Immersion Week 2003

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Solaris Performance analysis

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Solaris Performance Analysis

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Performance Resources

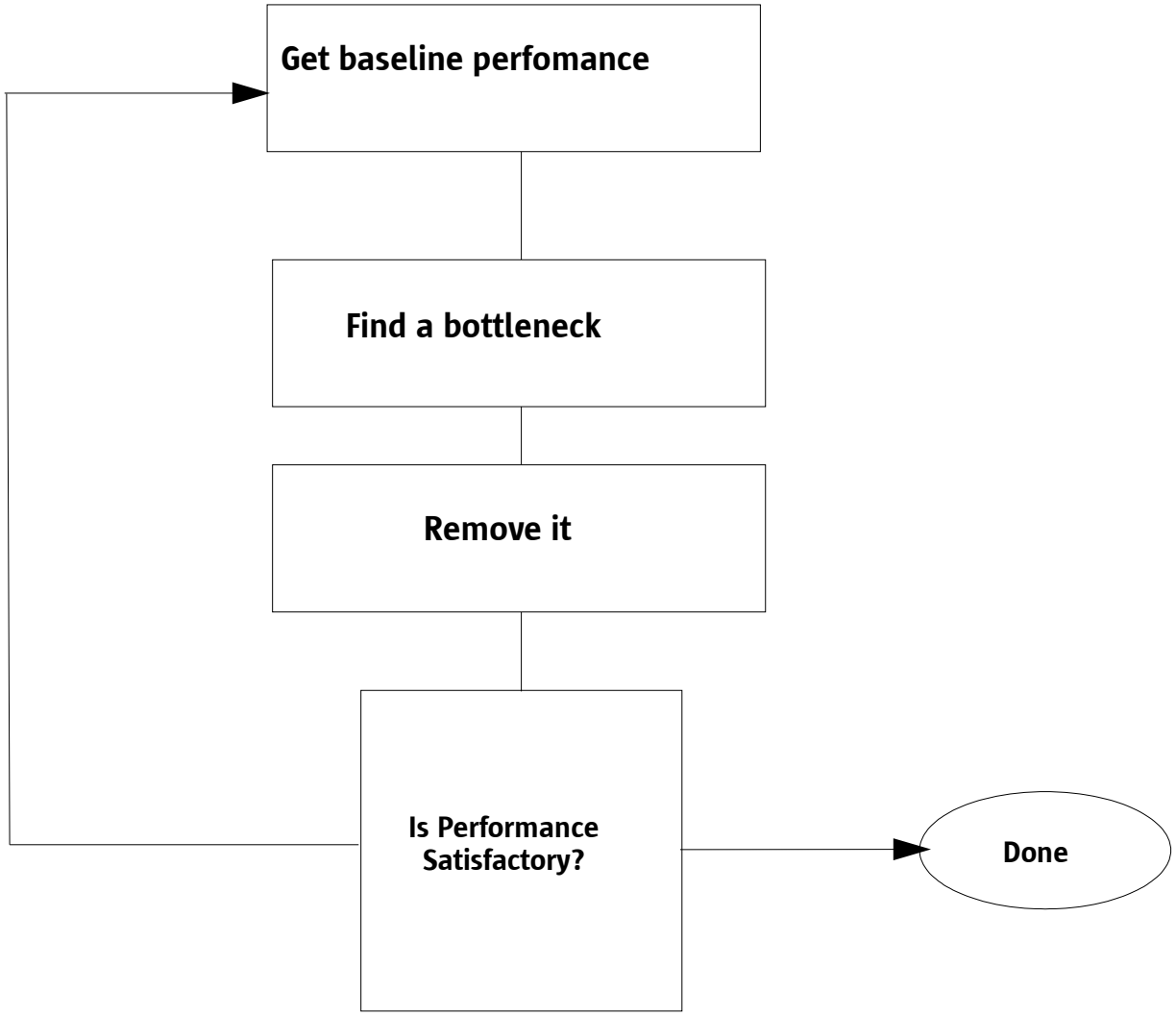
- Brian Wong
  - Configuration and Capacity Planning for Solaris Servers
- Adrian Cockcroft
  - Sun Performance and Tuning
- Rich McDougall and Jim Mauro
  - Solaris internals
- http://www.sun.com/sun-on-net/performance/
- http://www.sun.com/blueprints
- Sun Education SA-400
  - http://suned.sun.com/USA/catalog/

