes to take effect.

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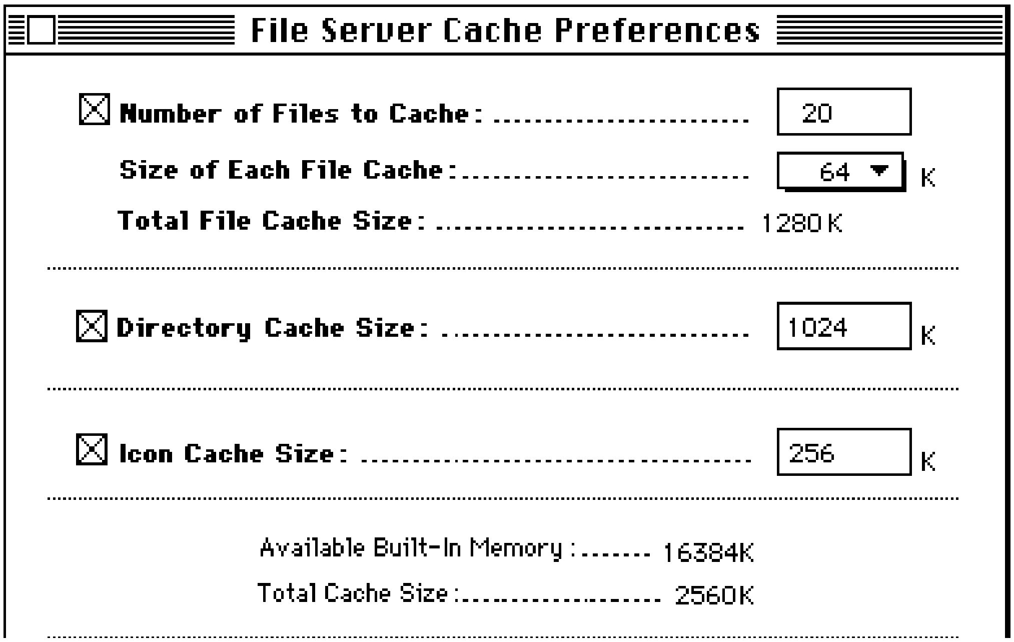

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Figure 2: File Server Cache Preferences Dialog

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