Solaris Performance Analysis Objectives

Upon completion the student will be able to:

- Identify a disk bottleneck using the iostat command.
- Identify and utilize the appropriate commands to locate a CPU performance problem.
- Identify and utilize the appropriate commands to locate a memory problem.

Basic Procedure



Potential Bottlenecks

- Disk
- Network
- Memory
- CPU

Disks Bottlenecks

- Not enough capacity
- Slow response time
- Poor Layout
- RAID configurations
- File system issues
- Database Issues

Identifying Disk bottlenecks

- Use sar, iostat
- look for service time, disk utilization, queue length, uneven distribution
- know whether array caching is being used

Relative Access times

Device	Real time (1s - 1 ns)	Seconds	Relative time
CPU Registers	2 nsec	2×10^{-9}	2 seconds
CPU cache	20 nsec	20×10^{-9}	20 second
Main Memory	200 nsec	20×10^{-8}	2-3 minutes
Disk	20 msec	20×10^{-3}	7 months

iostat -x 30 information

Wait - queue length, number of entries waiting for disk
svc_t - service time in millisec. >50 constantly is bad
%w - percent of time queue occupied
%b - percent busy <30% good >60% bad

```
                    extended device statistics
device     r/s   w/s    kr/s    kw/s wait actv  svc_t  %w  %b
fd0        0.0   0.0     0.0     0.0  0.0  0.0  279.0   0   0
sd0        0.0   0.0     0.0     0.0  0.0  0.0    0.0   0   0
sd1        0.1   0.9     0.7     6.3  0.0  0.1   72.1   0   1
sd4        0.0   0.0     0.0     0.0  0.0  0.0    0.0   0   0
sd6        0.0   0.0     0.0     0.0  0.0  0.0    0.0   0   0
nfs1       0.0   0.0     0.0     0.0  0.0  0.0    0.7   0   0
nfs2       0.0   0.0     0.1     0.4  0.0  0.0  298.1   0   0
 nfs3       0.0   0.0     0.2     0.0  0.0  0.0   35.4   0   0
```

Iostat -x -n -p Example

```
                    extended device statistics
 r/s    w/s   kr/s    kw/s wait actv wsvc_t asvc_t  %w  %b device
46.0    6.6  102.0     7.0  1.8  2.0   33.8   37.2  28 100 c0t0d0
46.0    6.6  102.0     7.0  1.8  2.0   33.8   37.2  28 100 c0t0d0s0
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s1
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s2
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s3
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s7
                    extended device statistics
 r/s    w/s   kr/s    kw/s wait actv wsvc_t asvc_t  %w  %b device
44.8   23.2  221.2    41.7  6.5  2.0   95.1   29.1  63 100 c0t0d0
44.8   23.0  221.2    40.1  6.4  2.0   94.6   29.1  63 100 c0t0d0s0
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s1
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s2
 0.0    0.2    0.0     1.6  0.0  0.0  237.9   26.9   5   1 c0t0d0s3
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s7
                    extended device statistics
 r/s    w/s   kr/s    kw/s wait actv wsvc_t asvc_t  %w  %b device
50.8    0.0  105.4     0.0  0.0  1.9    0.3   38.2   2 100 c0t0d0
50.8    0.0  105.4     0.0  0.0  1.9    0.3   38.2   2 100 c0t0d0s0
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s1
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s2
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s3
 0.0    0.0    0.0     0.0  0.0  0.0    0.0    0.0   0   0 c0t0d0s7
```

What is Service time?

- Time waiting on queue
- SCSI commands
- Head seek (1-15 msec)
- Rotational latencies (0-10 msec)
- Data transfer time
- Interrupt response

What can we do about Disk Bottlenecks

- Balance the load (striping, partitioning)
- More disks
- UFS Logging eliminates fsck
- Distribute swap
- Put related data on same partitions
- Don't fill up the disk
- Add memory (Array Cache/UFS/DB SGA)

Databases and file systems

- Default newfs parameters are NOT appropriate for DB
- UFS single writer lock prevents multiple writes to the same DB file
- use multiple DB files or ...
- use raw disk
- Mount file systems using concurrent direct I/O option

Raw vs. UFS

- Fast
- Eliminates single writer issue
- Difficult to manage
- Difficult to backup
- No cache or buffering

- Slower
- Easier to manage
- Easier to backup
- Listed in vfstab, mount, df, ls
- Cached in RAM

Concurrent Direct I/O

- Introduced in Solaris 8 01/01
- Similar to VxFS Direct I/O
- Approaching raw disk speeds
- Simple mount option
- Best of both worlds, fast and manageable.

DB newfs sample

newfs -i 200000 -c 200 -C 1 -m 0

- Reduce the number of inodes
- increase Cylinders per group
- inhibit read ahead of clusters
- reduce minfree

DB Tunables suggestions for large system

- set maxphys= 8388608 # Large SCSI transfers
- set ufs_LW= 4194304 #increase write throttle for large systems
- set ufs_HW=67108864
- set maxpgio= 65536   #speed up page scanner
- setfastscan= 65536   #speed up page scanner

What is QFS?

- Full 64-bit file system
- High performance parallel operations
- Eliminates some UFS limitations
  - 32K subdirectories
  - 1 TB file and file systems
  - Single writer lock
  - Data sharing
- Optimized for large and many files.

Pop Quiz
File Systems

How much space does newfs reserve on a partition?

Pop Quiz
File Systems

How much space does newfs reserve on a partition?
How can I change this default?

Pop Quiz
File Systems

How much space does newfs reserve on a partition?
How can I change this default?
Why is this a bad idea?

Pop Quiz
File Systems

How much space does newfs reserve on a partition?
How can I change this default?
Why is this a bad idea?
What else can I screw up with newfs options?

Measuring Network Throughput

netstat -i 5
Collision rate = colls / output packets
should be <5%

```
  input   hme0      output           input  (Total)    output
packets errs  packets errs  colls  packets errs  packets errs  colls
 7111436 0     6947310 0     385458 7111436 0     6947310 0     385458
 13      0     0       0     0      13      0     0       0     0
 21      0     1       0     0      21      0     1       0     0
 32      0     18      0     0      32      0     18      0     0
```

Alleviating Network problems

- Subnets
- Switched Ethernet
- Fast, Gigabit Ethernet
- ATM 155 or 622 for WANS
- Solaris Bandwidth Manager
- ndd tuning

What is NDD?

- Network driver configuration
- Controls TCP/IP parameters for data flow
- Highly recommended for web servers
- Also important for security and DoS attacks
- Adrian's tutorial
  - http://www.sun.com/sun-on-net/performance/TCP_tutorial.pdf
- Externally created tutorial
  - http://www.sean.de/Solaris/tune.html

Secure Solaris network installation

- Solaris Operating Environment Minimization for Security: A Simple, Reproducible and Secure Application Installation Methodology
  - http://www.sun.com/blueprints

Solaris 8 network enhancements

- Network Cache Accelerator library
- IP Multi-pathing
- Apache Web Server
- IPv6/IPsec
- Mobile IP
- PPP 4.0

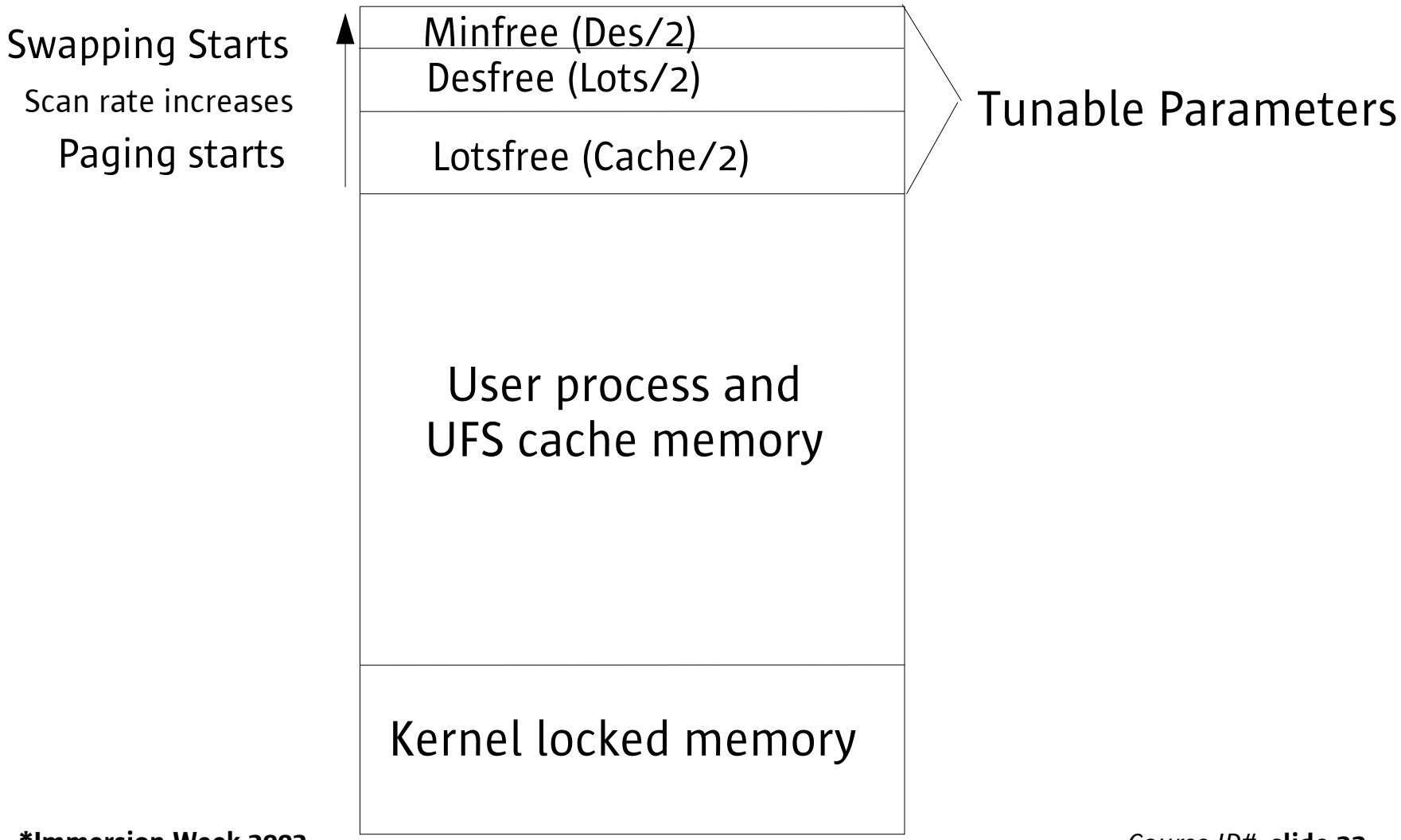
Memory Bottle necks

- Not enough real RAM
- Not enough system virtual memory
- Not enough process virtual space
- Unnecessary/unused processes
- User process memory allocation

What are swapping and paging? When do they occur? Who is responsible?

- Paging is the process of freeing or writing to disk (swap or ufs) pages not currently needed
- When memory gets low (pageout)
- When disk writes are required (fsflush, sync)
- Swapping removes entire processes out of memory (sched)
- When memory extremely low

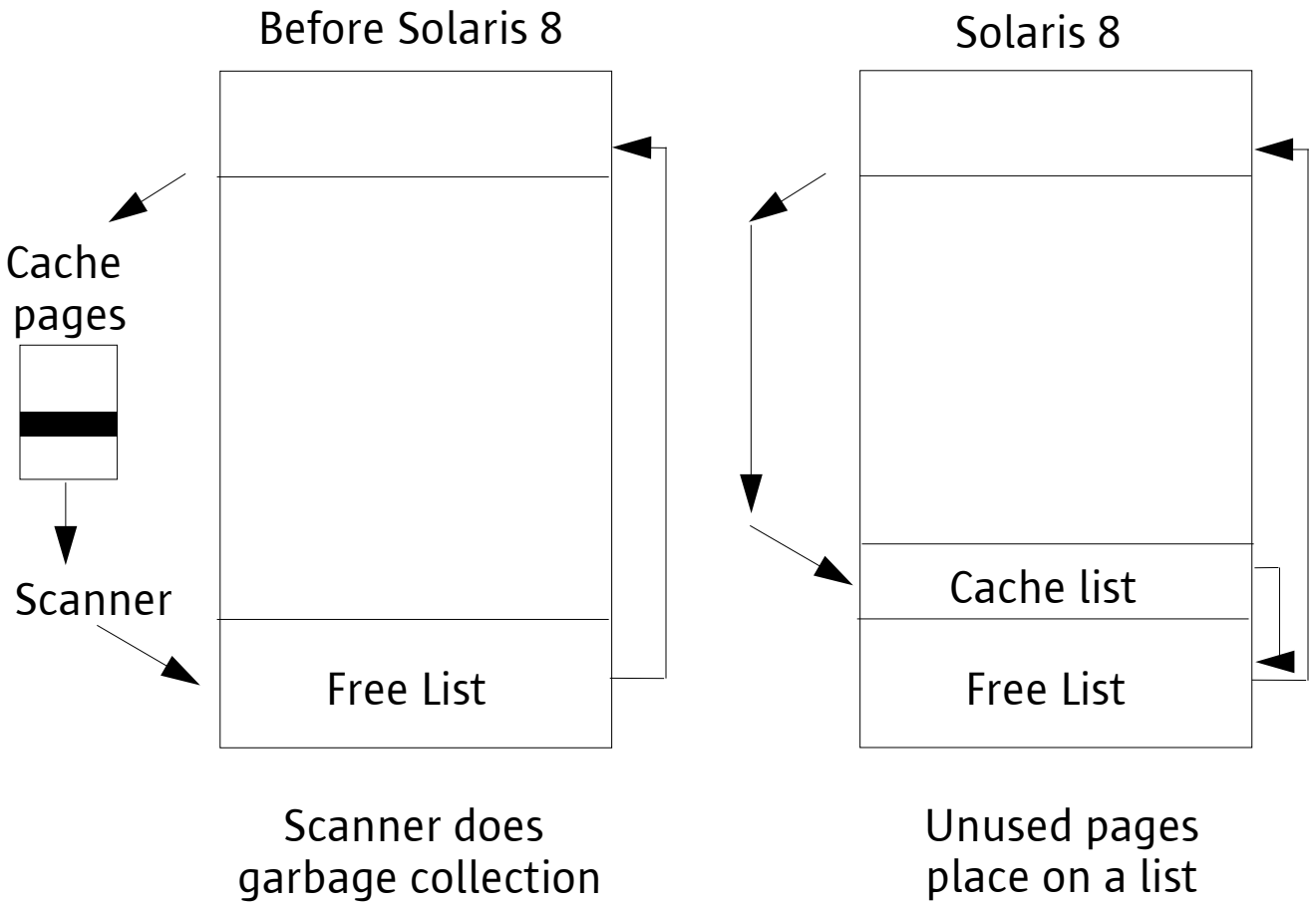
When does the page daemon run?



Priority Paging

- Forces paging of I/O pages before application pages
- Included in Solaris 7, patched into 2.6, 2.5.1.
- Default is off.
- Significantly enhanced the performance "feel" of a workstation 10-300% performance increases measured
- set priority_paging=1 in /etc/system
- Not an option in Solaris 8, must NOT be turned on.

New Solaris 8 VM behavior



Solaris 8 Virtual Memory

- vmstat FREE column is now accurate
- page scanner ONLY runs when there is a memory deficiency
- Leave vm tunables at default values
- DO NOT set priority_paging.
- New vmstat options available.
- Improved I/O throughput

When does fsflush run?

- Flushes part of pages every "fsflush" seconds (default 5)
- Guarantees all data written every "autoup" seconds (default 30)
- Configured in /etc/system

Determining memory status vmstat 5 (partial)

- w processes waiting to be swapped in
- swap, free - available space in KB
- sr - scan rate 0 is good, nonzero is bad

```
procs      memory            page
 r  b  w    swap  free   re   mf  pi  po  fr  de  sr
 0  0  0   11584 10824    0  136   1   0   1   0   0
 0  0  0   56496  3192    0  297   0   4   4   0   0
 0  0  0   56464  3160    0  243   0   4   4   0   0
 0  0  0   56304  3144    0  252   0   1   1   0   0
 0  0  0   56416  3112    0  252   0   4   4   0   0
```

How much Swap space?

- Physmem - kernel + swap = virtual mem
- Used in a round-robin fashion
- Used by core dump
- Can use partitions or files added dynamically (man swap)

No really!
How much swap space do I need?

- 32 MB RAM - 2X Swap
- 32-64 RAM 1.5X Swap
- 64-128 RAM 1X Swap
- 128-256 RAM .5X Swap
- >256 MB .35X mem

Pop Quiz

How can I tell when my virtual memory is used up?

Determining Virtual Memory Usage

```
swap -s
total: 147560k bytes allocated
 + 13800k reserved = 161360k used, 73968k available
```

Wsinfo, sdtwsinfo on panel (CDE 2.6 3/98) shows graphical bar, including %used

What is a memory leak and how do I find it?

- Process mallocs memory but never frees it.
- Use Process Manager (sdtprocess) and sort using the 'size' column.
- Watch for growing virtual memory usage.

Alleviating Memory problems

- Solaris Resource Mgr. can control VM usage.
- Memory bottleneck is also CPU, Disk bottleneck!
- Add memory or eliminate processes if scan rate to high
- Add swap if swap low (swap -a)
- Exit unused processes, control pigs, move some to other computers.
- Adjust page algorithms (kernel tuning)

CPU Bottlenecks

- Too much system time
- Process priorities
- Lock contention

Determining CPU Utilization mpstat

smtx - number of times a mutex lock not gotten
(>200/CPU is bad)
usr - CPU executing for user
sys - CPU executing for system (>35% is bad)
wt - idle time waiting for I/O to complete
idl - idle CPU time

```
CPU minf mjf xcal  intr ithr  csw icsw migr smtx  srw syscl  usr sys  wt idl
 10  136   0  614   300  100  297   51   20   15    0   827    4   4  19  73
 11   71   0  105   111    5  384  102   17    4    0   645    2   6  19  74
 14   78   0  126   221   75  387   90   17   13    0   585    3   2  32  64
 15  112   0   71   444  337  314   73   19    4    0   756    2   4  10  84
```

Determining CPU Utilization
sar -q 5 30

NOTE: Zeros are blank filled.
runq-sz - Size of the system-wide run queue
>4/CPU is bad
%runocc - % of time run queue occupied

```
16:27:40 runq-sz %runocc swpq-sz %swpocc
16:27:45
16:27:50
16:27:55
16:28:00     1.0       20
16:28:50     1.0       40
16:28:55     2.0       20
16:29:00     2.0       20
16:29:25     2.0       20
```

CPU usage example

Vmstat output

procs			memory		page					disk				faults			cpu		
r	b	w	swap	free	re	mf	pi	po	fr	de	sr	m1	m2	m3	m4	in	sy	cs	us	sy	id
0	0	0	724616	32464	0	0	0	0	0	0	0	0	0	0	0	628	1393	1095	0	0	99
0	0	0	724616	32464	0	22	0	0	0	0	0	0	0	0	0	666	20472	1134	3	3	95
0	0	0	724640	32488	0	22	0	0	0	0	0	13	13	13	0	787	116734	1131	12	14	73
0	0	0	724648	32496	0	21	0	0	0	0	0	0	0	0	0	649	118208	1122	13	14	74

mpstat output

CPU	minf	mjf	xcal	intr	ithr	csw	icsw	migr	smtx	srw	syscl	usr	sys	wt	idl
10	8	0	325	300	100	313	99	3	1	0	239	0	0	0	100
11	8	0	28	109	7	349	98	6	1	0	665	0	0	0	99
14	5	0	2	239	90	331	99	5	1	0	266	0	1	0	99
15	0	0	13	114	10	134	8	6	1	0	447	2	1	0	97
CPU	minf	mjf	xcal	intr	ithr	csw	icsw	migr	smtx	srw	syscl	usr	sys	wt	idl
10	11	0	338	301	100	262	83	10	4	0	23226	10	11	0	79
11	0	0	3	117	2	213	65	18	17	0	60267	27	25	6	42
14	5	0	4	193	56	366	99	20	8	0	1892	1	5	21	73
15	5	0	20	266	156	294	82	18	11	0	20119	8	10	0	82
CPU	minf	mjf	xcal	intr	ithr	csw	icsw	migr	smtx	srw	syscl	usr	sys	wt	idl
10	0	0	324	300	100	309	97	6	2	0	392	0	0	0	99
11	0	0	0	118	2	172	59	16	7	0	66116	27	30	0	43
14	0	0	0	208	60	234	73	19	7	0	50734	22	23	0	55
15	0	0	0	125	22	385	104	23	1	0	638	0	1	0	99

prstat features in Solaris 8

- User, project, processor based CPU utilization
- lightweight thread information
- System/user/sleep time per process
- trap, signal, system call, page fault information
- user lock information

Sample prstat output

```
   NPROC USERNAME  SIZE     RSS     MEMORY      TIME        CPU
     42 jlaurent   559M    251M     69%         2:05:00    76%
     34 root       253M    104M     29%         4:50:42    3.4%
      1 daemon     2648K  1208K    0.3%         0:00:00    0.0%

  PID USERNAME USR SYS TRP TFL DFL LCK SLP LAT VCX ICX SCL SIG PROCESS/NLWP
16691 jlaurent  33  33   -   -   -   -  39   -  459 328 12K   0 prstat/1
16561 jlaurent 4.5 2.6   -   -   -   -  92   -   80 120 402   0 soffice.bin/5
 9426 jlaurent 1.9 0.8   -   -   -   -  97   -  100  32  2K  23 netscape/1
17863 root     1.3 0.3   -   -   -   -  98   -  291  14  2K   2 Xsun/1
24684 jlaurent 0.1 0.0   -   -   -   - 100   -   10   0  23   0 wish8.1/1

  PID USERNAME  SIZE   RSS STATE  PRI NICE      TIME  CPU PROCESS/LWPID
   65 root     2768K  800K sleep   18    0   0:00:00 0.0% picld/4
   65 root     2768K  800K sleep   58    0   0:00:00 0.0% picld/3
   65 root     2768K  800K sleep   58    0   0:00:00 0.0% picld/2
   65 root     2768K  800K sleep   18    0   0:00:00 0.0% picld/1
   58 root     2072K  928K sleep   59    0   0:00:00 0.0% syseventd/11
   58 root     2072K  928K sleep   59    0   0:00:00 0.0% syseventd/10
   58 root     2072K  928K sleep   52    0   0:00:00 0.0% syseventd/9
   58 root     2072K  928K sleep   52    0   0:00:00 0.0% syseventd/8
   58 root     2072K  928K sleep   52    0   0:00:00 0.0% syseventd/7
```

CPU Run Queues

- Run queue indicates how far over utilized (or under configured) your system is.
- load average = running + run queue

Alleviating CPU problems

- More or Faster CPUs
- Add CPU cache
- Solaris Resource Manager
- Add memory if scan rate high
- Adjust process priorities (priocntl, nice)
- Control processor utilization (psrset)
- Adjust time slices (kernel tuning)

Pop Quiz

How can I get configuration information about the customer's running system?

Configuration commands

- psrinfo -v - number and speed of CPUs
- prtconf - memory and device tree information
- prtdiag - CPU, Cache, Board, Memory, SBUS slot info
- /etc/release - Solaris HW release info
- showrev -p - Installed patch info
- sysdef - kernel parameter info
- swap -l - swap partition info
- pkginfo - installed packages

Pop Quiz
Kernel Tuning

Can you give me a list of all the kernel tunable parameters?

Pop Quiz
Kernel Tuning

Can you give me a list of all the Solaris tunable parameters?

- docs.sun.com: Solaris Tunable Parameters collection
- Buy Adrian's book
- sysdef
- Parameters can be changed in /etc/system

Why should I use sar?

- sar collects all performance data
- sar inclues timestamps
- sar dumps to a binary file for review
- Examples
  - sar -A -o sarfile 5 30 >/dev/null &
  - Collect all data in background to file every 5 seconds 30 times and inhibit screen output
  - sar -u -f sarfile (Report CPU utilization from file)
- sar -u 5 30 (Interactive version)

Solaris 9 Performance Enhancements

- Memory Placement Optimization
- Large Page support
- File system loggin enhancements
- New threading model
- mtmalloc enhancments

Pop Quiz

- **What free graphical performance tools are available?**

Pop Quiz

- **What free graphical performance tools are available**
- **SEtool**
- **Memtool, Taz disk tool ftp://playground.sun.com/pub/**
- **Sun Management Center (aka SyMon) free with every server**
- **sdtperfmeter**
- **CDE sdtwsinfo, sdtprocess**

Adrian's Top Ten Tips

- Look for a disk bottleneck. More than 30% busy or 50 ms service time is a bad sign.
- When the customer says disks are no problem, insist on seeing iostat -x output
- After tuning other items, check disks again
- Use nfsstat -m to find a busy net or NFS server
- Don't worry about vmstat free RAM, it will not go above "lotsfree" (Sol7 and earlier).

Adrian's Top Ten (cont.)

- Don't worry about pagein, pageout levels, all file I/O is done this way.
- Sustained high scan rates indicate a RAM shortage
- Run queue length >4/CPU indicates CPU shortage
- If block procs = runnable procs, check again for slow disk
- If sys CPU time > user time find out why. (Other than NFS servers)

Lab 1
Memory and vmstat

cp /etc/system system.orig
vi /etc/system
set physmem=4000 # in pages = 16 MB Solaris X86
reboot
start terminal window with vmstat 5
start terminal with iostat -x 5
start file manager
start terminal window with applix -ss &
restore /etc/system when done!

What is the scan rate?
How much swapping is occuring?
What is the CPU idle and system time?
When does page scanning stop?
What is the threshold for paging?
What is the disk utilization?

Lab 2
Disk I/O and iostat

Start terminal with iostat -x 5
Start terminal
create file with 5 lines
find / -name xxx -print &
sh test.sh

What is the service time?
What is the busy percentage?
What is the queue length?

Lab 3
CPU

Start vmstat 5
su root
priocntl -c RT -e sh test.sh
ps -cle

What is the class and priority of the find processes?
What is the responsiveness of the cursor?
What is the CPU idle and system time?